DOCTOR OF PHILOSOPHY

Physical activity levels and fundamental movement skills of British preschool children

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Physical activity levels and fundamental movement skills of British preschool children

By

Clare Mary Petra Roscoe

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Coventry University

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Ethical Approval

REGISTRY RESEARCH UNIT

ETHICS REVIEW FEEDBACK FORM

(Review feedback should be completed within 10 working days)

Name of applicant: Clare Roscoe

Faculty/School/Department: [Faculty of Health and Life Sciences] Centre for Molecular & Biomomolecular

Research project title: Monitoring physical activity levels in children aged 3 to 5 years old in preschool and nursery Early Year's settings.

Comments by the reviewer

1. Evaluation of the ethics of the proposal:
OK

2. Evaluation of the participant information sheet and consent form:
OK

3. Recommendation:
(Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).

X	Approved - no conditions attached
	Approved with minor conditions (no need to re-submit)
	Conditional upon the following – please use additional sheets if necessary (please re-submit application)
	Rejected for the following reason(s) – please use other side if necessary
	Not required

Name of reviewer: Anonymous...

Date: 07/03/2013...

REGISTRY RESEARCH UNIT

ETHICS REVIEW FEEDBACK FORM

(Review feedback should be completed within 10 working days)

Name of applicant: Clare Roscoe

Faculty/School/Department: [Faculty of Health and Life Sciences] Centre for Molecular & Biomomolecular

Research project title: What are the nursery staff and parents' perceptions of preschool children's PA in relation to environment, facilities, play and barriers to PA? Do they differ between settings?

Comments by the reviewer

4. Evaluation of the ethics of the proposal:
all appropriate

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both sheets appropriate

6. Recommendation:
(Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).

	Approved - no conditions attached
X	Approved with minor conditions (no need to re-submit)
	Conditional upon the following – please use additional sheets if necessary (please re-submit application)
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Name of reviewer: Anonymous..

Date: 17/01/2014..

Certificate of Ethical Approval

Applicant:

Clare Roscoe

Project Title:

Monitoring physical activity levels in children aged 3 to 5 years old in preschool and nursery settings.

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

12 September 2016

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Abstract

In the UK, a large proportion of preschool children aged 2-4 years fail to meet the UK recommended physical activity (PA) guidelines of 180 minutes per day for their age. This is a cause for concern for preschool children's development and overall health, as the prevalence of overweight and obesity in their age group is continuing to rise. Awareness of preschool children's PA levels during both the week and weekend days and their fundamental movement skill (FMS) competency is crucial to understand. This will ensure that information can be gained to inform preschool staff, parents and policies to improve preschool children's health. The aims of this thesis were to, a) calibrate cut-points for the use of wrist worn GENEActiv accelerometers, allowing for analysis of preschool children's PA levels, b) be the first to compare PA levels of preschool children between weekdays and weekend days using objective measurements in the UK, c) investigate whether FMS influence PA levels and weight status in preschool children, in an area of low socioeconomic status, and whether such influence differs between weekend and weekdays, and d) investigate preschool staff and parents' perceptions of preschool children's PA and FMS, in relation to the environment, facilities, play and barriers to PA.

The initial stage of this research aimed to validate cut-points for use of wrist worn GENEActiv accelerometer data, to analyse preschool children's (4 to 5-year olds) PA levels via calibration with oxygen consumption values (VO_2). This was a laboratory based calibration study. Twenty-one preschool children, (13 boys and 8 girls) aged 4.7 ± 0.5 years old, completed six activities (ranging from lying supine to

running) whilst wearing the GENEActiv accelerometers at two locations (left and right wrist), these being the participants' non-dominant and dominant wrist, and a Cortex face mask for gas analysis. VO_2 data was used for the assessment of criterion validity. Location specific activity intensity cut points were established via Receiver Operator Characteristic curve (ROC) analysis. The GENEActiv accelerometers, irrespective of their location, accurately discriminated between all PA intensities (sedentary, light, and moderate and above), with the dominant wrist monitor providing a slightly more precise discrimination at light PA and the non-dominant at the sedentary behaviour and moderate and above intensity levels (Area Under the Curve (AUC) for non-dominant = 0.749-0.993, compared to AUC dominant = 0.760-0.988). This study established wrist-worn PA cut points for the GENEActiv accelerometer in preschool children.

The next study sought to be the first to compare PA levels of preschool children between weekdays and weekend days using objective measurements in the UK using the GENEActiv accelerometers. 185 preschool children (99 boys, 86 girls), aged 3-4 years old, participated in the study. PA was determined using triaxial accelerometry over a four-day period. None of the sample met the UK recommended 180 minutes or more of total daily PA. There was a significant difference in the percentage of time (relative) that preschool children spent in sedentary behaviour between week and weekend days ($P<0.05$); yet not between the light and moderate and vigorous PA. Preschool children's participation in moderate and vigorous PA in the week days and weekend days is extremely low, with it being lower during weekend days compared to week days. These findings indicate that interventions are needed to enhance PA on all days in preschool children.

The next stage of research as part of this thesis endeavoured to investigate whether FMS influences PA levels and weight status in preschool children (99 boys, 86 girls) aged 3-4 years, in an area of low socioeconomic status, and whether such influence differs between weekend and weekdays. This study also aimed to test whether FMS differs between boys and girls. FMS proficiency was determined, using the Test of Gross Motor Development 2. PA was determined using triaxial accelerometry over a four-day period. None of the sample met the UK recommended 180 mins or more of total daily PA for health. There were no significant differences in PA or weight status between preschool children with high, medium or low FMS competency ($P<0.05$). There were significant differences reported between hop, leap and skip with girls scoring higher, and the kick where boys scored higher ($P< 0.05$). There were also no significant correlations between overall FMS and MVPA during the week or weekend days. There were no significant differences in PA or weight status between preschool children with high, medium or low FMS competency, possibly because FMS competency had not developed to a high enough level to affect PA.

The final study investigated preschool staff and parents' perceptions of preschool children's PA and FMS, in relation to the environment, facilities, play and barriers to PA. Following institutional ethics approval, semi-structured focus groups were conducted in 4 preschools, with the inclusion of parents and staff of 2-4-year-old children from North Warwickshire, England. The focus groups consisted of between four and five participants and included both parents and staff. However, focus groups were homogeneous in terms of gender, socioeconomic background and predominately homogeneous in ethnic background. Thematic analysis was used to identify key themes and subthemes. Emergent themes included: spacious outdoor environment, the use of climbing frames and outdoor equipment for promoting PA and developing FMS, who was responsible for PA; time, cost, health and safety concerns as barriers to PA and staff training. Findings suggest that preschools provide good opportunities for PA and FMS, especially for preschool children from low socio-economic backgrounds, allowing them access to outdoor exercise and equipment. However, results from the focus groups highlighted a need for more staff training and greater parental involvement in relation to PA and FMS opportunities, to further improve preschool children's PA levels and develop their FMS. To increase PA and FMS in preschool children, interventions are required which continue with the current levels of PA in preschools, whilst including greater parental involvement and staff training for increasing PA levels and developing FMS.

All studies within this thesis have been influential in extending the understanding of preschool children's PA levels and FMS competency from a deprived area. The thesis has found that children do not participate in the UK recommended 180 mins of MVPA per daily. They are significantly more sedentary on the weekend days, their PA levels and weight status do not significantly differ depending on their FMS competency, and preschool parents and staff believe that preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low SES area, with the home environment needing to be more supportive in promoting PA and FMS. Levels of MVPA were found to be extremely low during both the week and weekend days, with them being slightly higher in the weekdays whilst in preschool. Therefore, future interventions are required to improve the MVPA levels in preschool children both in the preschool settings and at home. Equally, sedentary behaviour is required to be decreased during the weekend days, this combined with the qualitative feedback suggests that interventions are specifically required to improve PA levels and FMS competency in the home environment and parents may require training to achieve this. The research conducted within this thesis is important in informing future research/interventions and public health policies to improve the PA levels, FMS competency and weight status of preschool aged children living in a deprived area.

Acknowledgements

I would first like to acknowledge my Director of Studies and Supervisor Professor Mike Duncan and Professor Rob James. Thank you very much to both of you for your amazing support, energy, intellect and commitment. The opportunity you have provided me with, to work alongside you both has been greatly appreciated, and at the same time inspiring in terms of the knowledge and drive you have helped to instil in me. Throughout the whole process you have been there for me and supportive, so thank you.

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On a personal note, thank you to my parents for their unconquerable love and time. Their help in terms of looking after the Grandchildren has been truly appreciated! Without that love and support this thesis would have been impossible.

Finally, to my husband Mark and gorgeous girls Mia and Freya, it is these that have allowed me to still enjoy my life, manage my time and strive for my goal of completing this thesis. They have kept me focused, sane (at times insane!) and provided me with hugs that have made me determined to keep going through the harder times, for this I love them greatly!

The following publications have arisen from the research conducted in this thesis

Peer reviewed journal papers:

Roscoe, C. M. P., James, R. and Duncan, M. (2017). 'Calibration of GENEActiv accelerometer wrist cut-points for the assessment of physical activity intensity of preschool aged children'. *European Journal of Pediatrics* 176 (8), 1093-1098.

Roscoe, C. M. P., James, R. S. and Duncan, M. J. (2017). 'Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: a qualitative study'. *Qualitative Research in Sport, Exercise and Health* 9 (5), 619-635.

National-international conference presentations:

Roscoe, C. M. P., Birch, S., L., James, R. S. and Duncan, M. J. (2014). 'Comparisons between weekday and weekend physical activity in British preschool children'. Poster presentation at the 2014 European College of Sport Science (ECSS), Amsterdam, Holland.

Roscoe, C. M. P., Birch, S., L., James, R. S. and Duncan, M. J. (2014). 'Motor Competence and Weekend Sedentary Time Predict Body Mass Index in Pre-School Children'. Poster presentation at the 2014 Association for the Study of Obesity (ASO), Birmingham, England.

Roscoe, C. M. P, Birch, S. L., James, R. S. and Duncan, M. J. (2015). ‘Preschool and parental influences on physical activity and fundamental movement skills in preschool children from low socio-economic backgrounds: A qualitative study.’ Oral presentation at the 2015 British Association of Sport and Exercise Sciences (BASES), Burton, England.

Roscoe, C. M. P., Wilson, S., James, R. S. and Duncan, M. J. (2016). ‘Validation of GENEActiv wrist worn accelerometers for use with pre-school children.’ Poster presentation at the 2016 British Association of Sport and Exercise Sciences (BASES), Nottingham, England.

Roscoe, C. M. P., James, R. S. and Duncan, M. J. (2017). ‘Accelerometer based physical activity levels, fundamental movement skills and weight status in British preschool children.’ Oral presentation at the 2017 British Association of Sport and Exercise Sciences (BASES), Nottingham, England.

For both journal papers and all conference presentations, Clare Roscoe gained ethical approval, conducted the research (collected the data and performed the analysis) and wrote the first draft of each paper or presentation. Rob James and Michael Duncan both advised on the statistical analysis and provided comments and areas to improve on the draft papers.

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Chapter 1.

Introduction

1. Introduction

1.1 General Introduction and Thesis Outline

A large proportion of UK preschool children aged 2-4 years do not achieve the UK recommended physical activity (PA) guidelines of 180 minutes of PA per day (Department of Health 2011a). It has been reported that fewer than 1 in 10 (9%) children between the ages of 2-4 years meet the guidelines and 83% of this age group participate in less than an hour of PA daily, or they sufficiently meet 180 minutes some days but not all (NHS digital, 2016a). This has implications because current estimates suggest that 12.1% of preschool children are obese (BMI≥ 95th percentile for their age and gender) (Ogden et al. 2002).

Participation in PA is fundamental to the health and well-being of children (Adolph et al. 2012; Esliger and Tremblay 2007) and it is important that PA is integrated into their lives (Tucker 2008). This is especially important in respect to preschool children, because PA in this age group is imperative in delaying the onset of rapidly increasing body fat in children 4-6 years old (Moore et al. 2003) and offering protection against excess weight gain (Jiménez-Pavón, Kelly, and Reilly 2010). In 2015, 42 million children worldwide under the age of 5 years were estimated as overweight (WHO 2017), with weight gained by 5 years of age a predictor of being overweight in adulthood (Frank Fields' Report 2010; Gardner et al. 2009; Guo and Chumlea 1999; Reilly et al. 2005; Serdula et al. 1993). The prevalence of overweight and obesity among preschool children is unacceptable amongst developed countries and is increasing in developing countries (Hardy et al. 2012a). In the UK, excess weight gained by adolescent years may have occurred prior to children entering schools (Garnder et al. 2009). This is because according to the National Child Measurement Programme (NCMP) (2016), conducted on behalf of NHS digital (2016b), over a fifth of reception children were reported as overweight or obese, with 9.3% as obese in 2015/2016, this increased to over a third who were overweight or obese and 19.8% who were obese in year 6 (aged 10-11 years). This is supported by further research, where 14% of both boys and girls were classed as obese and 28% were overweight or obese, in children aged 2 to 15 years (NHS digital 2016b). PA levels and sedentary behaviour of children in the UK have been viewed as 'obesogenic' (obesity promoting) (Reilly et al. 2004; Reilly et al. 2005), with habitual PA declining and sedentary behaviour being the dominant state of preschool children's PA levels during their preschool day (Jackson et al. 2003; Raustorp et al. 2012; Reilly et al. 2005; Reilly 2010; Tucker 2008). One explanation for this trend is that too many children spend very little time outside and too much time inside watching television; this can be a result of parent's safety concerns of playing outside in local areas (Kimbro, Brooks-Gunn, and McLanahan 2011). Equally, children living in poverty may be deprived of safe and creative playtime, along with reduced access to age-specific extracurricular activities (Milteer, Ginsburg, and Mulligan 2012).

Childhood obesity remains a public health concern (de Onis and Blössner 2000), as children who adopt high risk behaviours including physical inactivity tend to maintain these risk factors through to adulthood (Pate et al. 1996). Obesity has associated health problems such as cardiovascular disease, hypertension, type 2 diabetes, sleep apnea, back pain and some cancers which can cause death; with the exacerbation of existing conditions such as asthma (Health Development Agency 2009; Must et al. 1999; van Loon and Frank 2011). Increasing activity levels in a sedentary population could be influential in preventing or at least postponing the onset of chronic diseases, especially as regular PA has been known to lower colon cancer and strokes (Blair, Wood, and Sallis 1994) and is associated with enhancing general health and quality of life (Haskell et al. 2007). Obesity and overweight are due to excessive or abnormal fat accumulation that present a risk to a person's health; a Body Mass Index (BMI) of 25-29.9 $kg{\cdot}m^2$ indicates overweight and ≥30 $kg{\cdot}m^2$ obese (World Health Organisation 2012). In its simplest form, obesity is a result of an imbalance in energy intake and energy expenditure (Moore et al. 2003), which can be caused by a poor diet and/or lack of exercise (Brown et al. 2009). Differing intensities of PA in preschool children could be important, as they may influence the timing of the "adiposity rebound", when BMI increases after reaching its low point in childhood; this period is critical in terms of risk for obesity later in life, because the earlier the adiposity rebound the greater the risk of obesity in adulthood (Jackson et al. 2003).

Time spent in outdoor play is negatively associated with BMI, for every hour of outdoor play, children scored approximately half a percentile point lower on BMI (Kimbro, Brooks-Gunn, and McLanahan 2011). Conversely, time spent watching television is positively associated with BMI, again with every hour of television watching, they scored approximately half a percentile higher on BMI (Kimbro, Brooks-Gunn, and McLanahan 2011). This is a major cause for concern and one which needs addressing, because if PA levels are decreasing and sedentary behaviours increasing for preschool aged children, then obesity is likely to rise in this age group. Children participate in different forms of play, one being free unstructured play, which involves the child having freedom to be creative, and semi structured play which is play with joint input by the child and adult (Milteer, Ginsburg, and Mulligan 2012). Play has been considered as an excellent way to increase PA in children and should be considered as a strategy in addressing the obesity epidemic (Cleland and Venn 2010). Directing attention towards preschool children is important as a large amount of 3 to 5-year olds spend their day in childcare settings and this would provide an opportunity to promote PA and healthy behaviours (Bower et al. 2008).

It is reported, that approximately one-third of overweight preschool children remain overweight as adults and have a greater chance of associated risks of obesity later in their life (Guo and Chumlea 1999; Reilly et al. 2005; Serdula et al. 1993), with PA levels being shown to be maintained from year to year (Pate et al. 1996). As a large proportion of preschool children are not sufficiently active, then long-term health concerns of preschool children could increase obesity levels and health care costs (Gordon-Larsen, Nelson, and Popkin 2004). Ensuring preschool children are physically active is imperative to promote PA for them currently and to provide them with the incentive to remain active and with better health into their adult life (Barnett et al. 2009; Pate et al. 1996; Sȧȧkslahti et al. 2004). Improved health will contribute to reducing cost implications to both the individual and the country. Therefore, it would be more appropriate to concentrate on preventing the problem from occurring as opposed to implementing interventions once obesity has occurred. Frank Fields'

Report (2010), agreed with early intervention as it stated that there is overwhelming evidence of children's life chances being predicted on their development in the first five years of their lives.

Recent evidence is emerging, which shows that engagement in PA during the preschool years has critical health and developmental implications that can continue across the life course (Stanley et al. 2016). It is well established that there are strong benefits of PA on musculoskeletal health, bone health, improved motor development, cardiovascular health, cognitive development and adiposity in normal and overweight children, and these benefits are greater in early childhood than later in life (Strong et al. 2005; Timmons et al. 2012). PA is an effective lifestyle choice in enhancing individuals' lives and delaying mortality (Lee, Paffenbarger, and Hennekens 1997). Up to one-thirds of all deaths in the UK are due to diseases that could in part, be reduced by engaging in regular PA (Allender et al., 2007). The link between physical inactivity and the development of non-communicable diseases are well established, with an increased risk of developing coronary heart disease (relative risk factor of 1.6), type II diabetes (relative risk factor of 1.20) and all-cause mortality (relative risk factor of 1.28), due to physical inactivity (Lee et al. 2012). A relative risk factor score of >1.00, indicates an increased probability of developing a disease.

There is a concern that too much of a child's day consists of sedentary activity ~ 6.1 (Dolinsky et al. 2011) and 10.8 hours per day (O'Dwyer et al. 2013), and only 9.5 minutes per day of moderate and vigorous PA (MVPA) (Dolinsky et al. 2011), with similar results reported by Taylor et al. (2009), of a mean of 16 minutes per day of MVPA for 4-year olds. Reilly, Kelly and Wilson (2010) found in a review of 13 studies using objective measurements of PA, that preschool children's PA levels in childcare settings were low and equivalent to < 60 mins per day of MVPA. Although the benefits of PA are known, unfortunately, it would appear that a high number of preschool children in the UK do not meet the government's recommended daily PA levels. However, Hesketh, Griffin, and van Sluijs (2015), in a UK-based study, did observe higher activity levels in preschool children in their study, with all the children meeting the current activity guidelines of 180 min of light, moderate and vigorous PA (LMVPA). This study did incorporate light PA levels, unlike Dolinsky et al. (2011) and this must be taken into consideration.

It has been recommended that preschool children should have at least sixty minutes of structured and sixty minutes of unstructured PA a day, whilst not being sedentary for 60 minutes at one time, apart from sleeping (National Association for Sport and Physical Education 2009). Updates to these guidelines of 120 minutes of PA, suggest that care providers should ensure that opportunities are planned for preschool children to engage in MVPA (Beets et al. 2011). Other interpretations of the NAPSE guidelines, have concentrated on sufficient PA being defined as a minimum of 60 minutes of MVPA per day (Tucker 2008). More recent recommendations stated that preschool children should ideally be participating in at least 180 minutes LMVPA per day, which should involve movement of their trunk from one place to another, through challenging activities that can be informal or formal, indoors or outdoors, to facilitate motor development and the ability to perform large muscle activities (Department of Health 2011a; NAPSE 2009; Reilly et al. 2012). The recommendation of 180 minutes of LMVPA is the main benchmark for preschool children's PA within the UK and it could be viewed as incorporating the NASPE (2009) recommendations. Depending on the recommendations that are followed, then many preschool children do not meet the UK recommended 180 minutes of LMVPA, but some may meet the 60 minutes of MVPA. It was reported that children engaged in 7.7 minutes of MVPA per hour at preschool, therefore, if a child attends for 8 hours they would engage in ~1 hour of MVPA and it would be unlikely they would then participate in a further two hours of PA outside of preschool (Pate et al. 2004). Preschool children in this study therefore achieved the 60 minutes of MVPA, however, they did not achieve the longer duration of 180 minutes of LMVPA. This is similar to the mean time spent in MVPA reported as 2% (Reilly et al. 2004) or 3%, which translated into 22 minutes per day (Kelly et al. 2006) during the week and 32 minutes a day during the weekend (Vasquez et al. 2006), this differs slightly from the 108 minutes in MVPA reported by Montgomery et al. (2004). This lack of participation in MVPA in preschool children can be a result of being prevented from playing freely, for example when there is no provision of outdoor play or use of gymnastic equipment. Furthermore, it was reported that for children between 2-4 years, only 9% of boys and 10% of girls meet the Chief Medical Officer's recommendations for PA (Health and Social Care Information Centre 2012), this highlights that PA in this age group is low and has the capacity to improve (HM Government 2014). Children normally engage in very short bursts of intense activity which is interspersed with varying levels of low and moderate intensity activities, which should be considered in future interventions (Bailey et al. 1995).

Identifying the levels of PA spent in LPA and MVPA during both the week and weekend would be appropriate in helping to determine when the children are most active. This information could be beneficial in preventing the UK developing into an obese society and reducing the cost to the individual and the country. It would also be informative to assess preschool children who live in deprived areas, as research in school aged children has shown that, children living in deprived areas have lower PA levels (Griew et al., 2010; Spengler et al., 2011) and suffer from multiple experiences of deprivation (e.g. increased traffic volume, pollution, poor housing), which provides less opportunity for PA (Bolte, Tamburlini, and Kohlhuber 2010). Therefore, assessing preschool children from deprived areas is imperative to determine their PA levels and to see it deprivation does impact on their life chances due to less PA.

Preschool settings are influential in promoting PA to preschool children due to the time that children spend in childcare. It is recommended that strategies to promote participation in PA, require activities that maintain or enhance perceptions of fundamental movement skills (FMS) competency (Foweather et al. 2015; Fox and Wilson 2008; Stodden, Goodway, and Langendorfer 2008). FMS consist of basic movements which include locomotor (e.g. skipping) and object-control skills (e.g. throwing) (Barnett, et al. 2009). These skills are key determinants of PA and improved motor competency of these skills is meant to enable children to be more active (Logan et al. 2015; Lubans et al. 2010; Seefeldt 1980). FMS competency has previously been stated as a prerequisite to physically function on a daily basis (Butcher and Eaton 1989; Venetsanou and Kambas 2011) as it provides the building blocks for future motor skills and PA (NASPE 2009). FMS competency amongst preschool children is essential in providing opportunities to participate in current and future PA (van Beurden et al. 2002). Motor skill competency and PA will strengthen together over time and therefore possess a reciprocal relationship, which prevents physical inactivity (Stodden, Goodway, and Langendorfer 2008). Butterfield et al. (2012) reported that there was a low probability of children prior to 5 years of age displaying FMS competency. It is therefore extremely imperative to research this area to understand early development of FMS. This is especially important, as preschool children are described as only being at the initial or elementary stages of FMS development (Gallahue and Donnelly 2003) and they require encouragement, instruction and practice to reach mature patterns of FMS (Foulkes et al. 2015). Understanding preschool children's FMS competency levels, will allow further research to address any areas of weakness.

Chapter 2.

Literature Review

2. Literature Review

2.1 Physical Activity

2.1.1 Overview

Currently there are policies and quality frameworks in place which aid in preventing obesity within preschool children in the UK. The ‘Healthy Weight, Healthy Lives’ policy is a national strategy which tackles obesity. It focuses on prevention and children, and aims to commit to early identification of at risk families, but does however state that an excess weight problem in children can only be tackled within the whole family (Department of Health 2012b). The ‘Healthy Lives, Brighter Futures’ strategy, has committed to a strengthened role in supporting children’s centres, through health-based programmes which focus on reducing child obesity and ensuring each centre has access to a health visitor. It aims to tackle obesity by training practitioners to work more effectively with parents (Department of Health 2012a). The Marmot Review Team (2010), through the ‘Fair Society, Healthy Lives’ review, published three recommendations relevant to preschool children’s obesity prevention:

1. Increased investment for pre-schools.
2. Strengthening the role of prevention.
3. The need for population-wide obesity prevention programmes.

The Department of Health (2011c) supported The Marmot Review Team’s recommendations by stating that more attention is required to improve the health of preschool children, however they made no specific mention of obesity prevention. A review of these policies clearly highlights that strategies are in place to tackle obesity in preschool children, however, more work is required to encourage PA to prevent obesity and associated health implications in children, prior to commencing school. Research has identified a positive link between sedentary behaviours and being overweight in preschool children. This is supported by Hardy et al. (2012a), who showed that almost 1 in 5 children (18.7%) in their study, started school overweight/obese and there was strong evidence that weight-related behaviour was higher among the overweight/obese children, as these children were most likely to have a television in their bedroom or were rewarded for good behaviour with sweets.

The preschool years are extremely crucial in terms of weight as the children start to establish PA patterns and eating habits. As most excess weight gain in primary school children is gained by 5 years old (Gardner et al. 2009), this creates a cause for concern and one which needs to be researched in terms of an intervention that could impact on reducing obesity in preschool children and later in their life. This approach is supported by Gardner et al. (2009) who stated that a single measure of weight at 5 years old may prove to be clinically valuable if it is collected appropriately and acted upon in terms of preventing and managing obesity and future diabetes and cardiovascular risks. Preschool years are also crucial in that they precede the increase in BMI known as adipose rebound. It has been reported that in more active children the adiposity rebound occurred at a later stage, which perhaps could reduce their risk of obesity later in life (Moore et al. 2003), highlighting the importance of having physically active preschool children. This helps to reduce the concern that overweight children will persist into adolescence and adulthood (de Onis and

Blössner 2000). Therefore, the PA and play that preschool children participate in could be vital to their weight status, health and physical development.

2.1.2 Play

Play has been considered as one way of being instrumental in achieving the previously mentioned strategies. Play is a key form of PA in children. There are two types of play, unstructured and semi structured play. Free unstructured play contributes to social, emotional and cognitive development (Milteer, Ginsburg, and Mulligan 2012), is therefore essential for children to participate in, and contributes to PA. Play involves children participating in a natural environment where they form relationships with other children and use play as a way of overcoming physical and social challenges. All children have the right to safe and regular PA, which will help to decrease lifelong health inequalities and produce children who will positively contribute to society in the future (Milteer, Ginsburg, and Mulligan 2012). Semi-structured play involves the preschool children having a choice of what they do, yet it is not entirely their decision/free play. An example would be children being provided with an activity card and they perform the activity how they see fit. This shares some similarities with what can happen in physical education lessons. Physical education lessons in schools have been reduced and extra-curricular sessions have started to reduce play/PA. Extra time has been devoted to reading and mathematics at the expense of time for physical education lessons and recess (McMurrer 2007; Caitlin 2008). According to the Youth Sports Trust survey, in the school year 2013-2014, key stage 1 children (5-7-year olds) spent an average of 102 minutes per week taking part in PE, compared to 126 minutes in 2009-2010

(YST 2015). This is obviously an issue from 5 years upwards and one that will impact on a child's PA levels, development and weight status as they progress into adulthood. However, it is also imperative that research occurs in terms of the content of 3-5-year olds PA and what sedentary behaviour, or intensity of PA they participate in daily.

2.1.3 Physical Activity Studies – BMI and Sedentary Behaviours

BMI is relatively cheap to obtain and easy to calculate, therefore it is used for population surveys and when assessing individual clients (NOO 2011). The National Obesity Observatory (NOO) have been involved with the NCMP, who have been looking at the BMI of children 4-5 and 10-11 years. They have used the prevalence of obesity and mean BMI (adjusted for age) to summarise the BMI of the child population by school year and sex (NOO 2010). The use of BMI through this NCMP has been the marker for measurement of weight status in the UK. The NCMP showed that in England in 2007/2008, 13% of 4-5 year olds were overweight (NOO 2009). This was again looked at in 2012/2013 when one in five children in reception were overweight or obese, boys 23.3% and girls 21.2%, and one in ten were obese, boys 9.7%, girls 8.8% (NOO 2014). When interventions are used to improve a child's health and PA, as the child is still growing and maturing, it is not possible to recommend a suitable effect size and therefore, it is more important to measure changes such as BMI centiles or specific z scores on a child growth reference instead of focusing on weight loss per se (NOO 2009). Fixed thresholds like those used for adults should not be applied to children, as they could provide misleading results. Therefore, children’s BMI is categorised using variable thresholds for the child’s age and sex (NOO 2011).

The British Heart Foundation National Centre (2011) conducted national PA audits of preschool settings and discovered that 98% of children’s centres provide some form of active play provision to children on a weekly basis, with 72% of staff receiving some specific training in PA, yet most centre managers would like to receive help with PA ideas through resources and training. The British Heart Foundation National Centre (2012) discovered that all nurseries provided PA opportunities daily, however there were differences in the time children spent playing outside. BMI measurements and plotting commence at 1 year of age, allowing overweight and obese children to be detected; this is a first step in obesity prevention. Preschool settings are therefore influential in improving the PA and health benefits of children from an early age. Large numbers of children attend preschools (Ward 2010), and basic movement patterns are developed and can be built on for PA later in life (Strong et al. 2005). Recent literature emphasises how relevant it is to embed PA into children’s lifestyles as early as possible and that preschool settings are influential in this process. For example, Reilly (2010) stated that PA levels within preschools are typically very low and levels of sedentary behaviour are typically high. This evidence clearly highlights the priority of providing clear guidance for preschool settings. Additionally, it would be advantageous for physicians and other primary health care providers to be actively involved in the promotion of PA and fitness in children, especially low active children, to reduce the negative health behaviours that inactivity is associated with (Pate et al. 1996).

Preschool children, with parents who have a high BMI or who are from a low socioeconomic status (SES), have been reported as at a greater risk of being overweight/obese and this has raised the requirement for studies to assess which PA behaviours are associated with being overweight in this age group (van Stralen et al. 2012). However, Kimbro, Brooks-Gunn, and McLanahan (2011) found that the poorest and wealthiest children have been reported as having lower BMI's when compared to those in the middle of the socioeconomic status scale. de Onis, Blössner, and Borghi (2010), stated that the rise in overweight and obesity since 1990 has been dramatic. If the number of overweight and obese preschool children continues to increase, then this will have enormous implications on their health and health costs. Especially as research identified that children aged 5 years old, who had a high weight/BMI, were indicated as a high risk for diabetes later in childhood (Ljungkrantz, Ludyigson, and Samuelsson 2008). If excessive weight gain was prevented in preschool children, then a healthier weight should be maintained when older (Gardner et al. 2009). This is supported by de Onis, Blössner, and Borghi (2010), who stated that the rise in overweight and obesity since 1990 has been dramatic. Therefore, prevention-orientated strategies (Ward 2010) need to be implemented to reverse the trends. Currently, a lack of physical training in preschool children represents a missed opportunity to prevent obesity in this age group (Flynn et al. 2006). There needs to be implementation of interventions to reduce barriers to indoor PA (Howie et al., 2012) and to reduce sedentary TV/video viewing to treat obesity (Mendoza, Zimmerman, and Christakis 2007) and improve weight status. Literature would suggest that PA needs to be increased for preschool children in both the preschool settings and through raised parental awareness of appropriate

PA at home (O'Dwyer et al. 2011). This is because high levels of PA, in preschool children, may delay the onset of rapidly increasing body fat which usually happens between 4 and 6 years of age (Moore et al. 2003).

When looking at weight status in terms of BMI measurements, non-overweight boys were reported as spending significantly more time in moderate intensity activity during the preschool day when compared to overweight boys (32.0 vs. 25.3 minutes) (O'Dwyer et al. 2011; Trost et al. 2003), with overweight boys spending significantly greater time in sedentary behaviours at the weekend (684 vs. 863 minutes); with weight status having no effect on girls PA levels (O'Dwyer et al. 2011). This aforementioned study cannot infer causality and only assessed a sample size of 50 preschool children, this low sample size reduces the power of the study and the design employed prevents any determination of causal relationships between PA and BMI. The sample chosen limits the findings being fully comparable to all populations, yet this is an issue with most studies, however, this study did measure PA levels over three days, allowing a reflective measurement off habitual PA to be determined. Very few children accumulate 60 minutes a day of MVPA and therefore they could be at risk of further weight gain (O'Dwyer et al. 2012), due to increases in adiposity. This research performed by O'Dwyer et al. (2012) was performed on a convenience sample consisting of 77 families, which included 79, 3-4.9-year olds from 8 Sure Start Centres in the North West of England. The participants took part in a 10-week intervention, where they were assigned to either an intervention or comparison group. This study was exemplar in that it used a whole system approach to tackle behaviour change, it targeted parents to promote PA with their children and actively involved and assessed both the children and the parents. O'Dwyer et al. (2012) measured PA using the ActiGraph accelerometer over a 4-day period, which included 1 weekend day, whilst using additional methods of a log-book for the parents to monitor the children's PA, and the completion of a shorter version of the Preschool-age children's Physical Activity Questionnaire (Pre-PAQ). This multi-methods approach, allowed objective and subjective evidence to be gathered and it highlighted a relationship between increased activity for parents and decreased sedentary behaviour for the children. Limitations in this study were the time that was required by the parents to promote and record PA that had occurred, therefore, caution must be shown when using subjective measures of PA, to prevent any participants from being discouraged to engage in future research. Research has demonstrated that hours of outdoor play are negatively associated with BMI and hours of television positively associated with BMI, with half a percentile lower on BMI for each hour/day spent in outdoor play (Kimbro et al. 2011). Hence, children with a greater standardised BMI are less physically active, more sedentary and have poorer motor proficiency, when compared to children with lower standardised BMI's (Wrotniak et al. 2006). This emphasises the requirement for a higher intensity of PA in preschool children, with the aim of lowering their weight status/obesity levels in terms of BMI.

2.1.4 Physical Activity Studies – Moderate to Vigorous Physical Activity

Children spend the majority of their day in sedentary behaviours and <5% of their day in MVPA (Finn, Johannsen, and Specker 2002; Jackson et al. 2003; Montgomery et al. 2004; Pate et al. 2004; Pate et al. 2008; Reilly et al. 2004), with some studies reporting a higher, yet still low proportion of time (<15%) in MVPA (Montgomery et al. 2004). Children's PA consists of few MVPA occurrences which last 20 minutes or more (Benham-Deal 2005). However, there is limited data existing on MVPA levels for normal weight and overweight preschool children (O'Dwyer et al. 2012). Four and five-year-old children spend less time in frequent light PA and MVPA and more time in sedentary behaviours than 3-year-old children (Bailey et al. 1995; Brown et al. 2009). A greater amount of time, ~43 min of each hour is spent in sedentary behaviour for 3-5-year olds (Pate et al. 2004), with 90% of indoor time and 75% of outdoor time spent in sedentary behaviour (Raustorp et al. 2012). PA, determined as counts per minutes, has been reported as significantly higher outdoors than indoors (Raustorp et al. 2012) and 27% of children's outdoor activity was in MVPA (Dowda et al. 2004). Therefore, establishing sufficient PA levels, whether that involves increasing light intensity and/or MVPA or reducing sedentary behaviour in preschool children, should be considered an important public health issue and should be effective in obesity prevention and treatment (Hinkley et al. 2012; Montgomery et al. 2004). This is a strong statement to make, and in terms of the measurement of PA by Montgomery et al. (2004) in making this conclusion, they used a socioeconomically representative sample of 36 preschool children from the Glasgow area, however, this was a relatively small sample size to represent all preschool children from a variety of SES backgrounds and geographical areas. PA was measured using a uniaxial CSA/MTI accelerometer, which although it only measures PA in the vertical plane, it was not considered to be a limitation, as previous studies have shown very little difference in measurement of PA between the biaxial and triaxial accelerometers (Puyau et al. 2002; Welk, Corbin, and Dale

2000). Montgomery et al. (2004) measured PA over a three-day period for all waking hours, as they considered this to be a reliable and representative sampling process reflective of the everyday PA of a preschool child for the entirety of their day. Finally, the accelerometers were set at 1-minute intervals, yet this may have limited the accuracy of measuring VPA of a preschool child. This study could be questioned due to only using a uniaxial accelerometer, a 1-minute sampling period and a small sample, therefore, the results cannot be fully comparable to all preschool children.

2.1.5 Physical Activity Studies – Duration of Physical Activity

According to previous research, which assessed 39 studies, half of preschool children participated in less than 60 min/day of MVPA, which is a level that is insufficiently active (Tucker 2008). Of these studies, 54% of the preschool children were active in accordance with NASPE's current standards of 60 minutes per day of MVPA, so 46% did not meet the recommended guidelines for PA and were therefore not active enough for health benefits (Tucker 2008). If these studies were reanalysed using a 120 min/day threshold for sufficient MPVA, then only 23% of the studies would have reported sufficient activity levels and this is still 60 min/day short of the UK recommended 180 min (Department of Health 2011b). This is a concern due to the limited amount of activity and the lower intensity of the activities being completed. The research conducted by Tucker (2008) was novel as it reviewed studies that only included preschool children, it incorporated 7 countries and had a large sample size of 10,316 (mean sample size 262) over a 21-year period. A strength to this research was that Tucker (2008) reviewed studies with a variety of PA assessment methods, those being, accelerometers, pedometer, self-reports, heart rate monitors, direct observations and doubly labelled water. Thirty six percent of the studies reviewed included more than one assessment method; the advantage of this was that there were two forms of measurement to support the outcome of the PA levels being reported. Conversely, it was stated that some of the PA measurements may have been used and sacrificed accuracy, for lower cost and larger sample sizes, as opposed to those such as doubly labelled water and direct observations which are higher in cost, accurate and assess a lower sample size. This review highlighted the importance of considering the measurement of PA that is used; it emphasised that consideration of cost is important but also the accuracy of the data that is collected and reported on is essential.

This said, preschool children are known to participate in a pattern of activity-rest-activity and unfortunately many of them do not engage in sufficient VPA over a day (Benham-Deal 2005). Many different reasons were given for participating less in PA, such as families engaging less in VPA, children watching TV more (Timmons, Naylor, and Pfeiffer 2007), less outdoor play at home (Benham-Deal 2005), differences between preschools PA participation (Pate et al. 2004), small classrooms, small playgrounds and fixed play equipment (Brown et al. 2009), and children with less well-developed motor skills (Williams et al. 2008). Additional studies have reported an inverse relationship between PA levels and time spent sedentary, and a positive association between PA levels and time spent participating in light intensity activities; so, a shift from sedentary activities to light intensity activities may increase total energy expenditure (Montgomery et al. 2004) and help to lower any associated issues with obesity.

2.1.6 Physical Activity Studies – Highly Active v Lower Active Children

Highly active (HA) children, when compared to lower active (LA) children, have been observed to be participating more frequently in activities that involve swinging and throwing and less frequently in walking. HA children participate in higher intensity activities compared to LA children whilst indoors (3.60% time in MVPA v's 2.70%), yet outdoors there is no significant difference (Howie et al., 2012). This study is one of very few to look at higher and lower active children, therefore, there is a gap in the literature that needs to be investigated more. The results of this study emphasise the relevance of PA indoors and future studies should aim to reduce any barriers to participating in PA indoors, whilst still including outdoor time. The Howie et al. (2012) study was limited to observations and accelerometry only being performed in preschool time, which questions the validity of the research in terms of total PA during weekdays and weekends (Howie et al. 2012). Therefore, further investigation is needed to provide more representative data of HA and LA in preschool children, both at preschool and at home. Future research observing the types of activity that preschool children participate in and the intensities that they are active at would be relevant. In summary, more rigorous studies are required to examine methods of increasing PA in preschool children, through both the preschool setting and parental involvement. Various factors, such as environment, fundamental movement skills and socio-economic status have previously been shown to affect the amount of PA children undertake.

Despite the limitations mentioned regarding the study conducted by Howie et al. (2012), it did have strengths as its sample size was relatively large, at 231, providing a reliable measure of power to detect differences in indoor and outdoor PA. The sample was taken from 20 preschools and included a mixture of commercial childcare, church affiliated preschools and Head Start Centres, in the United States of America. The children were all aged between 3-5 years and there was a stipulation that when measuring PA using the ActiGraph accelerometer, data collection was required for 3 or more days, for more than 4 hours a day. A further strength in this study, was that it used both an objective measure (accelerometry) of PA and direct observations, which were beneficial in providing combined methods to enrich the findings regarding PA of preschool children, as supported by the review of studies conducted by Tucker (2008). Contrary to the notion of two forms of measurement being a strength, it was reported within the study that having two methods brought limitations, as it was challenging to ensure that both methods were executed correctly.

2.1.7 Physical Activity Studies – Environments

Settings which have more supportive environments for high quality PA, such as outdoor space, achieved more MVPA, with less time spent in sedentary activities and a higher mean PA level and more children with normal BMI, when compared to settings with less supportive environments (Bower et al. 2008; Söderström et al. 2012). The time spent indoors and in low MVPA highlights a risk of not fulfilling the required daily amount of PA for preschool children (Raustorp et al. 2012), therefore, outdoor activities requiring large muscle movements should be employed in preschool children as often as possible (Benham-Deal 2005). Additionally, children of preschool age that are cared for in home-based settings often do not play outside daily (Tandon, Zhou, and Christakis 2012a); this demonstrates the requirement for outdoor activities for all preschool children across a variety of different settings. The opportunity needs to exist to promote involvement in terms of space and staff encouragement to allow children to increase their PA behaviours. Parents of overweight children may exhibit behaviours that discourage their children from participating in PA. However, parents must be willing to take responsibility for supporting their children to be physically active (O'Dwyer et al. 2012). Correlates of PA are viewed as multidimensional and work across individual, social and physical environments (Hinkley et al. 2012). Identifying the PA behaviour of highly-active children, in both indoor and outdoor preschool environments, through accelerometry is essential. This will help to contribute information for policy and preschool staff about ideal activities that children should be participating in and the effect of the environment in supporting such activities (Howie et al. 2012). Benham-Deal (2005), reported that indoor activities are performed 65% to 87% of the children's day; according to parental logs this involved watching television, performing arts and crafts and playing with small toys. This study also highlighted that outdoor activities were greater on weekdays, but there is a need to promote outdoor activities to improve MVPA (Benham-Deal 2005). It emphasised that outdoor spaces must allow children to engage in MVPA by providing environments that allow large motor activities. Therefore, future research should objectively examine the PA levels of preschool children through the use of accelerometery, to ideally capture the performance of high intensity activities during free living PA, such that this assessment would represent the patterns of activity in preschool children and would be influential in suggesting appropriate activities for preschool staff to utilise.

2.2 Fundamental Movement Skills and Physical Activity

2.2.1 Fundamental Movement Skills Competency and Participation in Physical Activity

FMS competency is a prerequisite for functioning on a daily basis and for participation in physical or sport-specific activities in later life (Butcher and Eaton 1989; Venetsanou and Kambas 2011), as they provide the initial building blocks for future, more complex motor skills and PA (Gallahue, Ozmun, and Goodway 2011; NASPE 2009). The development of FMS competency, has been reported as an important prerequisite for daily life skills and the ability to participate in PA (Cools et al. 2009; Stodden, Goodway, and Langendorfer 2008); therefore, FMS are imperative for preschool children and the preschool years are a critical time for FMS development (Gallahue and Donnelly 2003; Hardy et al. 2010). Adequate acquisition of FMS towards the end of the preschool years has been stated in the literature as crucial in terms of developing specialised and more complex motor skills for later in life (Stodden, Goodway, and Langendorfer 2008; Gallahue, Ozmun, and Goodway 2011). However, it is vitally important to recognise that in the very early years, FMS are influenced by biological maturation (Barnett et al. 2016) and after this, preschool children do not acquire FMS skills due to the maturation process but through instruction and practice (Martin, Rudisill, and Hastie 2009), whether that is from preschool staff or parents. FMS affect children’s physical, social and cognitive development (Iivonen and Sääkslahti 2014). FMS have been associated with adopting a physically active lifestyle (Stodden, Goodway, and Langendorfer 2008), whilst FMS have been viewed as a potential correlate of PA (Cliff et al. 2009; Fisher et al. 2005; Williams et al. 2008), with higher levels of FMS competency correlating with more PA (Lubans et al. 2010; Barnett et al. 2009) and greater physical fitness in preschool children (Okely, Booth, and Chey 2004; Haga 2009); conversely adequate PA could be viewed as providing a base for developing motor skills (Bürgi et al. 2011).

Improved performance and competency of FMS amongst children has been reported as positively correlated with participation in organised sport (Raudsepp and Paasuke 1995) and protective against overweight and obesity (Rodrigues, Stodden, and Lopes 2016). Failure to achieve FMS competency in these basic skills could present a barrier to participating in PA in childhood and achieving PA levels recommended for adults to maintain good health later in life (van Beurden et al. 2002). Hence improving FMS competency, could be a mechanism to increase children’s PA and improve their health (Foulkes et al. 2015). Motor skill competency and PA will strengthen together over time and therefore possess a reciprocal relationship, which will prevent physical inactivity (Stodden, Goodway, and Langendorfer 2008). Maturation is an important concept to consider in terms of activity level and motor skill development. Very active children may have developed biologically with good muscular strength, endurance and speed, yet may not be as developed in their perceptual systems and may have a less mature nervous system, with less nervous inhibition and control, which could contribute to poorer balance skills (Butcher and Eaton 1989). Balance is viewed as essential for all movements that individuals participate in, whether they are within limits of the base of support, for example standing or sitting, or they are in transit to a new base of support, such as walking (Yang et al. 2012).

FMS competency can be gauged by assessing both process and product characteristics of movement (Foulkes et al. 2015). Product based measures focus on the end-product and are typically quantitative, for example time, speed or distance (Logan et al. 2012). Process based FMS measures are more qualitative in their nature and focus on the developmental skill level of a child, by assessing the quality of their movement patterns (Hardy et al. 2010). Literature does state that the acquisition of FMS is influenced by the following correlates: bio-psychosocial, individual, weight status, sex, family and environmental factors (Barnett et al. 2013; Cools et al. 2011; Hardy et al. 2010). Preschool children, if provided with encouragement and opportunities for learning and practice, have the developmental potential to achieve FMS competency by six years of age (Gallahue and Donnelly 2003). Preschool children are in a critical phase for their FMS development, such that failure to make FMS advancements at this stage may mean preschool children attain lower competence levels later in their developmental stages (Gallahue and Donnelly 2003). The preschool years see rapid growth of the brain and neuromuscular maturation (Malina, Bouchard, and Bar-Or 2004); this can be influential for motor skill acquisition (Foulkes et al. 2015). Preschool children are viewed as confident and fearless and these traits may encourage engagement and persistence in activities that foster FMS competency (Stodden, Goodway, and Langendorfer 2008).

FMS develop differently in children and are known to be influenced by numerous critical determinants and have been classified into subsystems of the requirement of a task, the biology of the child (sex, heredity) and the environment (outdoors, who promotes the learning of skills, or SES background) (Iivonen and Sääkslahti 2014). Evidence suggests that boys perform better at object control skills than girls, but there seems to be a lack of consensus in the literature regarding sex differences in the locomotor skills, however, preschool children perform better at locomotor skills than object control skills (Foweather et al. 2015; Foulkes et al. 2015; Hardy et al. 2010; Ulrich 2000). Boys have been reported as more competent at throwing and kicking, which involves coordination and stability of limbs and trunk movement, whereas girls are more competent at running, hopping and galloping, which require correct leg movement/feet placement (Foulkes et al. 2015; Hardy et al. 2010). Unfortunately, in the preschool years, numerous studies report low FMS competency (Barnett, Ridgers, and Salmon 2015; Cliff et al. 2009a; Foulkes et al. 2015; Hardy et al. 2010). SES may also affect FMS competency levels. An example of this is young children from deprived areas may have limited access to safe outdoor play areas, or lack opportunities to engage in activities which help to promote and foster FMS, whilst they may also lack parental resources to allow access to equipment (Giagazoglou 2013; Goodway and Smith 2005). Facilities and equipment available in preschools can also affect FMS development and therefore FMS competency. Preschools with larger playgrounds, and increased balls and objects, see preschool children engage in more MVPA (Brown et al. 2009). Settings promoting more active play using the outside environment facilitate improvements in FMS (Foulkes et al. 2015). FMS competency is enhanced by active play and the promotion of MVPA, which are beneficial in allowing preschool children to practice FMS, and an environment conducive to receiving appropriate instruction and encouragement. Finally, weight status has been identified as a correlate to FMS, where a higher body mass index (BMI) is negatively correlated with motor coordination, stability and locomotor FMS, but not with object control skills competency (Barnett et al. 2016). The reasoning for this has been attributed to object skills being more static, whereas locomotor FMS involve shifting a larger body mass, which ultimately impedes functional movement (Duncan, Stanley, and Leddington-Wright 2013).

2.2.2 Moderate to Vigorous Physical Activity

FMS consist of locomotor skills such as running, skipping, hopping and jumping, and object control skills such as throwing, catching and kicking (van Beurden et al. 2002; Stodden, Goodway, and Langendorfer 2008); these are vital to the development of higher skills, for example an overarm throw, or the smash in volleyball. Motor development of children may be affected by a variety of factors including: diet; lifestyle; exercise; and access to facilities for PA (Lam 2011). Children with better developed motor skills have been reported as spending significantly more time in MVPA and VPA and significantly less time in sedentary behaviours, when compared to children with less developed motor skills (Williams et al. 2008). Girls have been reported as having significantly better visual motor control skills and spending more time in low intensity PA, whilst boys are significantly better at running and spend more time in high intensity PA (Butcher and Eaton 1989). This could be a result of girls receiving less encouragement from teachers and peers to participate in MVPA during preschool (Pate et al. 2004). National data on adolescent physical inactivity mirrors the data on early childhood FMS delays (Stodden, Goodway, and Langendorfer 2008), supporting the assumption that different levels of motor skill development in children may be an influencing factor in being physically active.

2.3 Intervention Studies and Training

2.3.1 Intervention Studies

Numerous intervention studies have assessed PA levels of preschool children using an intervention and control group (Finch et al. 2010; O'Dwyer et al. 2011; O'Dwyer et al. 2012). However, it is essential that such studies are robust in terms of the activity they offer and the support they provide. Finch et al. (2010) conducted a cluster randomised controlled trial design study, sampling long day care services, with 10 services randomly allocated to a PA intervention group and 10 to a control group, over 15 weeks. The children were between three and five years old, with 175 children per group. The intervention consisted of: delivering structured FMS; increasing opportunities for children to participate in PA through staff involvement; increasing staff role modelling of active play; promoting PA indoors and outdoors; and limiting sedentary behaviours (Finch et al. 2010). PA was measured using a pedometer on one-week day, over a six-hour period (Finch et al. 2010); pedometers are considered accurate, reliable and unobtrusive for measuring PA in preschool children (Pate, O'Neill, and Mitchell 2010). This study was important, as it included 'intervention implementation strategies' where all preschool staff attended a workshop to enable them to facilitate the intervention. Resources and instruction manuals were disseminated and follow-up support for staff was provided through phone calls and meetings. The control group received no intervention or support.

O’Dwyer et al. (2011), similarly to Finch et al. (2010), ran an ‘Active Play’ programme, which was an educational programme designed for staff and children in preschool settings. The programme aimed to increase MVPA in playtime, develop FMS, coordination, balance and enhance self-confidence to play freely (O’Dwyer et al. 2011). ‘Active Play’ trained staff, would deliver the programme and provide a resource pack of fun activities for the preschool staff, and post-training support was provided to preschool staff who requested it. This was the required outcome with the Finch et al. (2010) study and a method that appeared to be advantageous, as the staff were trained to be competent in delivering a set programme and this would benefit the preschool children by encouraging them to increase their PA levels. Twenty-seven boys (26% overweight) and 23 girls (43% overweight), three to five years old, were selected from 12 schools using a stratified sampling technique (O’Dwyer et al. 2011); initial differences in weight status could be a result of PA being higher in boys and older children (Jackson et al. 2003) and boys exhibiting significantly greater participation in MVPA and VPA than girls (Pate et al. 2004). Each school was randomly assigned to an intervention or comparison group. The intervention group received six-weeks of ‘Active Play’ sessions once a week for 30-40 minutes and an ‘Active Play’ resource task, which was delivered by the class teacher. Habitual PA was measured using an accelerometer over a minimum of three days (two weekdays and one weekend) and used 5s epochs to reflect the intermittent pattern of young children (O’Dwyer et al. 2011). This differed from the assessment measure for PA used by Finch et al. (2010), which was pedometer based and only measured on one day per week. Measurement over three days by O’Dwyer et al. (2011) was more robust as it gained a more reflective measurement of habitual PA of the preschool children, due to three days of assessment. FMS were also assessed using the Test of Gross Motor Development-2 (TGMD-2) looking at locomotor and object-control. An adapted version of the System for Observing Children's Activity and Relationships during Play (SOCARP) assessed the children's PA levels, activity type and social interactions (O'Dwyer et al. 2011). This study was important as it assessed PA through observations, accelerometers and assessment of FMS and therefore allowed a multi-method investigation of assessing PA. A multi-methods approach is considered beneficial as it allows researchers to be confident of their research outcomes, due to increased reliability and validity, whilst gaining a complete and contextual portrayal of what is being studied (Holtzhausen 2001).

A comparable study by O'Dwyer et al. (2012) assessed seventy-nine, three to four-year-old children who attended SureStart centres; they were randomly allocated to an intervention or control group for 10 weeks (O'Dwyer et al. 2012). The intervention was based around a socio-ecological model (SEM) and intended to influence total PA and sedentary behaviour. This intervention differed from the Finch et al. (2010) and O'Dwyer et al. (2011) studies, as it involved both active play for the children and an educational workshop for the parents. All families received instructional and educational material regarding positive changes in PA, along with follow-up support throughout the programme through text messages; the control group received no intervention or supportive materials (O'Dwyer et al. 2012). This study, although similar in method to the previous research, was innovative in that it involved parents to increase their children's PA levels, and additionally, it provided support throughout the programme in a modern format. PA was measured using an accelerometer for the children and parents using 5s epochs over 7 consecutive days, like O'Dwyer et al. (2011). Finally, a questionnaire was completed by the parents regarding their home and community environments, and both their and their child's PA levels. This study was influential in using a variety of methods to asses PA, therefore, for future research, a recommendation would be to utilise a multi-method sampling procedure to gain both qualitative and quantitative data, to better understand factors that could be affecting the PA intensities performed by preschool children. Equally, prior to any intervention studies taking place, it is vitally important to ensure that robust methods of PA assessment occur, that the views of preschool providers and parents are ascertained, along with the actual levels of PA and FMS in this population; only then can scientists effectively target interventions.

These aforementioned studies highlight the importance of both direct observations and accelerometry to assess PA in preschool children. Specific studies have provided support to parents and preschool staff in terms of text messages and resource manuals. These forms of support network have been influential in allowing the parents and staff to remain focused on the interventions. The studies conducted by O'Dwyer et al. (2011 and 2012) used 5s epochs on the accelerometers to relate to the intermittent nature of children's PA levels. This differs from previous research which was conducted at 15s epochs (Howie et al. 2012; Trost et al. 2003). Future research, on preschool children should ideally ensure that accelerometers use 5-15s epochs, to appropriately capture the PA levels of preschool children. In summary, numerous studies have employed different methods of assessing PA from accelerometry, pedometers, observations and questionnaires. It is therefore advisable that future studies employ a multi-methods approach, to gain more reliable and valid results of preschool children's PA intensity levels.

2.3.2 Staff Training

Very few practitioners have had any training to help them deliver programmes to promote one of the key themes of the Foundation Curriculum – Physical Development. This is made worse by the lack of further professional development resulting in many preschool practitioners having no physical development or physical education practical knowledge base, to deliver an effective programme, or ensure adequate provision in their setting. Bower et al. (2008) reported that of 96 centres evaluated, only 25% provided PA education or training for staff. Time spent in PE lessons needs to maximise the opportunities for children to be active. Reasons why children slow down or interrupt their activity is often due to adult leadership associated with rules and routines which are completed for health and safety reasons, but are time consuming, for example lining up prior to going outside (Raustorp et al. 2012). Preschool staff require the support and education to encourage PA for their preschool children (Tucker 2008).

2.3.3 Strengths of Research Studies

O'Dwyer et al. (2012) implemented an intervention which had a "learning by doing" approach, with the child and adult in mind, at a cost of £4.12 per family per week. The authors felt that involving both the child and adult was beneficial in aiming for greater adherence in an intervention and improving PA. A family based 10-week intervention associated with ‘Active Play’ and aimed at children 5 years or under found 1.5% and 4.3% less sedentary time during weekdays and weekends respectively, and 4.5% and 13.1% more total PA during weekdays and weekends days respectively, when compared to children in a control group (O’Dwyer et al. 2012). These findings support a need for more family based interventions as they are essential in health promotion for whole families and for supporting children to increase PA.

Finch et al. (2010) employed a cluster randomised controlled trial design using different strategies: increasing PA opportunities both indoors and outdoors; delivering structured FMS; increasing staff role modelling; and limiting sedentary behaviours. This research highlights the importance of involving a variety of different strategies when implementing an intervention to ensure adherence. Finch et al. (2010) aimed to increase PA opportunities and they achieved this by using staff to implement objective measures using a randomised design intervention, which used both theory and multi-disciplinary designs such as delivering FMS activities. In addition to this, Howie et al. (2012) used accelerometers and direct observations to measure PA in their children; this was viewed as a strength due to the validity of both measurements. Observations of children’s movement characteristics have also been recorded using the Observational System for Recording PA in children (Preschool Version, OSRAC-P) and MVPA was measured using accelerometers to determine differences in PA both indoors and outdoors (Howie et al. 2012). The preschool settings can be controlled in relation to clarity over time spent indoors and outdoors and accelerometers make it possible to determine fractions of MVPA and sedentary behaviour in these environments (Raustorp et al. 2012). Therefore, a key objective way to measure PA with preschool children, would be to use accelerometers and where possible a mixed method approach is advantageous.

2.3.4 Limitations of current research on preschool children

Convenience of samples and sample size can make it impossible to generalise results of individual studies to the national population (McKenzie et al. 2002; Raustorp et al. 2012). With the age of preschool children, a convenience sample may be used, because preschools, parents/guardians and the children themselves do not provide consent to participate in research, therefore, the available sample is used and this may not always be reflective of a nation. Studies found that direct observations limited to measuring PA during the school day (Howie et al. 2012) and objective measurements which did not determine a child's overall activity level both at home and in child care environments (Bower et al. 2008) are all forms of limitations in research. Limitations of studies have involved not targeting all levels of the socio-economical system. Whilst this could be considered a strength of a study, as research generally focuses on a specific group of children to reduce extraneous variables, it is key to ensure that researchers do not apply their findings to all populations. Some research has not considered the views of staff in child care environments (O'Dwyer et al. 2012), and this could be a limitation as staff have a close involvement with the preschool children, especially those in full-time child care, and they are aware of their PA levels, FMS and educational abilities. Also, interventions which do not focus on the Early Years Foundation Stage national curriculum (O’Dwyer et al. 2012), are less likely to be implemented in preschool settings once an intervention has been completed.

Accelerometers have been used as a primary objective measurement of PA, however they cannot accurately capture activities that are not step based, for example cycling (Colley et al. 2011) whereas pedometers cannot register cycling, swinging or the intensity of an activity in respect of energy expenditure (Boldemann et al. 2006), therefore, overall PA may be underestimated and energy expenditure that is upper body based cannot be measured. Research has concentrated on studies into PA and weight gain in preschool children, however not many of them have focused on the effect of early weight gain on later life (Gardner et al. 2009). This is clearly a limitation as PA and weight status in early years could have an influence on adolescent and adulthood ages and if this trend is supported through research then it would be influential in implementing changes in PA levels for children, staff and parents in preschool environments.

2.4 Ethical Consideration

Access could be considered an ethical issue. For example, parents may provide consent for their child to take part in research, however, it is essential that the preschool children are aware and in agreeance with what they must do, such that ascertaining this approval is vital. Therefore, children can provide verbal consent, or preschool aged children may express their consent through drawings and mark making (Harcourt and Conroy, 2004). If the preschool child’s body language or enthusiasm changes during the research, this needs to be considered and reminding them that they can withdraw at any point is crucial. Access, in a different sense, could involve when the preschool allows the children to be assessed. If children can only be assessed in their breaks or lunch, then this is the time they enjoy playing and being free and they may resent taking part in the research. Research with preschool children in an educational setting, presents ethical issues in the use of visual data and new technologies (Flewitt 2005). Ethical guidelines suggest that all educational research should be conducted with a respect for the participants, respect for knowledge and respect for the quality of the research undertaken (BERA 2011).

2.5 Socio-Economic Status on PA and FMS

Socio-economic status is a crucial determinant of health, as it influences individual's attitudes, experiences and exposure to health risk factors (Huurre, Aro, and Rahkonen 2003). There are a multitude of reasons for differences in habitual PA to exist across SES backgrounds, and these include socio-environmental influences, such as accessibility to safe facilities to participate in PA (Macintyre and Mutrie 2004). Children in a higher income household have been reported as spending more time involved in club sports, which provides greater opportunities for these children to be involved in PA (Kantomaa et al. 2007). Children who grow up in a low SES family are at a greater risk of a less healthy lifestyle, cardiovascular disease (CVD), a trend of lower PA levels and more time in sedentary behaviours, such as watching television, when compared to children from higher SES backgrounds (Drenowatz et al. 2010; Huurre, Aro, and Rahkonen 2003; Pollitt et al. 2007). Drenowatz et al. (2010) reported higher BMI in children from lower SES backgrounds and stated that this might be another factor which contributes to increased health risks amongst low SES children. Furthermore, Gottschling-Lang, Franze, and Hoffmann (2013), reported significant differences in the development of fine motor skills between children from a low and high SES, yet gross motor skills were not affected. The FMS competency of 3 to 6-year-old children showed a weak association with SES (Gottschling-Lang, Franze, and Hoffmann 2013). Literature does state that effect sizes of 0.25 are significant (Slavin and Fashola 1998) and with this in mind, the evidence reported by Gottschling-Lang, Franze, and Hoffmann (2013), could be interpreted as showing a strong association between motor competency and SES as they reported from 0.34 up to 0.52 for effect sizes at different age groups. These findings may be a result of depending on more craft activities and spending time with parents and this is associated with a higher SES (Brockman et al. 2009; Zivizni et al. 2008). Further research to identify the PA levels and FMS competency of preschool children from low SES backgrounds would help to improve the existing literature in this area and ascertain any specific patterns of PA levels and FMS of these children, to show whether they are more or less active and if so, when, during a normal week

2.6 Justification of the Current Research Study

Taking previous research into account, the aim of this thesis is to assess the PA and FMS competency of preschool children aged 3 to 5 years in different preschool settings, in the North Warwickshire area. The studies being performed in this thesis, will cumulatively allow for the assessment of preschool children’s PA, both during the week days when in preschool and the weekend days, when with parents, through both qualitative and quantitative methods. This will provide an insight into preschool children's PA levels from a deprived area and whether these children meet the UK recommend PA guidelines. To ensure the objective measurement of the preschool children's PA is specific to the preschool children, then a calibration study of the GENEActiv accelerometers will be performed to identify cut-points for different PA intensities and sedentary behaviour for preschool children. Assessing the preschool children's FMS competency will be beneficial to show their FMS development and importantly see whether FMS competency impacts on PA levels and weight status. Therefore, these studies will emphasise how active the preschool children are in North Warwickshire and whether FMS competency is influencing their PA levels. To achieve an accurate assessment of the preschool children's PA levels and their FMS competency, the thesis comprises of the following four studies:

Study 1: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children's PA.

Aim: This study will seek to calibrate cut-points for the use of non-dominant and dominant wrist worn GENEActiv accelerometers of preschool children (4 to 5-year olds), for assessment of the intensity of their PA levels.

Objectives:

- To use accelerometers to measure activity during six activities (ranging from lying supine to running);
- To use indirect calorimetry to simultaneously measure breath-by-breath oxygen consumption (VO_2), carbon dioxide expenditure (VCO_2) and

subsequent determination of energy expenditure, via the Metamax 3B analyser using established methods (Duncan et al. 2016; Harrell et al. 2005; Mackintosh et al. 2016) and recognised SI units;

- To calibrate the GENActiv accelerometer output via a criterion measure of PA (indirect calorimetry), allowing for accelerometer cut-points to be determined for sedentary, light and moderate and above PA for pre-schoolers.

Hypotheses

Null hypothesis: The GENEActiv accelerometer will not be able to accurately capture PA data in pre-schoolers.

Research hypothesis: The GENEActiv accelerometer will accurately capture PA data in pre-schoolers enabling cut-points to be determined to categorise intensity of physical activity in this population.

Study 2: Accelerometer based physical activity levels during week and weekend days in British preschool children from a deprived area.

Aim: To assess and compare PA levels in preschool children during the week and weekend days.

Objectives:

- To measure current PA using GENEActiv accelerometers over two-week days and two weekend days;
- To determine the amount of wear time and percentage (%) of wear time that each child spent in different intensities of PA for week and weekend days;

- To gain an insight into how active preschool children are and whether they are more active in week or weekend days.

Hypotheses

Null hypothesis: There will be no significant difference between PA levels during the week and weekend days.

Preschool children will not achieve the UK recommended PA guidelines of 180 mins of PA per day.

Research hypothesis: PA levels will be greater during the week days than the weekend days due to activities in preschool settings.

All preschool children will achieve the UK recommended PA guidelines of 180 mins of PA per day.

Study 3: Fundamental movement skills and physical activity levels of British preschool children, from a deprived area.

Aim: To assess whether preschool children's FMS competency is associated with their PA levels and weight status.

Objectives:

- To assess preschool children's locomotor, object control and total fundamental movement skills;
- To use accelerometers to determine the PA levels that preschool children participate in during a four-day period;
- To assess children's weight status using body mass index and waist circumference;

- To compare preschool children's FMS with their PA levels (study 2) to determine if there is an association between a preschool child's FMS and PA levels;
- To compare preschool children's FMS with their weight status to determine if there is an association between a preschool child's FMS and weight status.

Hypotheses

Null hypothesis: There will be no significant association between preschool children's FMS competency and PA levels, or between FMS competency and weight status.

Research hypotheses:

Preschool children with a higher FMS competency will have significantly higher PA levels.

Preschool children with a higher FMS competency will have significantly lower weight status.

Study 4: Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.

Aim: To qualitatively assess preschool staff and parent's perceptions of preschool children's PA in relation to environment, facilities, play and barriers to PA.

Objectives:

- To use focus groups to assess preschool staff and parent's perceptions of preschool children's PA in relation to environment, facilities, play and barriers to PA;
- To assess opinions of parents and staff from a variety of settings, ensuring staff and parents are involved in the focus group discussions;
- To make recommendations to improve PA for preschool children in their preschool settings.

Chapter 3.

Overview of Methodology

3. Overview of Methodology

3.1 Measurement of Physical Activity

The accurate measurement of PA is fundamental to evaluating the effectiveness of interventions and understanding relationships between PA and health (Haskell et al. 2007). Measurements can take two forms one being subjective, such as a child or parent completing a self-report on their PA, the other objective, which involves a direct observation using heart rate monitors, pedometers or accelerometers. Observation measures with real time data storage are more advantageous then subjective measures as they provide reliable information on patterns of PA over specified days (Trost et al. 2000). Studies support objective measures as being useful tools in determining field measurements of PA patterns in young children (Jackson et al. 2003; Pate 1993), especially as they allow for a more detailed profiling of PA and inactivity if the data collected is used to its full potential (Esliger and Tremblay 2007). Measuring habitual PA accurately is beneficial when observing the frequency and distribution of PA in children and looking at the amount of PA that could influence the health of preschool children. Measurement of PA in children has its own specific difficulties (Penpraze et al. 2006), due to the intermittent nature of children's PA and inability to record what intensity and activity they are actually completing. Accelerometers have been used to assess children's PA and multiple devices such as Actical, Actigraph and the RT3 have been validated for use within a child population (Phillips, Parfitt, and Rowlands 2013). PA monitors have become smaller, less expensive and more sophisticated and this has allowed measurement of PA not only in the laboratory but also in the field in habitual activities (Esliger and Tremblay 2007), therefore measuring each individual's normal routine and intensity at which they complete activities. Seven days has been suggested as optimal for measuring PA (Esliger et al. 2005; Trost et al. 2000), however this has been seen as debatable across different studies because individuals comply less with wearing the devices over a seven-day time period.

3.1.1 Pedometers

Pedometers are considered a cheap way of measuring PA and they have a lower analytical burden, therefore allowing larger sample sizes to be assessed (Colley et al. 2011). Pedometers record PA as a simple raw measure of ‘number of steps taken’ (Eisenmann and Wickel 2005). They measure the locomotor activities of daily life for example walking, running and varying speed or work intensities; when measuring PA in children their speed of locomotion needs considering in comparison to an adult (Eisenmann and Wickel 2005). Pedometers are appropriate for large scale studies due to their low cost, accuracy and reliability amongst children (Cardon and De Bourdeaudhuij 2007; Kilanowski, Consalvi, and Epstein 1999). Further advantages of the pedometers, are that they are unobtrusive battery-operated devices that are lightweight, the size of a match box and measure vertical movement (Cardon and De Bourdeaudhuij 2007; Finch et al. 2010); they are pleasant or very pleasant to wear by children (Cardon and Bourdeaudhuij 2007).

However, pedometers have been known to record fewer steps than actually completed during slow walking of younger children (Rowlands, Eston, and Ingledew 1997). Such a discrepancy may impact on the measurements of preschool children’s step counts and underestimate what they have completed (Eisenmann and Wickel 2005). It is also unclear how daily step counts and daily activity minutes relate and how many daily steps is equal to the recommended one hour of MVPA a day (Cardon and De Bourdeaudhuij 2007). Cardon and De Bourdeaudhuij (2007) reported a high correlation between pedometer outputs and accelerometer based minutes of engagement in MVPA in preschool children (r = .73), concluding that daily step counts provide valid information on daily PA levels and 60 minutes of MVPA is equal to 13, 874 step counts; with step counts during week days higher than those at the weekend. This raises a separate issue in relation to parents/guardians being more involved with promoting PA at the weekends and the possibility of the requirement to educate parents to have a greater understanding of PA and what activities to participate in. There is the requirement for further research to be completed into pedometry in preschool children as the children are receptive to wearing them, additional research is needed to assess their validity, especially when strong correlations are reported with accelerometers (Cardon and De Bourdeaudhuij 2007). Prior research on the topic area clearly indicates that pedometers have their own strengths and limitations and need to be considered carefully when using them with children.

3.1.2 Accelerometers

Studies have highlighted that accelerometers are a reliable way of estimating PA behaviour in children. They are light, small and robust, hence their suitability for the paediatric population (Cliff, Reilly, and Okley et al. 2009b), they are considered a promising measure of PA in children (Ott et al. 2000). When used to measure PA, most accelerometers operate using piezoelectricity derived from microscopic crystalline structures and the force produced from the acceleration causes crystals to be compressed, generating an electric charge which is proportional to the magnitude of the acceleration force (Cliff, Reilly, and Okley 2009b). Accelerometers are widely used for determining two important dimensions of PA, total amount (volume) of PA and intensity of activity (Penpraze et al. 2006), and they are considered to provide robust and detailed PA information (Esliger and Tremblay 2007). They are an appropriate objective measure in terms of validity, reliability and practicality as a method for measurement of intensity, duration and frequency of movement for sedentary behaviour and habitual PA in 3-5-year olds (Adolph et al. 2012; Cliff, Reilly, and Okley 2009b; Reilly et al. 2003; Reilly et al. 2008; Westerterp 1999); whilst also being advantageous as they eliminate biases that are associated with self-reporting measures of PA (Evenson and Terry 2009). Accelerometers explore activity patterns by differentiating between intensities of PA and the total volume of activity over a specified period of time (Raustrop et al. 2011). They collect data in natural free environments and this is divided into wear (all waking periods) and non-wear intervals (sleeping, showering, swimming) with zero counts over an epoch being registered when not worn or motionless (sitting) (Choi et al. 2011; Evenson and Terry 2009). In most studies accelerometers are worn during all waking hours and only removed for showering or swimming (Evenson and Terry 2009). Defining non-wearing time is important and should be carefully considered, to ensure whether the participant is sleeping or sitting, as this could affect the data in terms of analysis of the intensity of the activities that were actually performed; logs of sleep time are beneficial in identifying these periods. When the wear time of the participants are not known then researchers have suggested that consecutive periods of ≥ 20 minutes of zero counts are a means of defining non-wear time (Aadland and Johannessen 2015; Cain et al. 2013; Esliger et al. 2005). The cut-off of ≥20 minutes was considered very rigid and non-wear time defined as 90 minutes of consecutive zero or nonzero counts, have been reported as providing a better prediction of time spent in PA and sedentary behaviours (Choi et al. 2011).

Accelerometers can be set at different sampling intervals with the majority of studies being set at one-minute intervals. However, one study stated that one-minute sampling intervals may mask the short intermittent bursts of activity that are representative of young children and therefore used 15-second sampling intervals (Pate et al. 2004). PA data that is produced by accelerometers is not biologically meaningful (Jackson et al. 2003). Accelerometers measure acceleration multiple times in a specified frequency and summarise this as a count over a pre-specified time period (epoch) (Evenson and Terry 2009). Activity is measured in epochs (number of seconds) and for each of the epochs, movement data (activity counts) are added and logged. Total and average counts per minute (cpm) indicate the aggregate amount and the intensity of the PA (Esliger and Tremblay 2007). Data are then processed and analysed such that raw data counts are converted into more physiologically relevant units via an intensity prediction equation (Esliger and Tremblay 2007). This data is then categorised in terms of intensity, such as light, moderate and vigorous PA, via cut off points determined in studies that have calibrated accelerometer data against energy expenditure (Cliff, Reilly, and Okley 2009b; Raustorp et al. 2012). It has been proposed based on a study of 3-4-year-old Scottish children, that the following cut-off points are used <800 cpm for inactivity, 801 to 3200 cpm for light intensity activity and 3201-8204 cpm for moderate activity (Jackson et al. 2003). Equally, specific cut-off points related to 8-14-year old children using the GENEA accelerometers have been reported as <7 cpm for sedentary activity, 7-19 cpm for light intensity activity, 20-60 cpm for moderate intensity activity and >60 cpm for vigorous activity (Phillips, Parfitt, and Rowlands 2013). Therefore, depending on the accelerometers and population being used, different cut-off points are more appropriate for different intensities of exercise.

The accelerometers worn on the wrist are potentially more convenient and comfortable to wear when compared to waist worn monitors and this may lead to greater compliance during prolonged wearing when assessing habitual activity (Dieu et al. 2017; Zhang et al. 2012). Wrist-worn accelerometers are not required to be removed during the day for habitual activities, hence children’s compliance is improved and PA patterns in free-living conditions are assessed more accurately (Dieu et al. 2017). The waist worn accelerometers are attached on an elastic belt/belt clip, but the child will remove them for sleeping, changing their clothes and potentially for some sporting activities, for example swimming (Dieu et al. 2017), hence the possibility for lower compliance. Research has reported that when the waist-worn accelerometers are used, zero activity periods are recorded as ‘non-wear time’, however, the children may have been swimming and these periods are removed from the child’s daily PA and this may therefore misclassify their PA patterns and overestimate sedentary time (Choi et al. 2011; Dieu et al. 2017; Rey-Lopez et al. 2012; Ruiz et al. 2011). This said, Rowlands et al. (2014) reported that the assessment of children's habitual PA levels and time spent sedentary, estimated from the wrist or hip-worn GENEActiv accelerometer, were comparable with the uniaxial ActiGraph worn at the waist (r > 0.83). When considering preschool children, although the location of the accelerometers appears to be comparable, the compliance to wear the accelerometers is key and research seems to suggest that the wrist is a preferred location when compared to the waist.

When accelerometers are worn at the wrist, there is the debate of whether they should be worn on the dominant or non-dominant wrist. Studies using wrist-worn accelerometry to assess PA have used either the dominant or nondominant wrist without knowing the results between the two locations (Ellis et al. 2014; Hildebrand et al. 2014; Rowlands et al. 2014; Tudor-Locke, Barreira, and Schuna 2015). Dieu et al. (2017) found no significant differences between the accelerometer worn at the dominant and non-dominant wrist, regardless of the axis (Dieu et al. 2017). Although the dominant wrist is predominantly used more and is stronger when compared to the non-dominant wrist (Armstrong and Oldham 1999), findings show that PA measured at either wrist is the same (Dieu et al. 2017). These findings have important implications for future research which assesses PA levels of preschool children, using wrist worn accelerometers. Mean daily accelerometer data from the ActiGraph worn at both the dominant or non-dominant wrist, correlated (linear relationship, r = 0.88) with mean counts per minute from the ActiGraph worn at the waist (Dieu et al. 2017). These results correspond with a study using the GENEActiv accelerometer in children (Rowlands et al. 2014). It would be appropriate to state that the location at either the dominant or non-dominant wrist produces similar output and future research can utilise either wrist in children.

Preschool children have unique patterns of PA and measurements of acceleration need to capture differing intensities in short time frames over multiple planes (Adolph et al. 2012). The CSA 7164 uniaxial accelerometer detects vertical acceleration and was found to be practical for use in population-based field studies which involved children (Trost et al. 2000). An ActiGraph, uniaxial accelerometer measures acceleration in the vertical/longitudinal plane (up and down movement), is small, light, unobtrusive and worn on an elastic belt on the right hip (Cardon and De Bourdeaudhuij 2007; Cliff, Reilly, and Okley et al. 2009b; Evenson and Terry 2009; Williams, et al. 2008), with 83% of the children in one research study reporting accelerometers as very pleasant or pleasing to wear (Cardon and De Bourdeaudhuij 2007). Accelerometers are acceptable devices to classify preschool children's PA intensity into sedentary, light and moderate-to-vigorous levels (Adolph et al. 2012; Colley et al. 2011) based on accelerometer counts and activity energy expenditure (AEE), with no advantage between uniaxial (Actical, actiheart) or triaxial (RT3) (Adolph et al. 2012). However, uniaxial accelerometers could be viewed as limited, as they only measure PA in the vertical plane (Montgomery et al. 2004). Other accelerometers measure movement using two (biaxial) or three (triaxial) planes of movement, allowing movement in the anterioposterior axis (forwards and backwards) or in a triaxial movement also incorporating the mediolateral (side to side movement) (Cliff, Reilly, and Okley 2009b). Ott et al. (2000) stated that triaxial accelerometers may be more accurate to quantify motion/PA in children, than uniaxial accelerometers, as they measure motion in more than one plane. Conversely the triaxial accelerometer (TRiTrac-R3D) was found to significantly underestimate PA – energy intake and energy expenditure (EE) during sedentary periods in children and therefore, the TRiTrac-R3D was not discovered to be a valid method of assessment for total EE or PA-EE, yet during PA behaviours it was a good monitor (Rodriguez et al. 2002), as previously stated by Ott et al. (2000). The Actical accelerometer indicates the intensity of PA by measuring acceleration in all directions and its omni-directional ability allows it to capture a wider range of movement than a uni-axial device (Colley et al. 2011). In summary, due to the short intermittent bursts of activity that young children participate in (Bailey et al. 1995) and their inability to recall PA, then objective measures such as accelerometers should be used to assess PA (Cardon and De Bourdeaudhuij 2007). The triaxial accelerometers would be more appropriate to measure PA levels, as previously reported, they accurately quantify PA in children due to their ability to measure movement in one plane.

Accelerometers do however have limitations as they are expensive to purchase, not always readily available and do require technical expertise and specific hardware to use (Cardon and De Bourdeaudhuij 2007). Limitations also exist with the accelerometers worn at the waist, because people remove them to dress, sleep and participate in contact sports (Evenson and Terry 2009). Equally, non-compliance with children could exist as they remove them by choice or to participate in specific activities for example swimming. With the existence of numerous intensity cut-off values, which are used to convert accelerometer data into minutes of MVPA and the abundant accelerometers on the market, quantifying and tracking PA can therefore be very challenging (Tucker 2008). It also makes comparing activity between different studies more complicated/difficult as different studies will report PA in line with different cut-off points. Accelerometers do provide data on preschool children's intensity, frequency and duration of PA, yet not on the type of activity participated in (Trost 2007). Even though these limitations exist with accelerometers, they are still an extremely accurate measure of PA for preschool children, due to them offering a practical approach to measuring PA.

The question exists as to how many days of measurement are appropriate for producing a reliable representative measurement of PA using accelerometers. Literature has reported anything between 2 to 7 days and some research has been weekdays only and some included both weekdays and weekends. Penpraze et al. (2006) assessed children with a mean age of 5.6 years and measured their mean daily PA as counts per minute (cpm), which involved dividing total counts per minute by the number of minutes of monitoring per day, using ActiGraph monitors measuring acceleration in a vertical plane. It was concluded that mean daily PA was significantly higher for males (870 ± 87 cpm) when compared with females (771 ± 161 cpm; $p = 0.011$), with both males and females being significantly ($p = 0.02$) more active at the weekends (900 ± 245 cpm and 833 ± 219 cpm, respectively), than weekdays (858 ± 183 cpm and 747 ± 164 cpm, respectively) (Penpraze et al. 2006). A monitoring period of 7 days and 10 hours per day, produced the highest reliability in measuring PA in children aged 3-4 years, with the inclusion of a weekend day having a negligible effect on the reliability of the PA measurement (Penpraze et al.

2006). Over a 4-day period inclusion of a weekend day had a reliability estimation of total PA of 84% and this was reduced to 82% with four-week days.

It is important to note that there are implications with monitoring PA for 7 days in relation to cost and participant compliance as most accelerometers were returned with less than 7 days of monitoring and not all included a weekend day (Penpraze et al. 2006). Children aged 5-10 years have been reported as exhibiting significantly higher levels of MVPA at the weekends (Trost et al. 2000) so a weekend day should therefore be included when using accelerometers to provide a more habitual view of PA in preschool children. A further study measuring MVPA using a CSA 7164 accelerometer found that one day of measuring was low when looking at reliability coefficients (0.31-0.49) and measuring over 7 days was acceptable (≥ 0.70, ranging from 0.76 – 0.87), with between 2 and 3 days achieving a reliability of 0.70 and between 4 and 5 days 0.80 in young children (Trost et al. 2000). Studies on children between 6 to 8 years old have seen specific structured patterns in MVPA throughout the day. However, this pattern is not seen in preschool children, as they do not exhibit the same structure of a school day (Penpraze et al. 2006).

The number of hours a day that the accelerometers are worn for is also an important consideration in terms of assessing PA. Penpraze et al. (2006), using an ActiGraph accelerometer, determined that the difference in reliability of the PA measurement between 3 hours a day (R= 79%) and 10 hours a day (R=80%) was small, when measuring for 7 days. This is relevant as it means that the measurement of PA was stable, whether it was measured for 3 or 10 hours a day and this evidence would imply that preschool children could be monitored for less than all their waking hours in a day; in terms of compliance to wearing the monitors this is advantageous. Additionally, ≥3 hours of monitoring over ≥ 3 days, provided reliability coefficients of ≥ 0.60 (Cliff, Reilly, and Okley et al. 2009b), supporting the possibility that accurate estimates of PA can be determined with a minimum of 3 hours of measuring a day, as the difference in reliability between 3 and 10 hours is minimal. This is supported by Penpraze et al. (2006) who reported reliability as lower for children monitored for 11 or more hours in a 7-day period; with the estimated reliability for 13 hours a day being 52%, when compared to 80% for 10 hours of daily monitoring.

3.1.3 ActiGraphs (single plane ActiGraph accelerometers)

ActiGraph is a manufacturer of accelerometers, which measure human movement. All the ActiGraph models currently available are capable of determining activity counts and vector magnitudes from one to three axes (Sasaki, John, and Freedson 2011). ActiGraphs are a non-invasive way of measuring rest and activity levels in individuals. They are small (5.1 x 3.8 x 1.5 cm), lightweight (42.6 g) single plane (vertical) accelerometers, which collect and store accelerations between 0.5 and 2.0 Gs (Sirard et al. 2005). They are considered to be water resistant and can be worn in the shower or whilst swimming for accurate measurements. The analogue acceleration is converted to a digital signal; this value (count) is then stored in specified time interval (epochs) by the user (Sirard et al. 2005). They provide an objective measure of PA for virtually all ages of people, in different settings (Sirard et al. 2005); however, they are seldom used in measuring PA in preschool children (Finn, Johannsen, and Specker 2002; Reilly et al. 2003). This said, they have been validated for use in children in laboratories (Trost et al. 1998) and field settings (Ott et al. 2000; Eston, Rowland, and Ingledew 1998). Research has indicated that ActiGraph counts are highly correlated with VO_2 in 3 to 5-year-old children, during continuous structured exercise and free play activities, providing a valid measure of PA intensity and cumulative PA in preschool children (Pate et al. 2006). Like pedometers, they are normally worn around the waist near the hip; this allows them to measure gross motor activity. However, a great amount of PA measurements, involves the wrist and the ActiGraph in the form of a wrist watch. Data is collected, then this is downloaded to a computer using specific software for data analysis.

Previous studies have identified positive correlations between total activity reported by ActiGraph accelerometers and that of directly observed PA (Finn, Johannsen, and Specker 2002; Reilly et al. 2003). Only a few studies have analysed the ActiGraph's ability to categorise activity in preschool children by intensity (sedentary, light, moderate and vigorous) (Sirard et al. 2005). Understanding the amount of time spent in specific intensity categorises has the aim of providing a better understanding of the daily activity patterns of preschool children and can be influential in providing target activity levels for future PA interventions (Sirard et al. 2005).

ActiGraphs like other accelerometers do have limiting factors. When assessing PA with children, the lighter weight ActiGraphs need to be selected to increase adherence to wear time criteria, to aid and maximise the volume of data collected in any given study. The battery life of some of the ActiGraphs is short and this needs to be carefully considered when determining the duration of days for a study, or the ActiGraph that is used. Similarly, the memory of ActiGraphs is a factor to consider, along with the sample rate; the amount of memory determines how long measurements can be taken for. With the wGT3X+, if it is set at a sample rate of 30Hz, the battery life is 31 days and the memory limit 42.5 days, however if this is increased to 100Hz then the battery life is reduced considerably to 16.5 days and 12.5 days of memory limit, assuming that this is for an individual who is active for 16 hours and asleep for 8 hours (Actigraph 2003). The highest sample rate of one-minute intervals provides detail to measure sleep, yet this has been considered as too slow for measuring different intensities.

3.1.4 SenseWear Armbands

The Sense Wear Pro$_2$ Armband (SWP2) provides health professionals with the opportunity to see what impact, changes in daily activities have on energy expenditure (EE), energy balance and weight loss (Andre et al. 2006). The SenseWear Armband (SWA) is a wireless body monitor that is worn on the back of the upper right arm. It uses multi sensors including heat flux (measures heat being dissipated by the body), skin temperature, galvanic skin response (conductivity of the wearers skin) and a two-axis accelerometer to estimate EE and posture (Andre et al. 2006). Such multi sensors are important in accurately monitoring the physiological state of the participant more effectively than using accelerometry on its own (Manns and Haennel 2012).

Despite this, the SenseWear armband does have limitations. The initial version of the SWA significantly underestimated the energy cost of walking (by 6.9%), cycle ergometry (by 28.2%), and stair stepping (by 17.7%) (Jakicic et al. 2004). The initial version was also reported as overestimating the energy cost of arm ergometry (by 29.3%) and over-estimating resting EE in obese children (Predieri et al. 2013). The SenseWear Pro 2 Armband was then redeveloped and was validated in children of 9 years (Calabró, Welk, and Eisenmann 2009) and 11-14 years olds (Arvidsson et al. 2009). However, EE was underestimated in the 11-14-year-old cohort (Arvidsson et al. 2009). To date, no study has validated the use of the sensewear arm band in children under the age of 9 years. Caution should therefore be shown when using it with preschool children. The review of literature shows that SWA accuracy is improving, but the results of the validation studies still highlight inaccuracies and these devices do not appear suitable for use with preschool children as they have been developed for older children and adults.

3.1.5 GENEA (Gravity Estimator of Normal Everyday Activity) Accelerometers

One of the main criticisms of accelerometers has been the disguising of raw data acceleration outcomes via proprietary “count” units as it can hinder between model comparisons (Esliger et al. 2011). Additionally, increased battery life and memory storage have been required as improvements. As a consequence of such criticism, the GENEA has been developed to try and overcome these limitations. The GENEActiv (GENEA) accelerometer is described as a novel acceleration sensor. It is a triaxial ±6g seismic acceleration sensor (developed by Unilever Discover Colworth, UK; manufactured and distributed by ActivInsights Ltd., Kimbolton, Cambridge, UK), which is small (L36 x W30 x H12 mm), lightweight (16 grams), splash proof and can be worn at multiple locations on the body (wrist, waist and ankle) (Esliger et al. 2011; Phillips, Parfitt, and Rowlands 2013). The GENEA has a sample frequency range of 10-160Hz; it has 500 megabytes of memory to store ~8 days of data in raw mode or battery life for 10 days when recording at 80Hz (Esliger et al. 2011; Zhang et al. 2012). GENEA accelerometers measure data on a vertical, anteroposterior and mediolateral axis (x, y and z axis) (Phillips et al., 2013). Data can be downloaded from GENEA devices in what is known as a comma separated values file (.csv extension) or binary format (.bin extension); both files contain the same data yet the binary format is more efficient at nearly 8 times a smaller file size (Esliger et al. 2011).

There is evidence that the GENEA accelerometer discriminates very well between PA levels and sedentary behaviours. A study by Esliger et al. (2011), assessed adults and highlighted that wearing the GENEA at either the wrist or waist discriminated sedentary behaviour almost perfectly (0.97-0.98); the waist worn GENEA had greater classification accuracy (0.95) followed by the left (0.93) and right (0.90) wrist; this study did not account for the participants handedness. When the GENEA was on the right wrist they were unable to differentiate between light and moderate intensity, possibly a result of right handed participants completing movements such as writing and scratching with their right wrist. Equally a great amount of movement occurs at the limbs during daily activities which increases the difficulty in classifying the data collected on a wrist-worn GENEA (Zhang et al. 2012). This is contradictory to a different study which found that algorithms on the right wrist-worn GENEA (95.3-97%) were slightly better than the left wrist-worn GENEA (95.3-96.4%); additionally, the classification accuracy of the GENEA worn at the wrist was greater than other studies when monitors were worn at the waist for adults (Zhang et al. 2012). This is essential in relation to compliance issues, as when it was worn at the wrist the GENEA is attached using a watch strap and positioned over the dorsal aspect of the wrist midway between the radial and ulnar styloid process and when worn at the waist an elasticated belt is used to position the GENEA over the right hip, mid-clavicle line marked by the supraspinale (Phillips, Parfitt, and Rowlands 2013; Zhang et al. 2012). When data from the GENEA is converted into epochs, then the reliability and validity of it is comparable to the Actigraph and RT3 (Esliger et al. 2011). An additional study found the GENEA to have a high intra and inter-instrument reliability (coefficient of variation = 1.8% and 2.4%, respectively), a good criterion-referenced validity when compared to a multi-axis shaking table (MAST) (r = .97) and high validity and high concurrent validity with the ActiGraph GT1M (r = .74) (Phillips, Parfitt, and Rowlands 2013).

Another study by Zhang et al. (2012), used an innovative method which involved categorising PA tasks of adults into sedentary (lying, standing), household (window washing, sweeping), walking (4 - 6 $km \cdot h^{-1}$), stair climbing and running (8-12 $km \cdot h^{-1}$), using machine learning algorithms. The energy expenditure (METs (metabolic equivalents), mean ± SD) associated with each activity was as follows: lying (0.94 ± 0.23 METs), standing (1.13 ± 0.25 METs), window washing (3.37 ± 1.06 METs), sweeping (3.39 ± 0.67 METs), 4 $km \cdot h^{-1}$ walk (3.88 ± 0.69 METs), 6 $km \cdot h^{-1}$ walk (5.88 ± 0.98 METs), stair climbing (6.19 ± 1.10 METs), running 8 $km \cdot h^{-1}$ (11.13 ± 1.38 METs) and 12 $km \cdot h^{-1}$ (13.61 ± 0.6 METs) (Zhang et al. 2012). Results of the study demonstrated a high correct classification based on features extracted from streaming the data and the accuracies were high for both the right wrist (split mode 96.7%, 10-cross-validation 97.2%) and the left wrist (split mode 95.93%, 10-cross-validation 96.01%); these results show that the algorithms created classified activities efficiently with high accuracy using a wrist worn accelerometer (Zhang et al. 2012). Taking that into account and the fact that the GENEA is waterproof, then wearing the monitor at the wrist may lead to greater compliance during assessment of habitual activity in children and negate the need to remove the monitors (Phillips, Parfitt, and Rowlands 2013). This differed slightly to a study on 8-14-year olds, where activities were coded into four categories: sedentary (<1.5 METs), light (1.5-2.99 METs), moderate (3-5.99 METs) and vigorous (≥6 METs) and the accelerometer counts were coded into binary indicator variables (0 or 1), which were based on intensity (Phillips, Parfitt, and Rowlands 2013). GENEA wrist monitors demonstrated good criterion validity (right; $r = .900$, $p <0.01$; left: $r = .910$, $p <0.01$), whilst the hip showed excellent validity ($r = .965$, $p < 0.001$) and performed at the same standard as the ActiGraph GT1M ($r = .970$, $p <0.01$), overall hip GENEA demonstrated significantly higher criterion and concurrent validity. However, greater compliance to wear the wrist monitors may compensate for the lower validity scores (Phillips, Parfitt, and Rowlands 2013). The study found that increasing MET values corresponded with increasing accelerometer counts and that the child population cut-points (g s) were greater than those reported for adults (Phillips, Parfitt, and Rowlands 2013); this is of importance and something to be considered in this thesis.

Relative to the standard waist-worn monitors, such as Actigraph, a wrist-worn GENEA is more acceptable in terms of comfort and therefore compliance (Zhang et al. 2012). Comfort is important, because if participants remove monitors then zero counts are recorded and when analysis is undertaken it is not known whether the participant was actually sedentary or active, but not wearing the monitor, at that time. This needs to be known because if a participant is sedentary and the data are misinterpreted as the monitor being removed then sedentary time will be underestimated and mean activity overestimated (Zhang et al. 2012). Conversely, if the person has removed the monitor and been active then it could be classified as sedentary, and sedentary activity would be overestimated and mean activity levels underestimated (Choi et al. 2011).

In summary, the GENEActiv accelerometer is a triaxial device, which can discriminate effectively between sedentary behaviour and PA levels and does not need to be removed for activities. Additional advantages of it are that it has a good sampling frequency range (10-160Hz), a great classification accuracy and can be worn at multiple locations on the body. It has an excellent criterion validity when worn at the waist, however, the criterion validity when worn at the wrist is good and with preschool children greater compliance issues have been reported when worn at the wrist. When you compare the GENEActiv accelerometers to the Actigragh and SWA for example, lighter weight ActiGraph's need to be used to assess PA with children, to increase adherence to wear time and maximise the volume of the data collected. The memory of ActiGraph's is also a factor to consider, along with the sample rate, as this determines how long measurements can be taken for. The SWA was cited in numerous studies as significantly underestimating the energy cost of activities (Jakicic et al. 2004) and overestimating the energy cost of activities and resting EE in obese children (Predieri et al. 2013). The relevant literature would highlight that the SWA has some accuracy issues and has not been utilised with children. In the context of young children, the GENEActiv accelerometer is small, lightweight and can be worn on the wrist which has shown to have greater compliance results, therefore, it would be a good monitor to use when assessing PA level in preschool children.

3.2 Fundamental Movement Skills

3.2.1 Overview of Fundamental Movement Skills

There are multiple methods for the assessment of FMS, each with their advantages and limitations. The different types will now be critically analysed.

3.2.2 Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)

The BOTMP is a product-orientated instrument suitable for measuring children's gross motor proficiency (Lam 2011). Product-orientated tests are a form of a quantitative method, which concentrate on the final product and the intricate skill performance improvements, such as the result of a movement and its accuracy, for example how far a ball has been thrown. This is a popular and comprehensive validated tool for children aged between 4 and a half and fourteen and a half, and very few validated reliable tests of motor proficiency for children less than 6 years exist (Lam 2011). The BOTMP has been cited as the most popular motor assessment for children between 4 and a half and 14 and a half years old (Miles et al. 1988) and has been relied upon by professionals for over 25 years (Bruininks and Bruininks 2005). This assesses motor proficiency using 46 items which are clustered into eight subsets: running speed and agility; strength; balance; bilateral limb coordination; upper limb coordination; response speed; visual motor control; and upper limb speed and dexterity (Butcher and Eaton 1989). There is also a short form of the BOTMP that assess 14 items from the long form and provides a brief survey of general motor proficiency (Venetsanou et al. 2007). Lam (2011) stated that the BOTMP classifies measures into gross motor skills, fine motor skills and a third category of fine and gross motor skills. BOTMP testing is completed in a motor development laboratory and the children have to be taken there, which is time and energy consuming for the tester. When the BOTMP has been utilised, high scores have been associated with children who are involved with high active free play, and are generally associated with improved performance on the running speed/agility tasks and poorer on balance, visual motor control and upper limb speed/dexterity tasks (Butcher and Eaton 1989). In terms of the sub tests reliability, a test-retest correlation coefficient was reported as moderate (r = .64) (Venetsanou and Kambas 2011).

The BOTMP can be very time consuming, yet it is still used to measure children's gross motor proficiency. As the BOTMP is a product-orientated tool, the ability for it to accurately detect specific components of a motor skill and determine where improvements are required by a child is very difficult (Wrotniak et al. 2006). Therefore, it has been suggested, that a process-orientated test (TGMD-2) is used (Wrotniak et al. 2006), as this breaks down the skills into observable components and this is important for allowing children’s weaknesses to be identified and improved.

To obtain more practical outcomes, Venetsanou et al. (2007) examined the discriminative accuracy of the short form of the BOTMP test to identify motor incompetency and used the long form as a criterion. While the specificity (ability to correctly identify those without motor incompetency [true negative]) and positive predictive values of the short form were 100%, sensitivity (ability to correctly identify those with motor incompetency [true positive]) was poor (13.6%) (Venetsanou et al. 2007). A further limitation reported of the short form of BOTMP was that the negative predictive value was 72.5%, this indicated that 27.5% of cases classified as non-motor incompetent were motor incompetent, according to long form scores (Venetsanou et al. 2007). The consequences of this test are concerning because incorrect categorisation could have been detrimental to the child’s development because any further examination could have been missed. This is a key limitation which suggests that this test would be inappropriate in this thesis, also as it is primarily used for children who are primary school aged and not preschool. Furthermore, BOTMP’s cultural validity has been questioned in terms of its ability to reliably replicate motor skills (Vincon et al. 2017), because items such as stringing blocks or walking forward on a line may have little relationship to children’s daily activities (Kennedy, Brown, and Chien 2012). This questions the extent to which a standardised test and its results can be considered ecologically valid and represent skills required for daily activities of children. Therefore, the evidence reported here presents concerns with using the BOTMP as a form of measure of FMS in preschool children.

3.2.3 Movement Assessment Battery for Children 2 (MABC-2)

Studies have been performed using tasks based around the Movement Assessment Battery for Children-2 (MABC-2). The MABC-2 is a validated, norm-referenced and product-oriented assessment that quantitatively evaluates motor competency in children aged 3-16 years (Henderson, Sugden, and Barnett 2007). This method of assessment provides objective, quantitative data on motor competence (Henderson, Sugden, and Barnett 2007). The quantitative scoring is based on either the number of successful trials completed, or the amount of time to complete a task (Logan et al., 2014). The MABC-2 consists of three subscales: manual dexterity; aiming and catching; and balance (Logan et al. 2014). It has been used in a wide range of populations that includes typically developing preschool children (Fisher et al. 2005; Logan and Getchell 2010). Fisher et al. (2005) performed a study using 15 tasks based around the Movement Assessment Battery for example jumping, balancing, skipping, kicking and catching and reported that intraclass correlations for the test-retest reliability over a one-week period ranged from 0.92 to 0.98 for children aged 5-6 years old. This assessment was performed individually, with four to five children around as this prevented too many distractions occurring, which may happen with a large group. The children were shown what to do once and then they had to repeat the test; if the test was performed correctly they received one point and zero if not performed correctly. The score was then analysed for locomotive, manipulative and balance skills (Fisher et al. 2005). A further intervention using the

Australian “Get Skilled Get Active” resource assessed motor skills using a battery of FMS using 12 skills for example hop, balance, skip, and side gallop (Barnett et al. 2009). The skills mentioned that were utilised, were reported as having good test-retest reliability for preschool children.

As previously mentioned gender differences do occur in preschool children, with girls being better at balancing skills and boys more successful at running and jumping (Garcia 1994). Therefore, if greater consideration is taken to the subcategories of movement skills then relationships between movement skills and PA might be stronger (Fisher et al. 2005), rather than using one single overall score. Therefore, usage of a product-orientated process, rather than a process-orientated method in MABC-2 was a weakness.

3.2.4 Children’s Activity and Movement in Preschool Study (CHAMPS) Motor Skill Protocol (CMSP)

Williams et al. (2008) used an observation of PA in preschool, with assessment of two dimensions of gross motor skill: locomotor (run, jump, slide, gallop, leap and hop) and object control (throw, roll, kick, catch, strike and dribble). The CMSP involves assessing the behavioural characteristics or process characteristics of the aforementioned skills as it is believed that the more developed these skills the higher the chance that preschool children will engage in PA. The CMSP are based on ratings of the process characteristics locomotor and object skills, using scores of 0, 1 and 2 with a range of 0-73 for locomotor skills and 0-80 for object skills (Williams et al. 2008). Reliability estimates for the CSMP have been reported as ranging from

R = 0.88-0.97 for locomotor, object control and total scores, with R = 0.94 for concurrent validity based on Pearson correlations between CMSP and the TGMD-2 (Williams et al. 2008).

A strength of the CMSP protocol is that it can be used with a relatively large and diverse sample of preschool children (Williams et al. 2009). A limitation of a study conducted by Williams et al. (2009), into how concurrent validity was established, went against the recommended approach of administering the CMSP test and the criterion test (TGMD-2) in two different time frames, instead collecting data on both tests within the same time frame. Although this alteration to the preferred method occurred, coefficients were still high (0.94 - 0.98 for all motor skill assessments), suggesting that the CMSP is a valid measure of gross motor performance of preschool children (Williams et al. 2009), it is therefore a viable alternate measure for motor skills competency. An important limitation to consider if used with preschool children is that the CSMP has been tested on a smaller sample of 3-year-olds, when compared to 4-year-olds (Williams et al. 2009). There could be age-related differences in the role that the level of motor skill performance plays in PA behaviours of younger preschool children, however, this age range are both classed as preschool age and therefore this is probably not a major concern.

3.2.5 'The Move it Groove it' assessment method

'Move it Groove it' (MIGI) is a strategic intervention which aimed to increase PA in primary schools, taken from New South Wales (NSW) and it is a Process Orientated

Checklist (POC) to assess FMS (Bryant et al. 2014; van Beurden et al. 2002). MIGI is ran through the involvement of a health promotion team, 18 rural primary schools, and a university (van Beurden et al. 2003). The checklist comprises of eight FMS: sprint running, side gallop, hopping, skipping, catching, overarm throw, vertical jumping and static balancing, with each skill being broken down into five or six components which are essential to mastering the skill; the children are shown it once and must perform it three times (Booth et al. 1997; Bryant et al. 2014; van Beurden et al. 2002). The advantage of breaking down the assessment of the skills, is that the skill gains a measure of objectivity, beyond that of a single overall score, which is essential in providing a good foundation for measuring change over time (van Beurden et al. 2002). Each skill was given a mastery level variable: 'Mastery' if all components of a skill were performed correctly; 'Near Mastery' if all but one was performed correctly; and 'Poor' if fewer were performed correctly (NSW, 2003). These skills are considered vital in developing further higher skills e.g. overarm throw for a serve in volleyball or a smash in tennis. To make the skills comparable, an average percentage of the skill can be taken, which can then be used for statistical analysis and accounts for any learning effect caused, when performing the trial three times (Bryant et al. 2014). Prior to the MIGI method being implemented, training was completed using established protocols by an experienced tester, from both the NSW School Fitness and Physical Activity Survey (Booth et al. 1997) and the NSW Department of Education and Training State FMS Demonstration Project (Booth et al. 1999). The training involved each prospective tester repetitively rating children performing each FMS on a video, to compare with experts who had previously rated every component of each FMS performance (van

Beurden et al. 2002). The students were only awarded 'tester' status when they could reliably (>85% correct) score each component of all FMS in line with that of the expert panel (van Beurden et al. 2002). Therefore, the training procedures carried out prior to any testing commenced were commendable, as they ensured that the MIGI was performed within specified standards. Additional rigorous checks were made to ensure this method was reliable to be used. Inter-rater reliability was determined during field observations in schools, by pairs of observers, who scored the mastery level of 3 children completing the same FMS for all 8 skills, with each observer checked against two other observers (van Beurden et al. 2002).

A key limitation of the ‘MIGI’ assessment method, is that it is used primarily for school aged children (van Beurden et al. 2002) and has not been reported as being used with preschool children. When the MIGI assessment was carried out it was stated that there would have been greater accuracy and reduced variation in measurements, if two observers had scored every child for all FMS, not just the initial attempts (van Beurden et al. 2002). A key take home message from using the MIGI is that scoring the breakdown of skills into different components is beneficial in providing a good foundation for measuring change over time (van Beurden et al. 2002), such that it provides a detailed skill profile of each child, which could enable both parents and preschool staff to use to target the preschool children’s areas for improvement.

3.2.6 Test of Gross Motor Development-2 (TGMD-2)

The TGMD-2 examines a subset of locomotor and manipulative skills, which relate to activities that preschool children participate in, to assess gross motor development amongst 3 to 11-year olds (Hardy et al. 2010a; Logan et al. 2014). As this tool measures gross motor skill competency, its use is relevant to physical education classes, and both pre- and post-testing, therefore, it may discover valuable information which could guide teaching effectiveness and curriculum development (Logan et al. 2014). Gross motor skills need to be learned as they do not develop 'naturally' with age (Clark 2005). A child that does not exhibit the required muscular strength, balance, and perceptual/visual abilities accompanying typical development, is unlikely to successfully execute gross motor skills such as jumping and catching, even if they have been taught the correct technical aspects of the skills (Logan et al. 2014).

The TGMD-2 has been described as having an established validity and reliability amongst preschool children (O'Dwyer et al. 2011). This test is classed as a process orientated test, as it assesses the components that make up the skill, not the overall product/outcome of the skill, therefore it reflects the development of the skill not the physical growth and maturational levels of children (Barnet et al. 2013; Hardy et al. 2010a). This test comprises of two subsets (locomotor and object control) each made up of six skills (O'Dwyer et al. 2011). The locomotor skills include the following: run; gallop; hop; horizontal jump; skip; slide and leap. The object control skills include the following: striking a stationary ball; catch; kick; overhand throw and bouncing a ball. Each skill is made up of 3-5 performance criteria (Hardy et al.

2010a). Locomotor skills assess the coordinated movement of the centre of gravity from one specified point to another and object control skills assess the release and receiving of objects; these skills facilitate the development of more advanced skills (Hardy et al. 2010a). The criteria are determined as either present or absent over two trials, are these scores are totalled to provide the total gross motor skill score for a child (total FMS) (Barnett et al. 2013; Hardy et al. 2010a). Of the skills assessed a performance criterion of 3-5 is used to identify different criteria, over two test trials; with the maximum score of 38 for locomotor and 32 for object control skills (Hardy et al. 2010a). The TGMD-2 is a valid and reliable process orientated test used for FMS amongst preschool children with a test-retest reliability of = 0.88-0.96 (Hardy et al. 2010a). However, caution should always be shown, because even when the test reliability is at a coefficient of 0.95, there is still a 15% error that needs to be built in (Ulrich 2000). Researchers also need to be careful about making judgements exclusively on the TGMD-2 results, as the results alone do not tell us why a child performed at that level, in that situation and on that day; factors such as poor motivation and inexperience for example, need to be considered (Ulrich 2000). This said, the TGMD-2 is one of the most widely used measures of motor competency. It is a well-validated criterion- and norm-referenced standardised test, which assesses the FMS of children aged 3-10 years, with mean test-retest reliability coefficients reported as 0.96 for the locomotor skills and 0.97 for the object control (Robinson 2011), which emphasises the accuracy of the tests and its appropriateness with preschool aged children. A limitation of the TGMD-2 is that it does require a large amount of space and a wall to be administered (Ulrich 2000), so this must be considered prior to assessing preschool children. Finally, it could be suggested that there is a ‘ceiling effect’ with the TGMD-2, because once a child is able to gain maximum scores, it does not differentiate between their FMS ability, however, this happens in older children, not in preschool children as they are still developing.

Unlike the MABC-2 tool, which was a product orientated test and the BOTMP, which focused more on primary school children and had its cultural validity questioned, the TGMD-2 provides a more generalisable method for preschool children. The TGMD-2 as previously stated, is known to be valid and reliable, has a high test-retest reliability, it is a process orientated test and most importantly is used for assessing FMS amongst preschool children. Thus, using the TGMD-2 provides a consistent way to track FMS from preschool to early adolescence and would be a relevant measurement of motor competency in this thesis. In addition, the TGMD-2 may be considered a more appropriate measurement tool to discriminate levels of motor competency, and therefore, a better assessment to examine the relationship between motor competency and PA (Logan et al. 2014). This theory is based on the type of skills assessed by the TGMD-2 (object control and locomotor skills) and the greater discriminatory nature of its assessment (Logan et al. 2014). When considering the administration of the TGMD-2, it can be delivered to more than one child, therefore, group testing is possible with video analysis. However, a drawback of using video assessments are that the recordings show only one viewpoint and the researcher is not able to select the best angle (Smits-Engelsman et al. 2008). This differs to the MABC-2 that requires individual testing, which can cause logistical problems for preschool staff due to a lack of staff resources. Similarly, if preschool staff were to use either of these tools, then they are more likely to be experienced in identifying the presence or absence of characteristics of a motor skill (TGMD-2), than being able to undertake the specific training required to use the MABC-2, again, due to a lack of staff resources or money.

3.3 Measures of Weight Status/Obesity

3.3.1 Overview of Weight Status

BMI and WC have significantly increased over recent decades, with WC growing more rapidly than BMI amongst children (Lehto et al. 2011). With the increased prevalence of paediatric obesity there is a requirement for simple anthropometric tools to assess and identify children at risk of becoming obese and therefore requiring interventions (McCarthy, Jarrett, and Crawley 2001).

3.3.2 Body Mass Index (BMI)

BMI is calculated as body mass in kilograms, divided by height in metres squared (kg/m^2) (Trost et al. 2003). BMI is considered a good way of identifying overweight or obese children, as it is a less sensitive indicator of fatness, as it measures excess weight relative to height as opposed to fatness (Reilly, Dorosty, and Emmett 2000); it is also a common widespread method that is used internationally (Choy et al. 2011). The validity of BMI has been based on the assumption that BMI and adiposity increase together (Nevill et al. 2008). When using standard distributions for preschool children, they have been categorised as obese if BMI is $\geq$ 18$kg{\cdot}m^2$ and not obese if BMI <18 $kg{\cdot}m^2$, this corresponds closely with the 95th percentile for boys and girls, 3 to 5 years old (Herman et al. 2012). Worldwide the prevalence of overweight (BMI ≥ 85^{th} percentile) and obesity (BMI ≥ 95^{th} percentile) amongst preschool children (2-5 years), increased from 4.2% in 1990, to 6.7% in 2010 and is projected to increase to 9.1% by 2020 (de Onis, Blössner, and Borghi 2010). BMI is known to change substantially with age and due to this there is a requirement to produce cut off points related to age to define child obesity. It has been considered, that cut off points theoretically could be identified at the point on the distribution of BMI where health risks associated with obesity rise steeply (Cole et al. 2000). This is very hard to accomplish in children as they have less diseases related to obesity than adults. This prompted Cole et al. (2000) to devise their own cut off points, based on a heterogeneous mix of surveys from different countries, with differing prevalence rates for obesity; cut off points were defined in BMI units in young adults and extrapolated to childhood, which allowed the conservation of the corresponding centile in each dataset. The cut off points (Table 3.1) were then linked to widely accepted adult cut off points, of a BMI of 25 (overweight) and 30 (obese) $kg{\cdot}m^2$ and were recommended for use internationally (Cole et al. 2000).

Table 3.1 International cut off points for BMI for overweight and obese by sex between 3 and 5 years, defined to pass through to BMI of 25 and 30 kg·m^2 at age 18 years, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands and United States (Cole et al. 2000)

	Body Mass Index 25 kg·m^2		Body Mass Index 30 kg·m^2	
Age (years)	Males	Females	Males	Females
3	17.9	17.6	19.6	19.4
3.5	17.7	17.4	19.4	19.2
4	17.6	17.3	19.3	19.1
4.5	17.5	17.2	19.3	19.1
5	17.4	17.1	19.3	19.2

BMI is based on body mass and it fails to differentiate between fat mass and lean mass and is therefore, considered an imperfect measure of adiposity or leanness due to not providing an indication about fat distribution (Cole et al. 2007; Jansen et al. 2011; O'Dwyer et al. 2011); as such BMI has been criticised as a primary measure for overweight, in children. When a child has an increased BMI, it is reasonable to believe that they will have a larger amount of adipose tissue, therefore, making it more difficult to complete certain skills e.g. in sprinting, the reduced ability of the non-supporting foot to bend 90^o in recovery, hence obstructing movement in certain angles (Bryant et al. 2014). However, in children, BMI correlates with fat free mass greater at the upper end of the adiposity spectrum than the lower end, therefore BMI is a better predictor of lean mass, than fat mass, in thin children (Cole et al. 2007). Taking this into consideration the previous cut offs have been determined with the intention of comparing BMI irrespective of age, gender or country.

An alternative measure of body fatness in epidemiological research has been proposed and is called an inverse BMI (iBMI $cm^{2}\cdot kg$), which is a measure of leanness (Nevill et al. 2011), whereas BMI is more of adiposity. iBMI has predicted 97% variance in fat mass index (FMI, $kg\cdot m^{2}$) when determined via dual-energy X-ray absorptiometry (DEXA), yet similar to BMI which predicted 96.8% of the variance in FMI; importantly BMI was not normally distributed and iBMI was (Duncan et al. 2014). This therefore supports iBMI as a good proxy for body fatness. However, iBMI has never been examined/validated in preschool children and would therefore be inappropriate to use in this thesis, without such validation.

3.3.3 Waist Circumference (WC)

WC is used as an index of obesity and related health risks amongst preschool children, as it has links with coronary heart disease. WC is a straightforward simple measurement that is inexpensive, uses simple equipment and records a single value (McCarthy, Jarrett, and Crawley 2001). It can be used as an alternative measurement or additional measurement to BMI in children (McCarthy, Jarrett, and Crawley 2001). The WC can be measured on top of a t-shirt to the nearest 1cm, midway between the lowest rib and the iliac crest (Lehto et al. 2011). These measures are compared to smoothed percentile curves for WC (Kuriyan et al. 2011), using a non-elastic flexible tape measure and the child in a standing position. The value of WC in children is dependent on measurement error (within- and between-observer error) and is affected by observer training (McCarthy, Jarrett, and Crawley 2001).

It has been found that over a quarter of the children (26.8%) classed as in the highest WC quartile had an elevated blood pressure, revealing a high WC as a risk factor for elevated blood pressure and that elevated blood pressure was greater associated with WC than BMI (Choy et al. 2011); with the average WC being larger in the boys than in girls (Lehto et al. 2011). WC has also been reported as being helpful in detecting metabolic and cardiovascular risks amongst overweight children (Maffeis, Banzato, and Talamini 2008). Vast amounts of studies have found that PA is associated with a smaller WC and sedentary behaviour associated with a larger WC, also children with a larger WC have been known to become more sedentary as a result of their size (Lehto et al. 2011; Ortega, Ruiz, and Sjostrom 2007). PA has been more associated with WC than BMI; this may be due to PA being linked with measures of central adiposity, as PA could increase fat-free mass, which would increase BMI and not WC (Lehto et al. 2011). This is then contradicted, as a systematic review reported that WC and BMI are equally useful in identifying metabolic disturbances in children (Reilly, Kelly and Wilson 2010) and using WC to identify obesity has a limitation in that it does not consider height, yet it is growing more rapidly than BMI among children (Lehto et al. 2011), even though it has only just started to become an important measure of adiposity (McCarthy, Jarrett, and Crawley 2001). BMI represents a whole-body obese status and WC is considered more of an indicator of central obesity or abdominal obesity (Choy et al. 2011). Therefore, in preschool children, WC is viewed as potentially more important due to its specific link with central obesity and predicting total fat content, and therefore the cardiovascular diseases it is associated with.

Gaining normative data and cut-offs of WC is as beneficial as BMI in identifying overweight and obese conditions in preschool children and equally important in identifying children who would benefit from early dietary and exercise interventions (Kuriyan et al. 2011; McCarthy, Jarrett, and Crawley 2001). Sex-specific cut off points have been devised to divide WC into separate quartiles for boys and girls, with a cut-off point of 59 cm being best for WC to predict elevated blood pressure (Choy et al. 2011). Furthermore, in the Indian population, 48% of children were identified as having a WC above the 75^{th} percentile and 30% above the 90^{th} percentile (Kuriyan et al. 2011), highlighting the abdominal obesity problem in this population. This study concluded that using the 75^{th} percentile of WC, would be a good "action point" for identifying abdominal obesity in Indian children (Kuriyan et al. 2011).

McCarthy, Jarrett, and Crawley (2001) decided to research into WC percentiles for British children and table 3.2 shows the sample size and selected WC percentile values for 5-year-old girls and boys. It was reported that mean WC increased with age in both sexes, with the absolute increase being greater for boys (McCarthy, Jarrett, and Crawley 2001). USA boys had a higher WC than UK boys, which reflects higher incidences of overweight and obesity in the USA and highlights the requirement for developing population-specific standards (McCarthy, Jarrett, and Crawley 2001). Visceral adiposity is reported as highly variable in children and varies on ethnic background, this emphasises the different likelihood of problems that can happen in the UK for children from different ethnic groups (McCarthy, Jarrett, and Crawley 2001). It was then proposed that more validation against longitudinal data was required, yet provisionally the 85th and 95th centiles would be used to classify overweight and obesity respectively and used for both clinical practice and epidemiological studies (McCarthy, Jarrett, and Crawley 2001).

Table 3.2 Sample size and percentage values of percentiles of WC by sex at 5 years (McCarthy, Jarrett, and Crawley 2001)

			Percentiles						
Sex	Age	n	5th	10th	25th	50th	75th	90th	95th
Boys	5+	254	46.8	47.7	49.3	51.3	53.5	55.6	57.0
Girls	5+	401	45.4	46.3	48.1	50.3	52.8	55.4	57.2

5+ means: children aged 5.00-5.99 years

3.3.4 Percentage Fat (%Fat)

Dual–energy x-ray absorptiometry (DEXA) is used to determine body composition using a whole-body approach and is considered as the "gold standard" (Duncan et al. 2014 Tanvig et al. 2014). DEXA differentiates body weight into three components: total body fat-free mass (lean soft tissue); total body fat (fat soft tissue); and total body bone; these are measured via low-dose x-rays that scan the body (Morrow et al. 2016), with the process taking about 20 minutes per person. During the DEXA process participants lie down and are in a supine position with their arms extended near the trunk and lower limbs in extension, with a slight abduction of the feet (Duncan et al. 2014). DEXA data can be used to determine fat mass index (FMI, kg/m^2), using directly determined estimates of fat mass and recommendations regarding FMI in obesity related research (Duncan et al. 2014). The advantages of DEXA are that it has good precision, is accurate, it has a stable calibration, short scan times and low radiation doses (Blake and Fogelman 2007). This is then contrasted by the disadvantages of DEXA, which is primarily its cost, the machine is expensive and usually needs a trained radiologist to operate the machine and it does require the participant to lie still for up to 20 minutes. In some studies, using DEXA on children of 3 years of age, has taken up to 45 minutes, due to the children's age and the time-consuming element of the DEXA, with some scans (16.3%) considered inadequate (Tanvig et al. 2014). The use of DEXA is therefore a good process, yet it is expensive and needs preschool children to remain still for a long period of time.

Hydrostatic weighing is known as hydrodensitometry, or underwater weighing, and it measures the density of the body. This technique is based on Archimedes' principle, that when a body is immersed in water, it is buoyed by a counterforce that is equal to the weight of the water that is displaced, allowing body volume to be calculated (ACSM 2010; Morrow et al. 2016). This method has provided the criterion values for validating skinfold and girth measurements (Morrow et al. 2016). The equipment required for this process is generally expensive and it is problematic as not all preschool children are confident being under water, holding their breathe in a relaxed state, and such a test may actually be anxiety-provoking (ACSM 2010).

There is also a method process called air-displacement plethysmography which uses a cabin called the BOD POD, to measure body composition (Fields, Higgins,and Hunter 2004). The BOD POD body composition cabin is considered highly accurate and can detect small changes in body fat and lean body mass; it uses air displacement technology and is considered as accurate as hydrostatic weighing, yet quicker and easier to perform, with its range of error being ± 1 to 2.7% (National Institute for Fitness and Sport 2013). The BOD POD has been determined as the gold standard for assessing body composition in young children as it is validated for 2 to 6-year olds, is safe and comfortable, easy and fast to set up, takes about 3 minutes in the cabin, is non-evasive, requires limited technical expertise and it has a paediatric option of a customised inset for young children (Cosmed 2014; Fields, Higgins and Hunter 2004; National Institute for Fitness and Sport 2013). The BOD POD is very expensive and very few places have it, generally only universities and research institutions. When using the BOD POD the participant must sit quietly with no talking, in a relaxed state and breathe normally (National Institute for Fitness and Sport 2013); the ability to sit still with no talking is a concern when measuring preschool children.

3.3.5 Summary of Measures of Weight Status

The most useful measures that could be employed to assess weight status, based on literature and practical considerations, to provide the best fidelity data for preschool children, would be both BMI and WC. BMI and WC measurements enable comparisons with prior work, they are both useful in identifying metabolic disturbances in children (Reilly, Kelly and Wilson 2010) and they take account of the specific demands of working with preschool children. BMI as previously described is a common widespread method that represents whole-body obesity status and it is used internationally (Choy et al. 2011). WC is a straightforward simple measurement, which is inexpensive, uses simple equipment and records a single value (McCarthy, Jarrett, and Crawley 2001). It is considered an indicator of central obesity or abdominal obesity (Choy et al. 2011). WC and BMI can both be used together as a measurement of preschool children's weight status (McCarthy, Jarrett, and Crawley 2001).

3.4 Qualitative Assessment

The majority of research has used quantitative methods to gain an understanding of preschool children's PA levels and FMS, with very few studies using a qualitative approach (Jackson et al. 2003; Penpraze et al. 2006; Trost et al. 2000). Whilst quantitative approaches are useful, it is important to understand the perceptions and experiences of parents and preschool staff, regarding the PA patterns, FMS and environmental influences of preschool children. Understanding these perceptions is crucial to building the foundations for a physically literate life and to inform future interventions to enhance PA and motor development in this age group. Qualitative data is essential in providing contextual information and at the same time a rich insight into human behaviour (Guba and Lincoln 1994).

3.4.1 Direct Observations

Direct observations involve researchers, staff and parents observing children for a specified amount of time. Direct observations allow the researchers to capture the social and physical context of activities that are occurring and allow studies to go beyond pure PA assessments (Bailey et al. 1995). With respect to children's PA, they allow researchers to understand moment-to-moment activity in different settings and contexts (McIver et al. 2009). Direct observational methods are also advantageous in that they allow the ability to measure the duration, intensity and frequency of PA (Bailey et al. 1995).

The Children's Activity Rating Scale (CARS) was one of the initial systems that provided information on coding children's PA intensities, however it was restricted to rating the intensity of PA (McIver et al. 2009). The Behaviours of Eating and Activity for Child Health Evaluation System (BEACHES) (McKenzie et al. 1991) and the System for Observing Play and Leisure Activity in Youth (SOPLAY) are further tools to provide researchers with the opportunity to observe and code intensities of PA and global information e.g. are the participants inside or outside of their preschool settings. Unfortunately, these systems do not isolate moment-to-moment social and environmental information which some researchers may need to record (McIver et al. 2009). An Observational System for Recording Physical Activity in Children – Preschool Version (OSRAC – P) is a validated observational system that directly measures the children in set time periods and includes information on indoor and outdoor activities (Brown et al. 2006). This child focused system uses 5-second observation periods, each followed by a 25-second interval, with a total of 10-12, 30-minute sessions, and equalling 600-720 30 second intervals that are observed per child (Howie et al. 2012). OSRAC-P can be used to code observations for intensity (1-5), type of PA, social and environmental contexts, equipment use and play in open space. Coding observations for descriptions of PA are a good way of measuring PA as they do not incorporate *a priori* judgments about the energy expended (Bailey et al. 1995). The inter observer reliability for OSRAC-P has been above .80 across children, preschools and the time of day. A limitation of OSRAC-P is that it is limited to use in preschool settings only (McIver et al. 2009). To understand PA of children in their homes, an Observational System for Recording Physical Activity in Children – Home (OSRPAC – H) was developed, with this system useful as either a primary observational tool or in conjunction with a multi-method assessment of preschool children's PA (McIver et al., 2009). OSRPAC-H can document changes in time indoor or outdoor PA and also any parental encouragement and involvement in PA. This highlights a variety of systems that are utilised for directly observing PA in children along with the advantages and disadvantages and which to utilise depends on the context/setting as previously mentioned.

Direct observation does have limitations in that certain studies can only use their researchers to observe children in their preschool setting and therefore not at home in the evening or at the weekends, which limits data acquisition across these different settings. It can be costly in respect of investment in staff training to collect the data and can be cumbersome due to recording data on sheets and then having to input it into computers (Bailey et al. 1995); equally this also can increase the chance for errors to occur. Direct observations are considered to be essential in identifying the different types of activities occurring during a study, however, the quantification of the intensity of PA and therefore the specific energy expenditure are imprecise when measured using this method (Adolph et al. 2012). Direct observations are also costly and only useful with small sample sizes (Ott et al. 2000), therefore, reducing their usability in larger population studies.

3.4.2 Self-Reports

Self-reports can be self-administered or interviewer-directed, and they include the following: questionnaires; surveys; diaries and PA logs (Ceaser 2012). Self-reports are a common form of measuring children's PA levels due to their convenience in being administered, low cost, and the opportunity to collect a variety of PA variables over time (Sallis 1991). The ability for large numbers of people to be assessed using self-reports has meant that they are favoured by epidemiological investigators. A major problem with self-report measures of PA is the lack of objectivity they involve and their ability to have high subject reactivity (Pate et al. 2006). With relatively high levels of children (60-70%) reporting that they participate in high levels of PA when using self-reporting methods, where this was compared to more objective studies, which reported lower levels of PA, especially when cardiovascular fitness levels were monitored (Riddoch and Boreham 1995).

Self-report methods are not recommended for children under 10 years as children this age lack the cognitive ability to accurately recall information regarding their PA levels (Baranowski 1988; Sallis 1991). Direct observations do not actually occur in self-reports, rather individuals recall after the event, therefore biases cannot be ruled out (Sallis 1991; Sallis and Saelens 2000). Comparisons to previous events and misunderstanding what information is required to be recorded, coupled with social desirability biases may influence participants responses, therefore, perceptions might not reflect actual PA (Hodges et al. 2013; Sallis 1991; Marino et al. 2012). Therefore, in the context of examining preschool PA, self-reports are inappropriate and would have little value.

3.4.3 Interviews

Interviews are one of the most common methods of data collection in qualitative research, they are used to explore participants views, experiences, beliefs and motivations (Gill et al. 2008); whilst providing a deeper understanding of a topic area. Interviews are performed on individual participants, they are important for exploring sensitive topic areas where participants may not want to discuss any issues in a group (Gill et al. 2008).

There are three types of interviews: structured; semi-structured and unstructured. Structured interviews follow a verbally administered questionnaire, in which predetermined questions are followed and not deviated from, this form of interview does not allow participant’s responses to questions to be further analysed (Gill et al. 2008). These types of interviews are therefore quick to administer; however, they only allow limited participant responses, and if ‘depth’ to questions is required these are not appropriate (Gill et al. 2008). Semi-structured interviews use key questions, yet they allow the researcher to deviate and pursue any responses which they may want further clarification on from the participants (Britten 1999). This interview type is used frequently in healthcare, as it is flexible and provides participants with guidance on what to discuss, whilst allowing them the freedom to elaborate on information they find pertinent (Gill et al. 2008). These semi-structured interviews in previous studies, have been used to establish an insight into physical inactivity, perceptions of participation in PA, reasons for adherence/non-adherence to PA and what supportive components for PA maintenance exist (Adamsen et al. 2017). The final interview format are classed as unstructured, these are performed with little organisation and do not reflect preconceived ideas (May 1991). These interviews generally start with an open question and progress based on the participants' responses, therefore, they can be time consuming and hard to manage (Gill et al. 2008). They are considered only beneficial to use when great 'depth' is required, or very little information is known on a subject area (Gill et al. 2008).

3.4.4 Focus groups

Focus groups are conducted to elicit participants' beliefs, attitudes, and feelings, they clarify and extend data collected through other methods and they use group dynamics to generate qualitative data through encouraging interactions among participants (Bloor 2001; Freeman 2006; Gill et al. 2008); these group dynamics are the key reason for focus groups being employed. This interaction between participants encourages them to discuss their own views and feelings, providing depth and exploration of topics (Komatsu et al. 2017; Sewdas et al. 2017). Focus groups are similar in their nature to less structured interviews, however, they do not simply collect similar data from many participants at once, they allow the generation of collective views and the meanings behind these views to be collated (Gill et al. 2008).

Focus groups when conducted in the area of PA, have used a semi-structured approach (Persson et al. 2014), with open ended questions allowing a fluid conversation about topic areas to occur (Kvale and Brinkmann 2009). An interpretivist approach aims to understand the actions and perceptions of individuals through their own view and in their own social context (Bryman, Teevan, and Bell 2009). This lens is ideal as it allows for the examination of the participants experiences and perceptions of topics (Brydges, Denton, and Agarwal 2016), therefore, it would be relevant to utilise these semi-structured focus groups when assessing perceptions of PA levels and FMS in preschool children. This approach would ensure appropriate dialogue occurs between the researchers and participants, to construct a meaningful reality.

3.4.5 Summary of Qualitative Measures

Focus groups would appear to be the best method for assessing PA levels and FMS engagement of parents and preschool staff, on what they believe preschool children participate in. This would be the most appropriate method, based on both relevant literature and practical reasons. Focus groups as stated, are used to assess groups of participants and this would allow parents and staff to be assessed at one time, therefore, preschool settings would not have to release staff on numerous occasions and there would be less impact on the settings. Focus groups are advantageous in that they encourage participants to provide in-depth explorations of topics (Komatsu et al. 2017; Sewdas et al. 2017). When assessing parents' and staff perceptions of PA levels and FMS this would be beneficial as the information received would help to expand the knowledge in this area, whilst also being important in supporting the assessment of PA and FMS using quantitative methods. No study, to date, appears to have performed a qualitative approach in this manner and therefore there is a gap in the literature and the potential for future research to be performed to make a novel contribution to the literature. Therefore, qualitative research would be beneficial to be used alongside quantitative measures to provide different information to compliment objective assessments.

Thesis Study Map: Study One

Study	Objectives
Study One: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children's PA.	**Objectives: To determine GENEActiv calibration cut-points for the accelerometers when worn at the non-dominant and dominant wrist, of children aged 4-5 years (preschool children), for assessment of the intensity of preschool children's PA.**
Study Two: Accelerometer based physical activity levels differ between week and weekend days in British preschool children.	Objectives: To determine the intensity and duration of PA levels during the week and weekend days, in preschool children from a deprived area.
Study Three: Accelerometer based physical activity levels and fundamental movement skills in British preschool children.	Objectives: To investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low socioeconomic status.
Study Four: Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.	Objectives: To investigate preschool staff and parents' perceptions of preschool children's PA and FMS, from a qualitative perspective, considering the environment, facilities, play, socio-economic status and barriers to PA.

Chapter 4.

Calibration of GENEActiv accelerometer wrist cut-points for the assessment of physical activity intensity of preschool aged children

4. 1 Introduction

Physical activity during preschool years is critical to child development, health and well-being (Adolph et al. 2012; Esliger and Tremblay 2007). However, habitual PA is declining and sedentary behaviour becoming more dominant in the preschool population (Jackson et al. 2003). Objective monitoring of PA via accelerometry provides a useful means to accurately quantify PA behaviour (Westerterp 1999). However, few studies have used accelerometry in pre-schoolers, therefore, this topic requires additional scrutiny.

Assessing PA in very young children is problematic (Hardy et al. 2010b). Accelerometers are widely used to measure PA in public health research (Vale et al. 2015) and have been validated to assess PA and sedentary behaviour with paediatric populations. Therefore, the use of accelerometers with children is not novel, although fewer studies examine accelerometer data in younger children (<5 years old). The GENEActiv waveform triaxial accelerometer (ActivInsights Ltd, Cambridge, UK), is a recently developed accelerometer. It is lightweight (16g), small (43mmx40mmx13mm) and collects data on three axes (vertical, anteroposterior and mediolateral) at a rate of up to 100Hz.

Although the GENEActiv accelerometer has been validated as a PA measurement tool (Esliger et al. 2011) few studies have examined its utility with paediatric samples and none have calibrated its use in preschool children. Phillips, Parfitt, and Rowlands (2014) have validated cut-points for sedentary, light, moderate and vigorous PA using the GENEActiv accelerometers, for 8-14-year olds and recently, Duncan et al. (2016) cross-validated these cut-points for 5-8 year olds. While the validity of the GENEActiv accelerometer is unlikely to change in preschool children, the development of preschool population specific cut points for the GENEActiv accelerometer is crucial to better quantify PA.

Estimating energy expenditure (EE) from PA involves assigning activities an intensity level; metabolic equivalents (MET) values are a way of achieving this (Sallis et al. 1991). A MET is defined as the EE required when sitting quietly and is equivalent to resting energy expenditure (REE) ($3.5\ ml{\cdot}kg^{-1}{\cdot}min^{-1}$) (Ainsworth et al. 2000). Indirect calorimetry has been employed to determine MET values and to establish accelerometer cut points in children (Duncan et al. 2016; Harrell et al. 2005; Mackintosh et al. 2016). Research has shown that when calculating EE in preschool children it is essential to be aware that published adult METs are lower than estimated child METs using breath-by-breath oxygen consumption (VO_2) data (bias = -0.03 METs) (Ridley and Olds 2008). Specifically, REE is greater in children than adults (Harrell et al. 2005) to the extent that energy costs may be underestimated by almost 40% when using adult METs; therefore, adult METs should not be used for children (Schofield 1985). Mackintosh et al. (2016) suggested using an estimate of daily resting metabolic rate (RMR), calculating daily EE and an equation to provide a child MET. Saint-Maurice et al. (2016) suggested that an adjusted child REE of 1.33 adult-METs should be used (~2 METs) for classifying sedentary activities in children as it improves the classification accuracy of sedentary activities. Reilly et al. (2015) also reported that REE was equivalent to 1.9

adult METs for 4-6-year olds. Whilst sedentary activities in children are better characterised by adult-MET values that are greater than 2 (Harrell et al. 2005).

This study sought to calibrate GENEActiv cut-points for the accelerometers when worn at the non-dominant and dominant wrists, of children aged 4-5 years, for assessment of the intensity of preschool children’s PA. To achieve this, the output was calibrated with a criterion measure of PA (indirect calorimetry), which allowed for accelerometer cut-points to be determined for sedentary, light and moderate and above PA for preschool children.

4.2 Methods

4.2.1 Participants

Twenty-one preschool children (13 boys and 8 girls) took part following institutional ethics approval, parental informed consent and child assent. Participant information sheet and informed consent forms were sent to parents of each participating preschool (Appendix 1). Data was not collected from children until the signed consent forms had been returned. Mean ± SD of age was 4.7 ± 0.5 years old, height 1.1 ± 0.1 m; body mass 19.8 ± 2.8 kg and body mass index (BMI) 16.2 ± 2.2 $kg \cdot m^2$. A priori power calculation indicated that a sample of 21 participants was needed. Cohen’s (1988) *d* compares between dependant measures (matched pairs) and a *d* of 0.5 represents a medium effect size, alpha level of 0.05 at 80% power.

4.2.2 Anthropometric Assessment

Height was measured to the nearest mm, in bare feet, using a standard portable stadiometer (Leicester height measure, Leicester, UK). Body mass was measured to the nearest 0.1 kg using portable weighing scales (Tanita scales, Tokyo, Japan); the children were lightly dressed and barefoot. BMI was calculated as $kg \cdot m^{-2}$.

4.2.3 Assessment of Physical Activity

PA was measured using a GENEActiv waveform triaxial accelerometer (ActivInsights Ltd., Cambridge, UK). The accelerometer measured 1s epochs at a sample frequency of 87.5 Hz, to enable an accurate assessment of the intermittent activities of preschool children. A GENEActiv accelerometer was attached, using a watch strap positioned over the dorsal aspect of both the left and right wrist (non-dominant and dominant), midway between the radial and ulnar styloid process. Prior to testing of each participant, all monitors were synchronised with Greenwich Mean Time. The participants wore the accelerometers for the entirety of the testing.

Participants wore a paediatric face mask (Hans Rudolph, Kansas, USA), which was attached using a head strap. Breath-by-breath oxygen consumption (VO_2), carbon dioxide expenditure (VCO_2) and subsequent determination of EE were analysed using the Metamax 3B analyser (Cortex Bio physik, Leipzig, Germany) via established methods (Duncan et al. 2016; Harrell et al. 2005; Mackintosh et al. 2016) and recognised SI units to validate the cut-points. Respiratory volume was calibrated using a 3L syringe. The Metamax was calibrated with gases of known concentration (15% oxygen and 5% carbon dioxide), prior to commencing testing, and on every day of data collection thereafter. All testing took place between 9 am and 1 pm.

On arrival at the laboratory, the participant's height, mass and handedness were recorded. Participants were then familiarised with the equipment that they were to use, specifically the treadmill (Woodway, Wisconsin, USA). Children have inefficient and sporadic gaits, therefore walking at a constant speed, on a treadmill with an indirect calorimeter strapped to them, is not indicative of their normal movement, hence considerable time was spent familiarising them. The children did not wear a harness, therefore there was no extra carriage in terms of locomotion. This in-depth familiarisation process, followed similar protocols employed with paediatric samples (Duncan et al. 2016; Harrell et al. 2005; Mackintosh et al. 2016). After briefing about the testing protocol, participants were fitted with the GENEActiv accelerometers and the face mask. Each participant was then asked to perform activities representative of various aspects of preschool children's' daily life. To complete calibration analysis on 4-5-year olds it was important to start with locomotor activities as they form the predominant activity in an individual's day (Welk 2005). The following activities were performed in this study: sedentary activity (lying supine for 5 minutes); sedentary activity (playing with Lego® for 5 minutes); light activity (slow walking at 2.5 $km \cdot h^{-1}$), moderate activity (medium paced walking at 3.4 $km \cdot h^{-1}$, fast walking at 4.3 $km \cdot h^{-1}$ and running 5.4 $km \cdot h^{-1}$) on the treadmill, for 4 minutes at each speed, based on prior validation of walking speeds in 4-5-year-olds (Rose-Jacobs 1983). These activities were performed in order as per prior work (Phillips, Parfitt, and Rowlands 2014); at the end of each activity, participants moved straight to the next activity. Similar designs have been used with 8-14-year olds (Phillips, Parfitt, and Rowlands 2014) and 10-13-year olds (Crouter, Flynn, and Bassett 2015), however, in the present study, pilot data collection identified that walking/running speeds used by Phillips, Parfitt, and Rowlands (2014) and Crouter, Flynn, and Bassett (2015), were inappropriate for use with 4-5-year olds, therefore speeds indicated for children were used (Phillips, Parfitt, and Rowlands 2014). REE was calculated from the supine condition by removing the first 2.5 minutes of data and averaging the remaining data. For each activity, the absolute VO_2 ($L \cdot min^{-1}$), relative VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) and EE ($kcal \cdot min^{-1}$) were calculated by removing the first 2.5 minutes of data and averaging the remaining data. This was because Mackintosh et al. (2016) reported that children's EE had reached a steady state after 2.5 minutes, as was indicated by a plateau in VO_2 and VCO_2, where values varied less than 15%. VO_2 was then converted to EE using the values of 1L O_2 = 4.9 kcal (McArdle et al. 2015). An estimate of RMR was calculated for each participant using the sex-, age- and mass-specific Schofield-(WH) equation for basal metabolic rate (BMR) (kcal/day) in children for 3-10 years (Schofield et al. 1985). Child metabolic equivalents (Child METs) were then calculated by dividing the activity EE by the predicted RMR. This approach ensured that the MET values for each activity were at the required intensity. Using the GENEActiv Post Processing software (version 3.1), the raw 80 (87.5) Hz triaxial data were summarised into a signal magnitude vector (gravity-subtracted) (SVMgs), expressed in 1 s epochs (Esliger et al. 2011).

4.2.4 Statistical Analysis

To examine any differences in GENEActiv values at the non-dominant and dominant wrist, a series of paired t-tests were used for each activity. To establish cut-points for the GENEActiv accelerometers, the VO_2's for each activity were converted into child-specific METs as previously mentioned. METs and VO_2 ($L \cdot min^{-1}$) were all normally distributed apart from the medium walk. When two outliers were removed all VO_2 ($L \cdot min^{-1}$) were normally distributed according to the Shapiro-Wilk and Kolmogorov-Smirnov tests. The activities were then coded into one of three intensity categories: sedentary (< 2 METs), light (2–2.99 METs) and moderate (3–5.99 METs) as employed by Phillips, Parfitt, and Rowlands (2014) and Saint-Maurice et al. (2016). On examination, playing with Lego® was equivalent to sedentary activity, walking at a slow speed was equivalent to light activity and walking at medium and fast speeds and running were equivalent to moderate activity. It was not possible for the preschool children in the current study to run at a speed, for a 4-minute period, that was fast enough to be classed as a vigorous (≥6 METs) activity.

Accelerometer counts for the activities were coded into binary indicator variables (0 or 1), as multiple separate analyses were completed, based on the intensity (sedentary versus > sedentary, less than moderate versus moderate) allowing Receiver Operator Characteristic (ROC) curve analysis to be performed and the calculation of sensitivity (Se) and specificity (Sp) as described by Esliger et al. (2011). Therefore, the cut points are indicative of moderate intensity and above. The cut-points were selected to maximise both sensitivity (correctly identifying at or above the intensity threshold) and specificity (correctly excluding activities below the threshold for intensity). These ROC curves allow for the determination of cut-point scores (Pepe et al., 2004). ROC analysis was undertaken using the Statistical Package for Social Sciences (SPSS) (version 22, SPSS Inc., Chicago, Ill, USA).

4.3 Results

Table 4.1 shows the mean and SD of the accelerometer data for each activity. The increases in accelerometer output corresponded with an increase in the intensity of the activity for the GENEActiv on both the non-dominant and dominant wrist. There were no significant differences between the non-dominant and dominant wrist GENEActiv data ($P > 0.05$).

Table 4.1 Accelerometer output and METs for the preschool children by activity. Data represent mean and SD

	Lying	Lego ®	Slow Walk (2.5 $km \cdot h^{-1}$)	Moderate Walk (3.4 $km \cdot h^{-1}$)	Fast Walk (4.3 $km \cdot h^{-1}$)	Running (5.4 $km \cdot h^{-1}$)
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
GENEA non-dominant hand						
	2.15	4.86	11.13	12.24	16.13	26.89
	1.02	1.49	6.44	7.02	8.49	13.55
GENEA dominant hand						
	2.04	5.25	10.84	12.33	15.31	23.53
	0.93	1.33	6.35	6.61	8.15	13.48
METs						
	1.61	1.96	2.70	3.12	3.71	4.57
	0.29	0.33	0.50	0.46	0.50	0.56

Activity intensity cut-points were established via the ROC curve analysis, for the GENEActiv accelerometers worn at both the non-dominant and dominant wrist; the area under the curve (AUC) and the 95% confidence intervals are also included (Table 4.2). Cut points for the preschool children are presented as g s in Table 4.2. ROC curve analysis showed that GENEActiv accelerometers at both locations could discriminate between the different intensity levels. However, the non-dominant wrist monitors gave a marginally more precise discrimination at the sedentary behaviour and moderate and above PA and the dominant wrist monitors at the light PA levels (AUC for nondominant = 0.749-0.993; AUC dominant = 0.760-0.988). With regards to the different intensities, AUC was largest for sedentary behaviour, irrespective of location, making it easier to classify (0.993 non-dominant and 0.988 dominant). Analyses in the present study indicated that there was improved accuracy in the classification of sedentary behaviour at both the non-dominant and dominant wrists (non-dominant: Se = 90%; Sp = 90%; dominant = Se 100%; Sp = 10%). This shows, for this sample, that 90% of the data points for the non-dominant wrist fell into the classification of sedentary and 100% for the non-dominant wrist; this indicated a high number of true positives for both wrist monitors. This was not the same for the non-dominant wrist in light PA or the dominant wrist for light, and moderate and above PA. The energy costs of the activities are shown in Table 4.3.

Table 4.2 Sensitivity, specificity, area under the curve and resultant cut-points for activities undertaken by preschool children assessed via GENEA accelerometer

Intensity	Sensitivity (%)	Specificity (%)	Area under the ROC curve (95% CI)	Cut points (g s)
Non Dominant				
Sedentary	90	90	0.993 (0.98 – 1.0)	**<5.3**
Light	40	20	0.749 (0.65 - 0.85)	**5.3 – 8.6**
Moderate and above	86	40	0.917 (0.86 - 0.98)	**>8.6+**
Dominant				
Sedentary	100	10	0.988 (0.97 – 1.0)	**<8.1**
Light	10	85	0.760 (0.66 – 0.86)	**8.1 – 9.3**
Moderate and above	76	40	0.898 (0.83 – 0.96)	**>9.3**

Table 4.3 Energy expenditure of sedentary and active behaviours

	O_2 uptake ($L{\cdot}min^{-1}$)		O2 uptake ($ml{\cdot}kg^{-1}{\cdot}min^{-1}$)		EE ($kcal{\cdot}min^{-1}$)		EE (Child METs)	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Rest	0.22 ± 0.04	0.16-0.28	11.2 ± 2.1	7.5-14.1	1.09 ± 0.2	0.77-1.38	1.6 ± 0.3	1.3-2.1
Lego	0.27 ± 0.05	0.20-0.38	13.6 ± 2.2	9.1-18.5	1.32 ± 0.24	0.98-1.88	1.9 ± 0.3	1.5-2.7
Slow Walk	0.37 ± 0.09	0.25-0.57	18.7 ± 3.5	13.1-23.6	1.83 ± 0.42	1.21-2.82	2.7 ± 0.5	2.0-3.7
Medium Walk	0.43 ± 0.08	0.34-0.66	21.7 ± 3.2	18-28.1	2.11 ± 0.40	1.68-3.25	3.1 ± 0.5	2.7-4.2
Fast Walk	0.51 ± 0.08	0.38-0.63	25.8 ± 3.9	19-34.1	2.51 ± 0.41	1.88-3.43	3.7 ± 0.5	2.9-4.4
Run	0.63 ± 0.09	0.44-0.75	32.0 ± 4.4	24.2-41.3	3.07 ± 0.43	2.19-3.61	4.6 ± 0.6	3.5-5.6

4.4 Discussion

This study is the first to calibrate PA cut points for the GENEActiv, wrist worn, accelerometer in preschool children. This study contributes to the literature and provides important information that can be used to better classify sedentary behaviour, light and moderate PA in preschool children. Unfortunately, the preschool children in this study were unable to exercise at a vigorous intensity on the treadmill equivalent to that established by Phillips, Parfitt, and Rowlands (2014) highlighting the demands of exercise testing in this population. However, the classification of moderate and above intensity PA is appropriate for this population in respect to assessing whether preschool children meet the UK recommended 180 min PA guidelines per day (Bentley, Jago, and Turner 2015).

The research design assumed that playing with Lego® would be classed as a sedentary activity. The term “sedentary” is typically defined by both low EE (resting metabolic rate) and a sitting or reclining posture (Pate et al. 2008). Lego® in this study was classed as sedentary, with a MET value of 1.9 ± 0.3, however it was at the top end of the sedentary category. There is evidence that suggests predominantly sedentary activities such as seated play and crafts, can be light intensity in preschool children, but would be sedentary in older children and adults (Vale et al. 2015). This data demonstrates that playing with Lego® was classified as sedentary behaviour, yet very close to being light activity for these preschool children as stated by Vale et al. (2015).

The EE (kcal·min^{-1}) and EE (Child MET) values increased with increasing activity intensity and GENEActiv accelerometer counts. The MET values for the moderate walk (3.1 ±0.5 METs), fast walk (3.7 ±0.5 METs) and run (4.6 ± 0.6 METs), were all in the moderate and above intensity classification, suggesting that these activities were expending similar energy. The MET costs of activities, playing Lego® through to running, were all calculated using child MET values in this study. This was appropriate as MET costs are influenced by age (Ridley and Olds 2008) and the MET values reported in this study increased as the intensity of the exercise increased, suggesting that the MET values used in this study were suitable to identify levels of PA.

ROC curve analysis showed that the GENEActiv accelerometer at both the non-dominant and dominant wrist can distinguish between sedentary behaviour, light, and moderate PA, similar, to research performed on 8-14-year olds (Phillips, Parfitt, and Rowlands 2014). The cut-points determined in this study are location specific for the non-dominant and dominant wrists. Although comparable, they were lower than those previously reported at the wrist, for 8-14-year olds for sedentary behaviour, light and moderate and above PA intensities (Phillips, Parfitt, and Rowlands 2014). This difference, supports the relevance of, and need to, calculate specific cut-points for different age categories.

In this present study, a fixed order of activities was followed which went from sedentary to running. This may have been a limitation due to the more sporadic nature of preschool childrens' daily movement patterns. Children are reported as having a higher oxygen cost during weight bearing activities, which is possibly a result of their 'wasteful' gait during walking and running (Spurr et al. 1984), due to their higher stride frequency as they have shorter limbs. Therefore, assessing different activities, for example weight bearing and free-living activities may produce varied results. Additionally, there may have been the possibility, although unlikely, of an order effect where fatigue from earlier activities could have influenced later activities (Duncan et al. 2016). Finally, as the preschool children moved from one station to another, it may be appropriate to readdress the 'transition' time for future research to prevent any carry-over effect in the oxygen uptake between activities. However, as this present study measured VO_2 by removing the first 2.5 minutes of data and averaging the remaining data of an activity (Mackintosh et al. 2016), it is likely that the measurements of EE reflected steady-state conditions in the various activities involved.

The results of the present study showed relatively poorer performance for the light cut-points than any other PA intensity when referring to the AUC (non-dominant = 749; dominant = 760). This may be because there is reported to be greater 'noise' in light PA intensity levels for younger children, making it more difficult to differentiate from sedentary activities (Vale et al. 2015). This has implications for future studies (chapter 5 and 6), because when preschool children's PA levels are assessed, it will be difficult to clearly discriminate between sedentary behaviours and light PA, especially as Lego® was at the top end of the sedentary category. Therefore, some children who play Lego® with more vigorous arm movements and role play enthusiasm, could be identified as completing light PA due to their movements. As children spend a large percentage of their time in light PA, there is the need to better classify this intensity using the GENEActiv accelerometers to avoid any misreporting of PA intensities; this is supported by Duncan et al. (2016).

The present study successfully used accelerometry to create a new way of objectively distilling PA counts into meaningful units for preschool children, however, some limitations should be considered. Recruiting 4-5-year-old children, and subsequently using indirect calorimetry whilst exercising, was challenging and more time consuming than if older children or adults were the population. This resulted in a relatively small sample size for the calibration of the new cut-points. Secondly, the data did not show a greater skew towards either the non-dominant or dominant hand, as the non-dominant was more accurate in determining sedentary and moderate and above PA and the dominant light PA. In this current study, none of the activities required the use of one hand more than the other, however it was not noted if the children did favour one hand more than the other in the activities.

It would be beneficial for future research to cross validate the cut-points reported here, with an independent sample and evaluate their efficacy in a free-living environment than the laboratory based, predominantly ambulatory activities used in this study.

4.5 Conclusions

The current study developed cut points for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years. The newly developed cut-points, were lower than, but broadly comparable to the cut-points previously validated in 8-14-year olds (Phillips, Parfitt, and Rowlands 2014). To conclude, the cut point for GENEActiv accelerometers when worn at the non-dominant and dominant wrist for preschool children (4-5-year olds) are as follows: sedentary (non-dominant: <5.3g/s; dominant:<8.1g/s), light (non-dominant: 5.3-8.6g/s; dominant: 8.1-9.3g/s) and moderate and above (non-dominant: >8.6g/s; dominant: >9.3g/s). Therefore, these cut-points can be used in future research to help classify PA; they will help researchers to determine activity levels of preschool children wearing wrist-based GENEActiv accelerometers. However, any future study using children of different age or ethnicity should estimate new cut-points for their own study population.

Thesis Study Map: Study Two

Study	Objectives
Study One: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children PA.	Objectives: To determine GENEActiv calibration cut-points for the accelerometers when worn at the non-dominant and dominant wrist, of children aged 4-5 years (preschool children), for assessment of the intensity of preschool children's PA. Key Findings: • Cut points were developed for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years. • The newly developed cut-points, were lower than, but broadly comparable to the cut-points previously validated in 8-14-year olds. • The cut points for GENEActiv accelerometers when worn at the non-dominant and dominant wrist for preschool children (4-5-year olds) are the following: Sedentary (non-dominant: <5.3; dominant:<8.1), light (non-dominant: 5.3-8.6; dominant: 8.1-9.3) and moderate and above (dominant: >8.6; dominant: >9.3). • These cut-points have the potential to be used in future research with preschool children to help increase their compliance rates with PA.
Study Two: Accelerometer based physical activity levels differ between week and weekend days in British preschool children.	**Objectives: To determine the intensity and duration of PA levels during the week and weekend days, in preschool children from a deprived area.**
Study Three: Accelerometer based physical activity levels and fundamental movement skills in British preschool children.	Objectives: To investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low socioeconomic status.
Study Four: Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.	Objectives: To investigate preschool staff and parents' perceptions of preschool children's PA and FMS, from a qualitative perspective, considering the environment, facilities, play, socio-economic status and barriers to PA.

Chapter 5.

Accelerometer based physical activity levels differ between week and weekend days in British preschool children

5.1 Introduction

Physical activity during preschool years is critical to a child's development and overall health and well-being (Adolph et al. 2012; Esliger and Tremblay 2007), such that it is important that PA is integrated into early childhood (Strong et al. 2005; Tucker 2008). The prevalence of overweight and obesity among preschool children is high amongst developed countries and it is increasing in developing countries (Hardy et al. 2012a). In 2015, 42 million children worldwide under the age of 5 years were estimated as overweight (WHO 2017). Childhood obesity is an increasing public health concern (de Onis and Blȯssner 2000) and weight gained by the age of 5 years, has been reported as a predictor of being overweight in adulthood (Guo and Chumlea 1999). Therefore, PA in preschool settings promotes a better childhood health status, which enhances health later in adult life (Barnett et al. 2009). PA levels and sedentary behaviour of children in the UK have been viewed as 'obesogenic' (obesity promoting) (Reilly et al. 2004; Reilly et al. 2005), with habitual PA declining and sedentary behaviour being the dominant state of children's PA levels during their preschool day (Jackson et al. 2003; Raustorp et al. 2012; Reilly 2010; Tucker 2008). Although studies have examined PA in children aged 5 years and above, fewer studies have been conducted with preschool children. This limited evidence base in UK preschool children's PA levels, is therefore a cause for concern. The preschool age is important, because a large amount of 3 to 5-year olds spend their day in childcare settings, providing the perfect opportunity to promote PA and healthy behaviours (Bower et al. 2008).

It has been recommended that preschool children should have at least sixty minutes of structured and sixty minutes of unstructured PA a day, whilst also not being sedentary for 60 minutes at one time, apart from sleeping (NASPE 2009). Further UK recommendations stated that preschool children should ideally be participating in at least 180 minutes PA per day, which should involve movement of their trunk from one place to another, through challenging activities that can be informal or formal, indoors or outdoors, to facilitate motor development and the ability to perform large muscle activities (Department of Health 2011a; NAPSE 2009; Reilly et al. 2012). The recommendation of 180 minutes of PA is the main benchmark for preschool children's PA within the UK and it could be viewed as incorporating the NASPE (2009) recommendations; this study will relate to these UK PA guidelines.

Studies have discovered that preschool children spend the majority of their day in sedentary behaviours and a low proportion of their day in MVPA (<15%) (Jackson et al. 2003; Montgomery et al. 2004; Pate et al. 2008). Many preschool children do not meet daily PA recommendations, as it was reported that children engaged in 7.7 minutes of MVPA per hour of preschool (Pate et al. 2004). Therefore, if a child attends preschool for 8 hours they would only engage in ~1 hour of MVPA and it is unlikely they would participate in a further two hours of PA outside of preschool. Of children aged between 2-4 years in England, only 9% of boys and 10% of girls meet the Chief Medical Officer's recommendations for 180 minutes of PA per day (Health and Social Care Information Centre 2012), highlighting that PA in this age group is low and has the capacity to improve (HM Government 2014). In the context of preschool children, objective monitoring of PA via accelerometry, provides a useful means to accurately quantify PA behaviour (Adolph et al. 2012; Cliff, Reilly, and Okley 2009b; Reilly et al. 2003; Westerterp 1999). Evidence from previous studies do not state that PA should be different between the week and weekend days, however, it has been reported as differing. O'Dwyer et al. (2014) reported that there were discrete periods during the after-preschool hours and at the weekend when PA levels were low, yet children who attended preschool for full days engaged in 11.1 min MVPA less than those attending for half days, suggesting that the preschool environment is related to decreased PA. Therefore, additional research is required to identify any potential differences in PA between weekdays and weekends in preschool children.

The accurate measurement of PA is fundamental in evaluating the effectiveness of interventions and understanding relationships between PA and health (Haskell et al. 2007). Measuring habitual PA accurately is beneficial when observing the frequency and distribution of PA in preschool children and identifying the amount of PA that could influence their health. Objective monitoring of PA is important and accelerometers have become a reliable and valid way of estimating children's PA (Pate et al. 2006; Phillips, Parfitt, and Rowlands 2013), whilst also showing promise in monitoring preschool children's PA. Accelerometers are an appropriate objective measure in terms of validity, reliability and practicality as a method for measurement of intensity, duration and frequency of movement for sedentary behaviour and habitual PA in 3-5 year olds (Adolph et al. 2012; Cliff et al. 2009a; Reilly et al. 2003; Westerterp 1999). Accelerometers can be set at different sampling intervals with some studies being set at one-minute intervals (Adolph et al. 2012; Evenson and

Terry 2009). However, one-minute sampling intervals may mask the short intermittent bursts of activity that are representative of young children and therefore shorter sampling intervals have been recommended (Pate et al. 2004; Rowlands 2007). As very few studies have used objective monitoring of PA via accelerometry in preschool children, then further research is required to examine the intensity of PA that these children participate in, on weekdays in preschool and at the weekend.

This is the first study to compare PA levels between week and weekend days, using objective measurements in the form of the newly calibrated GENEActiv accelerometer cut-points for preschool children in the UK. The study aimed to determine whether the intensity and duration of PA varies between weekday and weekend days.

5.2 Method

5.2.1 Participants and Data Collection

Participants in this study were preschool aged children from 11 preschools in North Warwickshire, England. Data was collected between April 2013 and January 2017; across all seasons. The participants were a convenience sample and included 185 preschool children (99 boys, 86 girls), aged 3-4 years, of the sample 6 were Black/African Caribbean, 171 were Caucasian and 8 of South Asian origin. Only 4 out of the 185 participants were full-time, the remainder were part-time nursery attendees. Ethics approval was granted by the Faculty of Health and Life Sciences Ethics Committee, Coventry University. A participant information sheet and informed consent form (appendix 2) were sent to all parents/guardians, along with an information sheet for parents (appendix 3) and children (appendix 4). Testing did not commence until signed consent forms had been received. North Warwickshire was chosen as it incorporates preschools that are considered to have the highest levels of deprivation in the County. This is supported by the highest Super Output Area (SOA) score, ranked as the 76^{th} most deprived Local Authority District out of 326 in England (Warwickshire Government 2010). Within Warwickshire there are nine SOAs that are in the top 10% of the most deprived SOAs in England on the Index of Multiple Deprivation (IMD) 2010 (Warwickshire Government 2010); these are all within the Nuneaton and Bedworth Borough, which is where this study was completed.

5.2.2 Anthropometric Assessment

Height was measured to the nearest mm, in bare or sock feet, using a standard portable stadiometer (Leicester height measure, Leicester, UK). Body mass was measured to the nearest 0.1kg using portable weighing scales (Tanita scales, Tokyo, Japan); the children were lightly dressed (t-shirt and light trousers/skirt) and barefoot or in socks. The measurements were repeated twice and the average score was recorded. Body mass index (BMI) was calculated as kg/m^2 and weight status categorised as overweight/obese or normal weight using standardised international cut-points (Cole et al. 2000).

5.2.3 Assessment of Physical Activity

Daily total PA was measured using a GENEActiv waveform triaxial accelerometer (ActivInsights Ltd., Kimbolton, UK). The accelerometer measured at 10 epochs (s) and a sample frequency of 100 Hz, to enable an accurate assessment of the intermittent activities of preschool children (Hasselstrøm et al. 2007; Obeid et al. 2011; Vale et al. 2009). The GENEA accelerometer was attached using a watch strap and positioned over the dorsal aspect of the right wrist (dominant wrist), midway between the radial and ulnar styloid process. Accelerometers worn on the wrist are more convenient to wear and lead to greater compliance during prolonged wearing when assessing habitual activity (Zhang et al. 2012). The participants wore the accelerometers for four consecutive days; this included two week and two weekend days. Each child was required to wear the accelerometers for 6 hours or more per day. All children received a letter to take home describing how and when they should wear the GENEActiv accelerometers (appendix 5). None wear time was defined as 90-minute windows of consecutive zero or nonzero counts (Choi et al. 2011). The accelerometers were worn at all times by the children. The amount of wear time and percentage (%) of wear time that each child spent in different intensities of PA was calculated for weekday and weekend days. It is recommended that four days, including one weekend day, is optimal for measuring habitual PA (Trost et al. 2000). Given the logistics of ensuring children aged 3 years of age wore the accelerometer for the whole monitoring period, participants were included in the final data analysis providing they had worn the accelerometer for 3 days and for a minimum of six hours each day, similar to previous research (Benham-Deal 2005; King et al. 2011; Trost et al. 2003). Of the sample, 178 children's accelerometer data was recorded; 7 were not useable. This was due to the children either not wearing the GENEActiv accelerometers or technical difficulties with the accelerometers or recording of the data. The final sample included in the analysis was 178 children. The same sample of children were also used for analysis in Chapter 6.

For each of the epochs (number of seconds), movement data (activity counts) were added and logged; these were then processed and analysed. Accumulated activity counts were categorised in terms of intensity such as sedentary behaviour, light, moderate and vigorous PA (Adolph et al. 2012). Cut points for sedentary behaviour, light PA and moderate and vigorous PA were used to determine PA intensity of the preschool children. These cut points have been used as they were determined specifically for children aged 4-5 years, albeit they were calibrated in a laboratory-based study, they are the most relevant cut-points for the children's age in this study (3-4-year olds). These are the closet cut-points that are calibrated and reported in the literature (as determined in chapter 4, by Roscoe, James, and Duncan 2017) for the age of child being assessed in this study. This difference in age should have very little impact on the results, as they are as closely aligned in age as possible and 4-year olds/preschool children have been used for the calibration and ultimately are assessed in this study. The cut points were as follows: dominant hand < 8.1 cpm for sedentary activity, 8.1-9.3 cpm for light activity and 9.3+ cpm for moderate and vigorous PA. For the non-dominant hand < 5.3 cpm for sedentary activity, 5.3-8.6 cpm for light activity and 8.6+ cpm for moderate and vigorous PA (as determined in chapter 4, by Roscoe, James, and Duncan 2017). On the accelerometers, the 'Epoch Converter' creates epochs of 1, 5, 10, 15, 30, or 60 seconds; the means for each parameter and the Sum Vector Magnitude are calculated for each epoch (GENEActiv, 2012). Furthermore, children were classified as either meeting (sufficiently active) or not meeting (insufficiently active) the 180 min a day of PA for 0-5-year olds.

5.2.4 Statistical Analysis

The percentage of time in sedentary behaviour, light PA and MVPA was determined as was the mean amount of time (min) spent in sedentary behaviour, light PA and MVPA, during the week and weekend days. Each data set was tested for skewness and kurtosis. Arcsine or inverse data transformation techniques were then used on any data set that did not have a normal distribution, as follows: mean time sedentary for the week and weekend (arcsine transformation); MVPA at the weekend (inverse transformation); percentage time for sedentary behaviour at the weekend (inverse transformation); and MVPA at the weekend (inverse transformation). Any differences in PA due to gender or day of the week were analysed using a series (separate ANCOVA for each category of PA) of 2 (weekday vs. weekend) X 2 (gender) repeated measures analysis of covariance (ANCOVAs) controlling for wear time. The Statistical Package for Social Sciences (Version 22, SPSS Inc., Chicago, Ill, USA) was used for statistical analysis and the alpha level was set a priori at P = 0.05.

5.3 Results

Descriptive characteristics, including mean time (min) spent in the different intensities of PA during the week and weekend days, are summarised in Table 5.1. Of the sample, none of the 178 children met the UK recommended 180 min or more of PA (moderate and vigorous intensity) per day. Two, circa 1%, of the children did meet the 180 mins on one of their days, but not for all days.

Results indicated that preschool children spent 91.9% and 1.8% of time in sedentary behaviour and light PA on weekdays, and 96.9% and 1.1% of time in sedentary behaviour and light PA at the weekend, respectively. During weekdays, 6.3% and during weekend days 2.0% of time was spent in moderate and vigorous PA. The percentage (%) daily time in different intensities of PA during weekday and weekends for preschool children can be viewed in Figure 5.1.

Table 5.1 Children's descriptive characteristics. Data represent mean ± SD, n = 178

Age (years)	3.4 ± 0.5
Mass (kg)	16.8 ± 2.5
Height (cm)	101.7 ± 4.8
Body mass index (kg·m^2)	16.3 ± 1.9
Waist circumference (cm)	55.0 ± 3.9
Mean wear time (min) during the week	527.0 ± 99.0
Mean wear time (min) during the weekend	581.0 ± 126.0
Mean sedentary behaviour (min) during the week	527.0 ± 94.0
Mean sedentary behaviour (min) during the weekend	565.0 ± 117.0
Mean light PA (min) during the week	10.0 ± 15.0

Mean light PA (min) during the weekend		7.0 ± 10.0
Mean moderate and vigorous PA (min) during the week		36.0 ± 22.0
Mean moderate and vigorous PA (min) during the weekend		12.0 ± 9.0
Sedentary behaviour (%) during the week		91.9 ± 4.3
Sedentary behaviour (%) during the weekend		96.9 ± 2.0
Light PA (%) during the week		1.8 ± 2.4
Light (%) during the weekend		1.1 ± 1.5
MVPA (%) during the week		6.3 ± 3.6
MVPA (%) during the weekend		2.0 ± 1.6
Met PA guidelines of at least 180 min per day total PA (%)	Sufficiently Active	0
	Insufficiently Active	100

a. b.

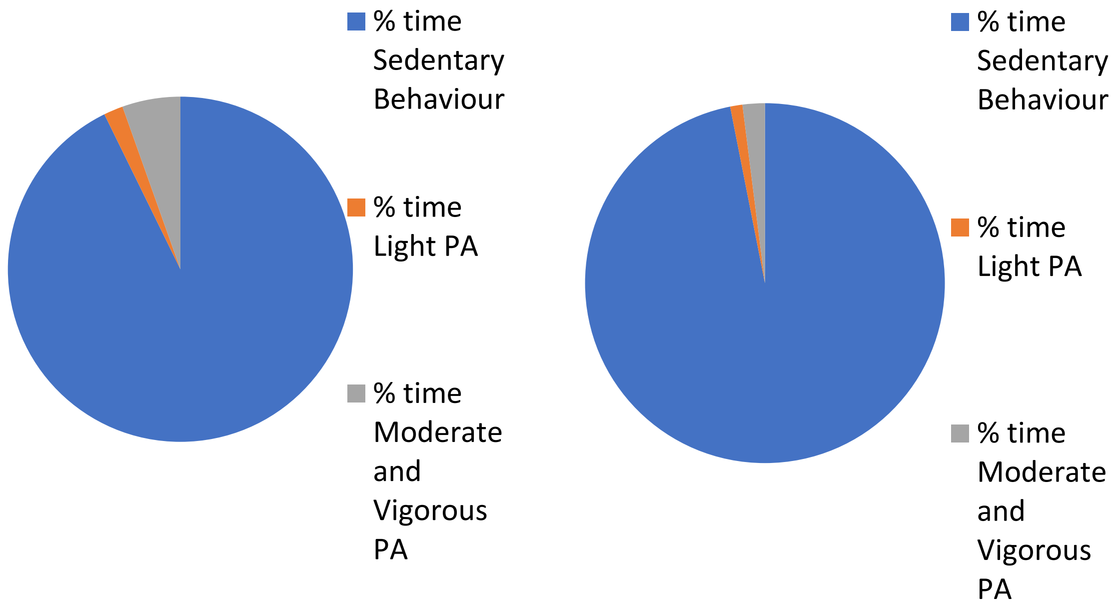

Figure 5.1 Percentage (%) daily time in different intensities of physical activity a) weekday and b) weekends for 178 preschool children

There was a significant difference in the percentage of time (relative) spent in sedentary behaviour between week and weekend days (P<0.05); yet not between the light and MVPA. There was a significantly smaller percentage of time spent in sedentary PA (mean diff = 91.874, P = 0.001) during weekdays compared to weekends. This pattern was reversed for moderate and vigorous PA (mean diff = 4.545, P = 0.001) with a larger proportion of time spent in vigorous PA during weekdays, compared to weekend days (Figure 5.1). There was no significant difference in the mean-time (absolute) between the week and weekend, in any of the intensities.

Wear time had no effect on PA as there was no significant interaction ($P > 0.05$) between wear time and week day, or wear time and weekend day for the significant difference reported for the percentage of time (relative) in sedentary behaviour. Gender had no significant effect on PA (all $P > 0.05$), apart from the mean time and percentage time spent in sedentary behaviour ($P < 0.05$).

5.4 Discussion

The current study sought to compare PA levels of preschool children between weekday and weekend days and the key finding of this study is that there are significant differences in PA between week and weekend days. Additionally, this study found that none of the children were considered 'sufficiently active', failing to participate in the UK recommended level of at least 180 min of light PA and MVPA per day of total PA for health. As the majority of this sample (98%) were part-time preschool children, then this could be reflective of this specific preschool child. The children in this study spent time in both the preschool setting and with their parents, in the home environment. It would be pertinent to assess preschool children who are full-time, to ascertain if this provides a similar or different outcome in their PA levels. This would be influential in identifying whether the results of this study are reflective of British preschool children, or if the time children spend in preschool affects their PA levels. Studies have shown that parents have a significant impact on PA in their preschool children on week and weekend days (Hesketh et al. 2014; Oliver, Schofield, and Schluter 2010; Sigmundová et al. 2016; Vollmer et al. 2015). Therefore, other explanations for the differences in sedentary behaviour between the week and weekend days, could be a result of parents displaying higher sedentary behaviours when they are with their children, and children are exposed to these behaviours and copy them during the weekend days (Sigmund et al. 2008) and there is known to be a stronger significant association observed during the weekend days than on weekdays (Sigmundová et al. 2014). Moore et al. (1991) discovered that children who have one physically active parent, have a relative odds ratio of their child being active of between 2.0 (mother) or 3.5 (father), whereas if both parents are active then the relative odds ratio is 5.8; with no difference reported between week versus weekend day. Sigmundová et al. (2016) discovered that if mothers are more active, then their children are more likely to be more physically active, this was observed to be significant on weekend days. This is essential in terms of promoting PA in the whole family, especially focusing on the weekends, may have been a contributing factor to the sedentary behaviour patterns reported in this current study.

The current study extends understanding in this area, as it is the first study to identify the levels of PA of British preschool children for both week and weekend days. A second key finding of this study is that there are differences in the percentage of time spent in different intensities of PA between the weekdays and weekend days for preschool children. During the week days, the children undertook significantly less sedentary behaviour (91.9% v 96.9%), when compared to weekends. This is when using the right wrist, which in this study was the dominant hand for 169 of the children (91.4% of the sample). As the accelerometers were worn on the dominant wrist, they may have slightly underestimated MVPA based on the findings of chapter 4. This finding contradicts research by Vásquez et al. (2006) in Chilean children, who objectively measured PA via a Tritrac-R3D research ergometer and reported that preschool children spent more time in sedentary activity in day-care centres (week vs. weekend) and the children were more active at home in the weekends. These differences were also linked with the children's diet and discovered that energy balance was appropriate during the week, as the energy intake in the preschools was reduced. This could explain the differences, as the day-care settings were providing less energy intake; therefore, the children may have been less inclined to be active. Equally these findings could have been representative of the cultural background, geographical location or differences in the method used for objective measurement of the children involved. A further reason for potential differences between sedentary behaviour of the preschool children during the week and weekend days, could be attributed to the time that children spend watching television or playing on computer games, smart phones/tablets (screen time). Previous research has shown that preschool children whose parents limit television viewing, spent significantly less time in sedentary behaviour (Hnatiuk et al. 2015). Preschool children during the weekdays spend on average, less than 1 hour engaged in 'screen time', yet at the weekends it is more than 78 min a day. Therefore, during the weekdays only 6.7 % of girls and 7.1 % of boys exceeded 2 hours of screen time, when compared to the weekend days, where 27.0 % of girls and 21.4 % of boys reported excessive screen time (≥ 2 h/day); parents also reported considerably higher amounts of screen time at the weekends than on weekdays (Sigmundová et al. 2016). Similarly, significantly higher amounts of screen time were observed in 5 to 6-year-old English children and their parents (Jago et al. 2014). The amount of screen time children in this current study participated in could have been a contributing factor to the differences in the sedentary behaviour during the week and weekend days.

The current data show that a substantial proportion of each day is spent in sedentary behaviour in British preschool children. This data is reported across a wide measurement period and across all seasons and therefore provides a spread of representative data for the whole of the year. However, this study did not assess each child at different points throughout the year, as it is very labour intensive and demanding to assess PA in preschool children at one time point and to assess them again across different seasons, would likely lead to much higher attrition, hence why this approach was taken. Therefore, this study did not consider seasonal adjustments, however, future research may consider this, to identify if preschool children are more active in the summer months, when compared to the cold environment in the winter months.

The amount of time spent in different intensities of PA varies between weekdays and weekends, with less moderate and vigorous PA accrued during weekends. However, MVPA is very limited on either of these parts of the week. Such a finding might be suggestive that regular engagement in the preschool environment provides greater opportunities to accrue PA, which may not be present in the home setting. The light intensity minutes were very low during both the week and weekend days, this appears to reflect the METs that were reported in chapter 4. The wrist worn accelerometers may not be very precise at detailing light ambulation, as was identified in chapter 4, where playing with Lego® was at the top end of the sedentary category, therefore, future research to determine the accuracy of the light PA classifications would be beneficial. Similar research using the Actigraphs has shown that using the cut-point of 160cpm to distinguish light intensity from sedentary behaviours is questionable (Vale et al. 2015). It is believed that this threshold may misclassify sedentary behaviours such as seated play and crafts as light intensity, this would cause an overestimation of total PA minutes and underestimate steps per day (Vale et al. 2015), that are required to achieve the daily UK 180 minutes of recommended PA. This is a current problem, as there is no consensus on the optimal cut-points for distinguishing sedentary from light PA in preschool children (Vale et al. 2015). Also, the cut-points used for light intensity PA in this study are taken from laboratory derived tasks that were constant in nature, where in fact, real life activities of preschool children are more varied and intermittent. This may have made it more difficult to differentiate light PA from sedentary behaviour, as the determination is dependent on the cut-point used. However, this is a feature of most of the research using accelerometers to classify/assess PA (Vale et al. 2015; Youngwon et al. 2014).

Parental influence on PA during the weekend days may therefore be an important factor that needs to be given greater attention by public health professionals; this could be a result of parents lacking an understanding of appropriate PA to deliver to their children, or a lack of time. Despite this, the extant literature on parental influence on PA levels in British preschool children is scarce. Additional work is required on this topic, in the context of week day to weekend day variations in children's PA. Equally the LPA and MVPA of preschool children could further be improved through interventions, both in preschools and at home with parents.

Using wrist worn accelerometers can be logistically and practically challenging with preschool children (Cliff et al. 2009a), where the accelerometer can sometimes be regarded as uncomfortable or an annoyance when worn for long periods of time. In the current study, although a cut-off of 6 hours per day was employed for inclusion in the data analysis, the participants exceeded this value with total mean wear time, per day, for all days being over 577 min (>9.6 hours), mean wear time for the weekdays being 573 min (9.6 hours) and for the weekend days 581 min (>9.7 hours). We took this to be indicative, that the majority of the children in this study were comfortable wearing the accelerometers.

Although the current study successfully used accelerometry as an objective monitoring tool in preschool children, some limitations should also be considered. Some of the accelerometers failed to record data and this manufacturer problem caused no data to be recorded for seven participants. GENEActiv accelerometers when worn at the wrist may not be detailing light ambulation precisely due to the low levels of light PA reported. Equally, wrist worn accelerometers in young children may also be impacting on light data, however, the research does appear to show that the location whether at the wrist or hip has no significant difference in the PA levels reported (Dieu et al. 2017; Rowlands et al. 2014). As previously stated, the preschool children were assessed once in a season and not across all seasons. Although children were assessed throughout different seasons which provided representative data, the lack of assessing each child in all seasons should be considered a limitation of the study. The preschool children that were monitored were drawn from a deprived part of the UK. It has been reported that the prevalence of obesity amongst 4-5-year olds in the most deprived 10% of areas in England, is approximately double the levels of the least deprived 10% of areas (Public Health England 2014). In this current study 10.8% (20 out of 185) were considered obese. Low SES children face greater barriers to becoming physically active and as they age low SES individuals have higher rates of obesity and associated comorbidities (NOO 2014). Additionally, people from lower SES groups predominantly live in areas that do not support walking and cycling (The Marmot Review Team, 2010). This viewpoint would suggest that deprived areas do not facilitate PA as effectively as other areas and as such, people living in deprived areas may not participate in PA as frequently. This said, further research comparing both high and low socio-economic status groups would be welcome to extend the literature in preschool children. Understanding the levels of PA in this group of preschool children is useful to allow for the planning of early interventions to improve current and future health.

5.5 Conclusions

The current study is the first to objectively compare PA levels between weekdays and weekend days in preschool children in the UK, and one of the first to report objectively monitored PA levels of preschool children from deprived areas in the UK.

The results of this study suggest that none of the preschool children in this sample achieved the UK recommended guidelines of PA for health. This study indicates that preschool children participate in more MVPA during the weekdays, when compared to the weekend days, however, participation in MVPA was minimal throughout the week. This information can help to promote future interventions which focus on enhancing PA and encouraging participation in LPA and MVPA, during both the week and weekend days, to improve physical development and a healthy weight status in preschool children.

Thesis Study Map: Study Three

Study	Objectives
Study One: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children PA.	Objectives: To determine GENEActiv calibration cut-points for the accelerometers when worn at the non-dominant and dominant wrist, of children aged 4-5 years (preschool children), for assessment of the intensity of preschool children's PA. Key Findings: • Cut points were developed for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years. • The newly developed cut-points, were lower than, but broadly comparable to the cut-points previously validated in 8-14-year olds. • The cut points for GENEActiv accelerometers when worn at the non-dominant and dominant wrist for pre-schoolers (4-5-year olds) are the following: Sedentary (non-dominant: <5.3; dominant:<8.1), light (non-dominant: 5.3-8.6; dominant: 8.1-9.3) and moderate and above (dominant: >8.6; dominant: >9.3). • These cut-points have the potential to be used in future research with preschool children to help increase their compliance rates with PA.
Study Two: Accelerometer based physical activity levels differ between week and weekend days in British preschool children.	Objectives: To determine the intensity and duration of PA levels during the week and weekend days, in preschool children from a deprived area. Key Findings: • One of the first studies to objectively compare PA levels between weekdays and weekend days in preschool children in the UK, from deprived areas in the UK. • None of the preschool children in this sample achieved the UK recommended guidelines of PA for health. • Preschool children participate in more MVPA during the weekdays, when compared to the weekend days; however, participation in MVPA is minimal for both days. • This study's findings can help to promote future interventions which focus on enhancing PA and encouraging participation in MVPA in both the week and weekend days to improve physical development and a healthy weight status in preschool children.
Study Three: Accelerometer based physical activity levels and fundamental movement skills in British preschool children.	**Objectives:** To investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low socioeconomic status.
Study Four: Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.	Objectives: To investigate preschool staff and parents' perceptions of preschool children's PA and FMS, from a qualitative perspective, considering the environment, facilities, play, socio-economic status and barriers to PA.

Chapter 6.

Accelerometer based physical activity levels and fundamental movement skills in British preschool children

6.1 Introduction

One factor that may influence children's PA levels and weight status is FMS. FMS as previously stated in chapter 3 provide the building blocks for future motor skills and lifelong PA (Logan et al. 2012; NAPSE 2009; Stodden, Goodway, and Langendorfer 2008; van Beurden et al. 2002). FMS are commonly developed in early childhood and include locomotor and object control skills (Logan et al. 2012). Mastering FMS amongst preschool children is essential in providing opportunities to participate in current and future PA

FMS and PA can be influenced by a range of individual, social and environmental factors (Butcher and Eaton 1989; Hinkley et al. 2008; Hinkley et al. 2012; Barnett et al. 2013). Preschool children vary in their behaviour and the relationship between behaviour and motor proficiency is a concern. This is because children choose different activities and intensity levels as part of their 'free play', with more active children participating in more gross movement skill activities (Butcher and Eaton 1989). Preschool children's FMS are to a degree rudimentary, as they are still at the developmental stage, and consequently a relationship with PA is weak but emerging (Foulkes et al. 2015; Gallahue and Donnelly 2003; Stodden, Goodway, and Langendorfer 2008); they require further practice and instruction to reach mature patterns of movement required for primary school (Foulkes et al. 2015). Motor skill competency and PA will strengthen together over time and therefore possess a reciprocal relationship, which prevents physical inactivity (Stodden, Goodway, and Langendorfer 2008). In the preschool years, children demonstrate variable levels of motor skill competency and it is believed that there will not be a strong relationship between fitness and motor skill competency or PA (Stodden, Goodway, and Langendorfer 2008). This is because preschool children are still at the 'developmental stage' and their differing motor skill levels reflect this lack of relationship. This supports Stodden and colleagues (2008) belief that there will not be a strong relationship between FMS competency and PA levels and weight status. Foulkes et al. (2015) reported that both girls and boys of preschool age demonstrate low competency levels amongst object-control skills, when compared to locomotor skills, however, they concluded that both skills should still be targeted for improvements. This broader approach to PA interventions will enable preschool children to develop a repertoire of FMS, rather than explicitly targeting locomotor or object-control skills (Foweather et al. 2015).

Gu (2016) reported a weak association between FMS and PA, with locomotor skills, not object control skills, explaining a significant variance in children's LPA and MVPA. Preschool children with better locomotor skills are reported to participate in more MVPA on weekdays and more LPA on weekends; preschool children with higher object-control skill competency participate in more LPA on weekdays and more LPA, MVPA and LMVPA at weekends (Foweather et al. 2015). These findings pose the question of whether different types of FMS are best promoted during different time periods throughout the week. This links with chapter 5 and the importance of understanding if the sedentary behaviour and PA levels that were reported, correlate with FMS competency of preschool children. Conversely, it was reported that preschool children with better developed motor skills spend significantly more time in MVPA and VPA and significantly less time in sedentary behaviours, when compared to children with less developed motor skills (Williams et al. 2008). This evidence would suggest, in line with the Stodden, Goodway, and Langendorfer (2008) conceptual model, that developing FMS competency is important in influencing obesity related behaviours, for example PA and preventing sedentary behaviour in preschool children (Gu 2016).

Data on adolescent physical inactivity mirrors the data on early childhood FMS delays (Stodden, Goodway, and Langendorfer 2008); this supports the assumption that different levels of motor skill development in children may be an influencing factor on both their PA and weight status. Research has previously recognised that impaired FMS development is associated with obesity in early childhood (D'Hondt et al. 2013). Also, an individual with a low SES has a greater chance for a delay in their FMS development (Hardy et al. 2012) and are at a greater risk of being obese (Castetbon and Andreyeva 2012). This suggests that the SES of a preschool child will affect their FMS development, weight status and PA levels. This was further supported by Foulkes et al. (2015) who stated that research amongst low SES preschool children would be beneficial to help monitor their current levels of FMS competency and would help to target interventions to increase FMS competency. Very few studies have examined the influence of FMS on PA and weight status in British preschool children from a less deprived area and further research is therefore required. This research would help to link the findings from chapter 5 with any correlation in FMS competency and explore any potential association between chapter 5 and 6.

Participation in PA is fundamental to the health and well-being of children (Adolph et al. 2012; Esliger and Tremblay 2007) and it is important that PA is integrated into their lives in early childhood (Strong et al. 2005; Tucker 2008). Unfortunately, preschool children spend the majority of their day in sedentary behaviours and are not sufficiently active enough to provide benefits to their health (Jackson et al. 2003; Montgomery et al. 2004; Pate et al. 2008; Reilly 2010; Tucker 2008), such as protection against weight gain (Jimenez-Pavon, Kelly, and Reilly 2010) and improvements in cardiovascular health (Bürgi et al. 2012), bone health and motor development (Hardy et al. 2010b; Janz et al. 2010). As previously stated in chapter 1, only 9% of preschool boys and 10% of preschool girls in England, meet the Chief Medical Officer's recommendations for 180 mins of PA per day (Health and Social Care Information Centre 2012), this is very low and has the capacity to improve (HM Government 2014). Although studies have commonly examined PA in children aged 5 years and above, far fewer studies have been conducted with preschool children. For this reason, additional research is required into the amount of time that British preschool children engage in different intensities of PA.

FMS competency is fundamental for PA in preschool children, a child who possesses greater FMS competency is known to participate in various physical activities and this helps the child to avoid being obese (Chung and Kang 2016). Studies involving preschool children have acknowledged a significant correlation between FMS and BMI (Kim, Han, and Park 2014). Conversely, Catenassi et al. (2007) identified no relationship between FMS when measured using the TGMD-2 and BMI in preschool children. This was consistent with further research which also reported no significant relationship between FMS and BMI (Chung and Kang 2016; Houwen et al. 2009; Khalaj and Amri 2014). Siahkohian et al. (2011) proposed that non-contributory mass could lead to inefficiencies in movement, because obesity influences the body by increasing the mass of different body parts. However, Chung and Kang (2016), discovered no differences in FMS competency and BMI, and suggested this is because FMS competency concentrates on the assessment of the process skills needed to run, skip, throw and catch, not the product/outcome. Therefore, over a short time period, FMS competency are independent of cardiovascular endurance, muscular endurance, height and weight, as they rely on cognitive-understanding and physiological responses, not on their motor abilities and physical fitness (Chung and Kang 2016). This research appears to suggest that both obese and overweight preschool children, develop FMS competency at the same rate as healthy weight preschool children. However, the correlation between FMS and BMI in the literature, remains controversial. We currently do not know which comes first, in terms of obesity or FMS competency delays, further research is required to discover this. Therefore, the BMI of preschool children in deprived areas needs to be assessed, to identify if there is any association with their FMS competency levels.

This study aims to measure FMS, PA levels and weight status in preschool children, to determine whether FMS influences PA and weight status. The findings from this study, could help to inform strategies used to increase FMS and PA in preschool children. Therefore, the aim of this study is to investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low SES.

6.2 Method

6.2.1 Participants and Data Collection

Participants in this study were preschool children from 11 preschools in North Warwickshire, England. The participants were a convenience sample and included 185 preschool children (99 boys, 86 girls), aged 3-4 years, these were the same children that were used in Chapter 5. Data was collected between April 2013 and January 2017, across all seasons. Ethics approval was granted by the Faculty of Health and Life Sciences Ethics Committee, Coventry University. A participant information sheet and informed consent form (appendix 2) were sent to all parents/guardians, along with an information sheet for parents (appendix 3) and children (appendix 4). Testing did not commence until signed consent forms had been received. North Warwickshire was chosen as it incorporates preschools that are considered to have the highest levels of deprivation in the County. This is supported by the highest Super Output Area (SOA) score, ranked as the 76th most deprived Local Authority District out of 326 in England (Warwickshire Government 2010).

6.2.2 Anthropometric Assessment

Height was measured to the nearest mm, in bare or sock feet, using a standard portable stadiometer (Leicester height measure, Leicester, UK). Body mass was measured to the nearest 0.1kg using portable weighing scales (Tanita scales, Tokyo, Japan); the children were lightly dressed (t-shirt and light trousers/skirt) and barefoot or in socks. The measurements were repeated twice and the average score was recorded. Body mass index (BMI) was calculated as body mass (kg) divided by height (m) squared (kg/m^2). BMI was compared to a BMI-for-age chart, which considers weight, stature and age of a child, to determine whether the child was of normal weight or overweight (≥ 95th percentile); BMI for age is recommended as a reasonable measure for assessing overweight in children (Barlow and Dietz 1998; Bellizzi and Dietz 1999; Dietz and Bellizzi 1999; Himes and Dietz 1994). The Waist Circumference (WC) was measured on top of a t-shirt to the nearest 1cm, midway between the lowest rib and the iliac crest (Lehto et al. 2011), using a non-elastic flexible tape measure and the child in a standing position. WC was compared to standardised international cut-off points and weight status categorised as overweight/obese or normal weight (McCarthy, Jarrett, and Crawley 2001).

6.2.3 Assessment of Physical Activity

PA was measured using a GENEActiv waveform triaxial accelerometer (ActivInsights Ltd., Cambridge, UK). The accelerometer measured at 10 epochs (s) and a sample frequency of 100 Hz, to enable an accurate assessment of the intermittent activities of preschool children (Hasselstrøm et al. 2007; Obeid et al. 2011; Vale et al. 2009). The GENEActiv accelerometer was attached using a watch strap and positioned over the dorsal aspect of the right wrist, midway between the radial and ulnar styloid process. The participants wore the accelerometers for four consecutive days; this included two week and two weekend days. Each child was required to wear the accelerometers for 6 hours or more per day. All children received a letter to take home describing how and when they should wear the GENEActiv accelerometers (appendix 5). Non-wear time was defined as 90-minute windows of consecutive zero or nonzero counts (Choi et al. 2011). The accelerometers were worn at all times by the children. The amount of wear time and percentage (%) of wear time that each child spent in different intensities of PA was calculated for weekday and weekend days. It is recommended that four days, including one weekend day, is optimal for measuring PA (Trost et al. 2000). Given the logistics of ensuring children aged 3 years of age wore the accelerometer, in the current study, participants were included in the final data analysis providing they had worn the accelerometer for 3 days, this included one weekend day and for a minimum of six hours each day, similar to previous research (Benham-Deal 2005; King et al. 2011; Roscoe, James, and Duncan 2017; Trost et al. 2003). Of the 185 children sample, accelerometer data was recorded for 178 children; another 7 children's data were not useable due to the children either not wearing the GENEActiv accelerometers or technical difficulties with the accelerometers or recording of the data. The final sample included in the analysis was 178 children.

For every epoch (number of seconds), movement data (activity counts) were added, logged, processed and analysed. Accumulated activity counts were categorised in terms of intensity such as sedentary, light, moderate and vigorous PA (Adolph et al. 2012). The cut-points determined in chapter four, by Roscoe, James, and Duncan (2017), for sedentary, light, moderate and vigorous PA for children aged 3-5 years were used to determine PA intensity. The cut points were as follows: dominant hand < 8.1 cpm for sedentary activity, 8.1-9.3 cpm for light activity and 9.3+ cpm for moderate and vigorous PA. For the non-dominant hand < 5.3 cpm for sedentary activity, 5.3-8.6 cpm for light activity and 8.6+ cpm for moderate and vigorous PA. On the accelerometers, the 'Epoch Converter' creates epochs of 1, 5, 10, 15, 30, or

60 seconds; the means for each parameter and the Sum Vector Magnitude are calculated for each epoch (GENEActiv 2012). Furthermore, children were classified as either meeting (sufficiently active) or not meeting (insufficiently active) the UK recommended 180 min a day of MVPA for 0-5-year olds.

6.2.4 Assessment of FMS

The Test of Gross Motor Development (Ulrich 2000) was employed as a measure of FMS (appendix 6). TGMD-2 examines a subset of locomotor and object control skills which are required in context-specific sports and PA (Logan et al. 2017). The TGMD-2 relates to activities that preschool children participate in and it assesses gross motor development amongst 3 to 11-year olds (Hardy et al. 2010a). The TGMD-2 has been described as having an established validity and reliability amongst preschool children, with a test-retest reliability of = 0.88-0.96 (Hardy et al. 2010a; O'Dwyer et al. 2011).

The TGMD-2 is classed as a process orientated test, as it assesses the components that make up the skill, not the overall outcome of the skill, therefore it reflects the development of the skill not the physical growth and maturational levels of children (Barnet et al. 2013; Hardy et al. 2010a); as such it is better placed for the assessment of preschool children. This test comprises of two subsets (locomotor and object control) each made up of different skills (O'Dwyer et al. 2011). The locomotor skills assessed were: run, gallop, hop, horizontal jump, skip, slide and leap; the object control skills assessed included: striking a stationary ball, catching, kicking, overhand throw, bouncing a ball (Hardy et al. 2010a); these are vital to the development of higher skills, for example an overarm throw for the smash in volleyball. Each skill is made up of 3-4 specific performance criteria, which were either present or absent and were totalled to provide the total gross motor skill score for a child (total FMS) over two attempts (Barnett et al. 2013; Hardy et al. 2010a).

Administration of the TGMD-2 followed the administration guidelines for this test (Ulrich 2000). Prior to data collection, a senior member of the research team who had previous experience of delivering the TGMD-2 protocol trained the field tester. The children were assessed in small groups (2-3) and the tests were administered by one tester to ensure consistency. The tests took part primarily in an outside area/playground, apart from in one preschool which had access to the adjacent primary school's hall. The skills were physically demonstrated and verbally explained to ensure all children had the same clear information on the different skills. If any child did not understand a task correctly then they were provided with a further verbal description and asked to repeat the trial of the skill again (Foulkes et al. 2015; Foulkes et al. 2017). The children all had a practice attempt prior to being scored on their two tests. All children were videoed, using a camcorder (Sony, Tokyo, Japan) at standard frame rate, completing the skills, allowing the skills to be analysed after the occasion to ensure that appropriate time was spent administering the skills and identifying the inclusion of all criteria after the assessment. All 12 skills were assessed in a standardised order and the testing took between 30-35 min per group. The skills were always performed in the following order: run, gallop, hop, leap, horizontal jump, skip, slide, two-hand strike, stationary bounce, catch, kick and overhand throw.

The children's FMS competency was assessed using the guidelines of the TGMD-2 protocol (Ulrich 2000). All video analyses were completed by the trained assessor. Inter-tester reliability was established prior to the commencement of testing, using pre-coded videos of 10 children, there was 84.5% agreement across the 12 skills (range = 81.7-88.4%); this was similar to work by Foulkes et al. (2015). Intra-tester reliability was also performed again using pre-coded videos of an additional 10 children, with the test-retest completed 1 week apart, 93.9% agreement was determined across the 12 skills (range = 90-98%). There is no specified minimum level of percentage agreement, however, 80-85% was previously deemed acceptable (van der Mars 1989). If at any point the assessor was unsure whether a child had performed a criterion or not, then both the assessor and trainer viewed the videos and agreed on a score, this was in agreement with Foulkes et al. (2015) and (2017). In line with the TGMD-2 assessment criteria for each skill, and both trials of the skill, the run, gallop, hop, jump, slide, strike, catch, kick and throw were all scored out of 4 and the leap, skip and bounce were out of 3; zero represented absence of components for a skill. The scores were totalled over two attempts to provide the locomotor, object control and total gross motor skill score for a child (total FMS) (Barnett et al. 2013; Hardy et al. 2010a).

6.2.5 Statistical Analysis

The percentage of time spent in each of sedentary, light and MVPA was determined as was the mean amount of time (min) spent in sedentary, light and MVPA. Data for total FMS, locomotive FMS and object control FMS were analysed separately. The participants were split equally into tertiles for their total FMS, locomotive FMS and object control FMS. This was to identify whether being in the lower, middle or higher FMS tertile for these measurements impacted on PA, BMI and WC. The effect of any differences in the FMS measurements on PA, BMI and WC were analysed using a univariate ANOVA, with WC, BMI or PA as the dependant variable and gender and the specific FMS tertile as the fixed factors. Independent t-tests were also performed to identify if there were any significant differences between each FMS between boys and girls. Pearson's correlation coefficients were performed between the overall total FMS scores, locomotor FMS and object control FMS and the percentage of time in MVPA during the weekdays and the weekend days, to see if there was a relationship. This was to provide a view of the children's global FMS scores in comparison to the week and weekend days. Additionally, Pearson's correlation coefficient was performed between BMI and WC against total FMS, locomotor FMS and object control FMS separately. A two-tailed t-test was used to test for significant differences, as we could not predict the nature of the relationship when referring to previous research, such that we could not predict whether an increased FMS score would cause increased PA levels. Pearson's correlation requires parametric data; therefore, arcsine transformation was conducted on the percentage time data (non-parametric) prior to statistical analysis (Wilson et al. 2010). The Statistical Package for Social Sciences (Version 20, SPSS Inc., Chicago, Ill, USA) was used for statistical analysis and the alpha level was set a priori at P = 0.05.

6.3 Results

Descriptive characteristics, including overall (week and weekend days) mean time (min) spent in the different intensities of PA, are summarised in Table 6.1. Overall

FMS and PA level means and standard deviation for the week and weekend days, for each tertile of FMS, are given in Table 6.2. 9.25% of the sample were classed as overweight/obese and none of the children met the UK recommended 180 min or more of PA (moderate and vigorous intensity) per day. Two, circa 1%, of the children did meet the 180 mins on one of their days, but not for all days. Results from the ANOVA analysis indicated no significant difference in PA levels, BMI or WC of the children between tertiles of total FMS, locomotive FMS or object control FMS (all $P>0.05$).

Table 6.3 shows the locomotive FMS and object control FMS scores of the participants. This table highlights that the girls scored significantly greater at the hop, leap and skip (locomotor skills) and the boys significantly higher at the kick (object control) ($P<0.05$). Table 6.4, further supports this by showing the overall locomotive FMS and object control FMS for boys and girls. The girls overall scored higher on the locomotor skills, yet not significantly higher ($P= 0.08$) and the boys were significantly higher at most of the object control FMS ($P<0.05$). There was no significant difference in total FMS score between boys and girls (boys = 50.4 ± 15.6, girls = 52.9 ± 14.6). There was no significant correlation between overall FMS and MVPA during weekdays or weekends (r = -.030, $P>0.05$ for weekdays; r = .070, $P>0.05$ for weekends), (Figures 6.1 and 6.2), nor between locomotor FMS and MVPA during weekdays or weekends (r = -.002, $P>0.05$ for weekdays; r = .079, $P>0.05$ for weekends), between object control FMS and MVPA during weekdays or weekends (r = -.072, $P>0.05$ for weekdays; r = .040, $P>0.05$ for weekends), between BMI and total FMS, locomotor FMS and object control FMS (r = .038, $P>0.05$ for total FMS; r = .039, P>0.05 for locomotor FMS; *r* = .029, P>0.05 for object control FMS) and no significant correlation between WC and total FMS, locomotor FMS and object control FMS (*r* = .068, P>0.05 for total FMS; *r* = .079, P>0.05 for locomotor FMS; *r* = .034, P>0.05 for object control FMS).

Table 6.1 Children's descriptive characteristics. Data represent mean ± SD, n = 178

Age (years)		3.4 ± 0.5
Mass (kg)		16.8 ± 2.5
Height (cm)		101.7 ± 4.8
Body mass index ($kg{\cdot}m^2$)		16.3 ± 1.9
Waist circumference (cm)		55.0 ± 3.9
Mean wear time (min) during the week and weekend		577.0 ± 90.0
Mean sedentary behaviour (min) during the week and weekend		545.0 ± 85.0
Mean light PA (min) during the week and weekend		9.0 ± 12.0
Mean moderate and vigorous PA (min) during the week and weekend		25.0 ± 14.0
Sedentary behaviour (%) during the week and weekend		94.2 ± 2.8
Light PA (%) during the week and weekend		1.5 ± 1.8
MVPA (%) during the week and weekend		4.3 ± 2.3
Met PA guidelines of at least 180 min per day total PA (%)	Sufficiently Active	0
	Insufficiently Active	100

Table 6.2 Overall FMS (0-90) and percentage of time spent in MVPA for each tertile. Data represent mean ± SD.

n = 178

	FMS Tertile		
	Low Tertile	Medium Tertile	High Tertile
Overall FMS	34.0 ± 8.5	52.7 ± 4.3	67.5 ± 5.7
PA levels (Percentage of time in MVPA weekdays)	1.87 ± 0.17	2.31 ± 0.14	3.10 ± 0.58
PA levels (Percentage of time in MVPA weekend days)	0.23 ± 0.10	0.52 ± 0.08	0.85 ± 0.17

Table 6.3 FMS competency score of the 12 FMS. Data represent mean ± SD

	Locomotive FMS (0-52 is possible)			Object Control FMS (0-38 possible)		
	All participants (n = 178)	Boys (n = 97)	Girls (n = 81)	All participants (n = 178)	Boys (n = 97)	Girls (n = 81)
Run	7.3 ± 1.2	7.2 ± 1.4	7.4 ± 1.1			
Gallop	4.0 ± 2.3	3.8 ± 2.5	4.3± 2.0			
Hop*	3.2 ± 2.4	2.8 ± 2.5	3.7 ± 2.3			
Leap*	2.7 ± 1.8	2.5 ± 1.8	3.1 ± 1.8			
Jump	4.8 ± 2.1	4.8 ± 2.3	5.0 ± 1.8			
Skip*	3.2 ± 2.3	2.6 ± 2.1	4.0 ± 2.4			
Slide	6.0 ± 2.1	5.8 ± 2.3	6.4 ± 2.0			
Strike				4.6 ± 2.0	4.7 ± 2.1	4.5 ± 1.9
Bounce				3.2 ± 1.6	3.3 ± 1.7	3.0 ± 1.6
Catch				4.7 ± 1.7	4.7 ± 1.7	4.8 ± 1.8
Kick*				4.2 ± 1.9	4.6 ± 1.8	3.8 ± 1.9
Throw				3.4 ± 1.9	3.6 ± 1.9	3.1 ± 1.9

*Denotes a significant difference between the girls and boys FMS scores ($P < 0.05$) (one tailed)

Table 6.4 FMS competency score for locomotive, object control and total FMS. Data represent mean ± SD

Locomotive FMS			*Object Control FMS			Total FMS		
All (n = 178)	Boys (n= 97)	Girls (n = 81)	All (n = 178)	Boys (n= 97)	Girls (n = 81)	All (n = 178)	Boys (n= 97)	Girls (n= 81)
31.5 ± 10.4	29.3 ± 10.5	34.2 ± 9.7	20.2 ± 6.1	20.8 ± 6.3	19.4 ± 5.9	51.7 ± 15.1	50.2 ± 15.5	53.5 ± 14.6

*Denotes a significant difference between the girls and boys FMS scores (P< 0.05) (one tailed)

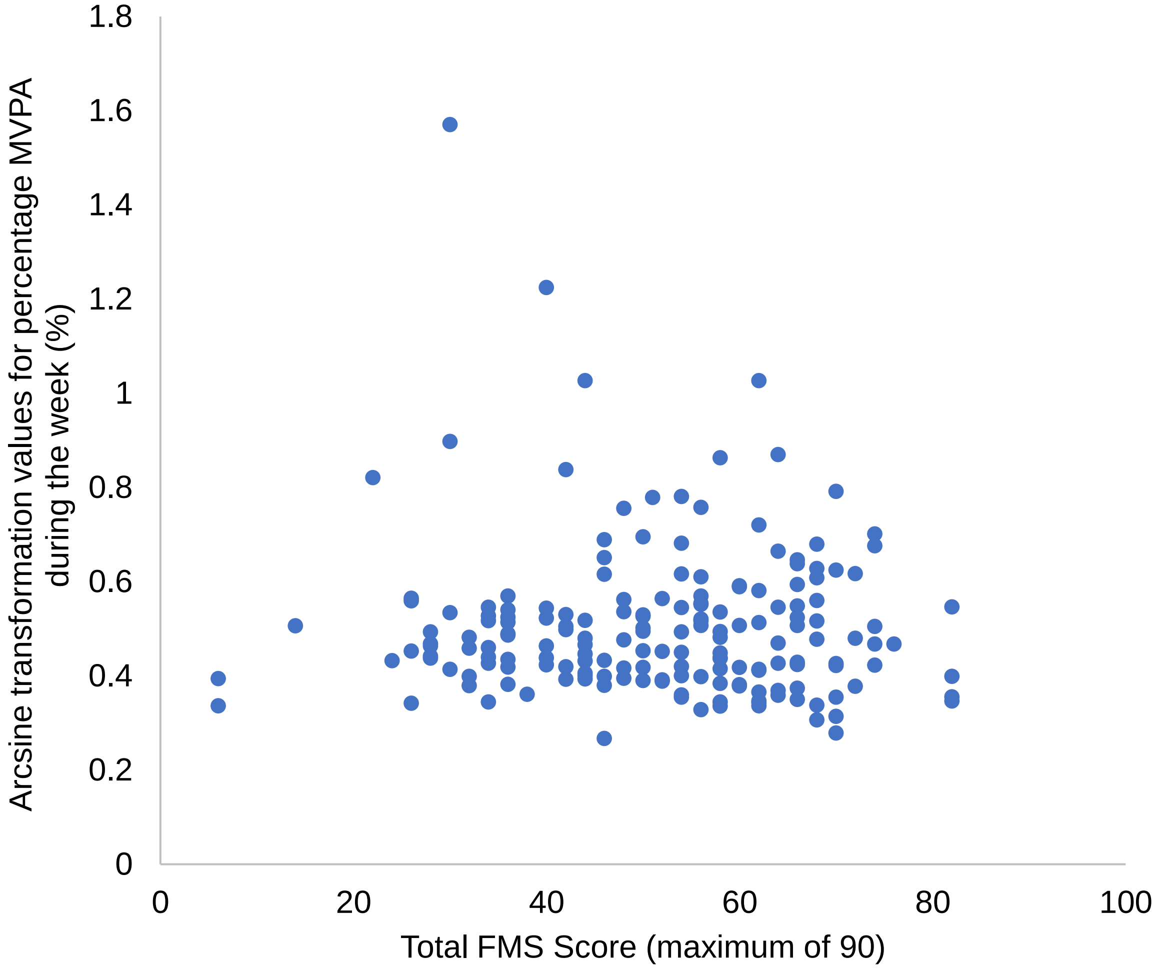

Figure 6.1 Total FMS score against the arcsine transformation values for mean percentage MVPA during the week days

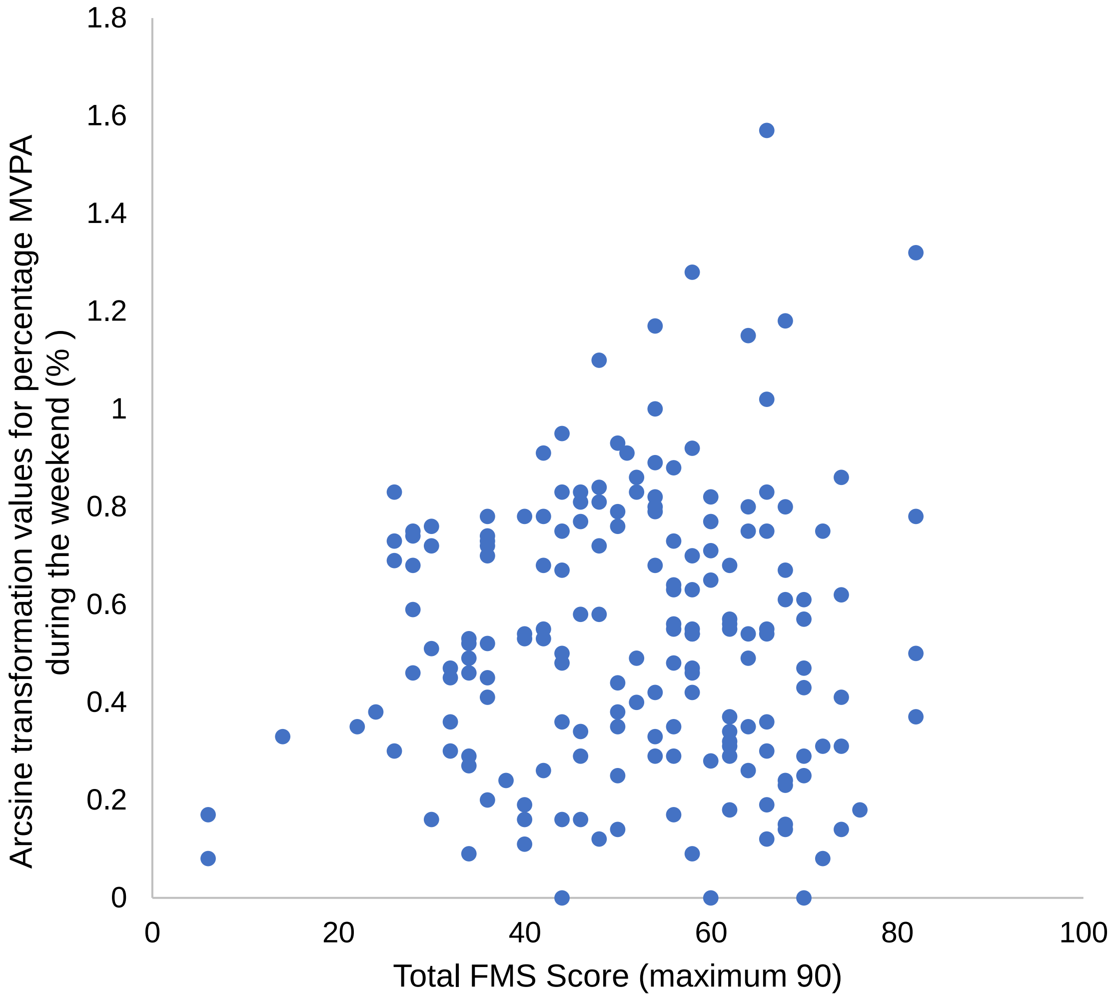

Figure 6.2 Total FMS score against the arcsine transformation values for mean percentage MVPA during the weekend days

6.4 Discussion

The current study sought to assess PA levels, FMS and weight status in preschool children. Knowledge of associations between FMS and PA levels and weight status could be insightful for understanding variation in the development of preschool children and their health (D'Hondt et al. 2013; Williams et al. 2008). The current study discovered that none of the preschool children were considered 'sufficiently active' as none met the UK recommended level of at least 180 mins per day of total PA for health. This is similar to assertions made previously, based on direct observations, that American preschool children tend to be sedentary (Pate et al. 2008). This is further supported by UK based studies that found that preschool children did not accumulate sufficient PA for health benefits (O'Dwyer et al. 2012; O'Dwyer et al. 2013), with very few preschool children accumulating even 60 min MVPA (O'Dwyer et al. 2011). Conversely, Foweather et al. (2015) reported that 86% of their sample met the recommended PA guidelines (Department of Health 2011a). This study similarly observed 3-5-year-old children from a deprived area, however they were from a large urban city in the Northwest of England and their sample size was slightly higher at 240 children. The geographical location and sample size may have resulted in differences between Foweather et al. (2015) and this current study.

The current study extends understanding in this area, as it is the first study to examine differences in PA, BMI and WC, between children, as a function of motor competency. This study also helped to test Stodden and colleagues (2008) model as the measurements used in this present study were appropriate to test the assertions of the Stodden model. Motor competency of the preschool children was established via tertiles as low, medium or high. The key finding of this study is that there are no significant differences in PA level, BMI or WC, between preschool children classified as low, medium or high for locomotive, object control or total FMS. These findings are not necessarily unexpected, as the Stodden, Goodway, and Langendorfer (2008) model acknowledges that the association between motor competency and PA, which leads to a healthy weight, differs in the developmental stage from that evidenced in older children. In early childhood (preschool years) the strength of the association is weak, and children demonstrate variable levels of motor skill competence and PA that are weakly related. Therefore, the results of the present study align with this assertion by Stodden, Goodway, and Langendorfer (2008) as there was no correlation between FMS and MVPA during week or weekend days. The importance of preschool children receiving further practice and instruction to reach mature patterns of movement required for primary school is further highlighted by the present study, to ensure they gain FMS competency and further research would be valuable to determine whether this then results in greater PA levels and improved weight status (Foulkes et al. 2015). Perhaps participation by only children from one deprived area, resulted in the sample in the current study being too homogenous in terms of motor competence, for a relationship between overall FMS and PA levels. That said, the participants in this study had a total FMS score ranging from 6-82, with a mean total FMS score of 52 out of 90. The range of FMS scores would suggest that the participants in this study were broadly representative of low, medium and high FMS competency.

Seefeldt (1980) proposed a model of hierarchical order of motor skills development, which includes four levels: reflexes, fundamental motor skills, transitional motor skills (FMS performed in a variety of ways which are required to participate in entry-level sports. For example, throwing for accuracy), and specific sport skills and dances; if transitional motor skills are improved then children should have the ability to master complex motor skills. Progression through the levels occurs due to development in terms of growth, maturation and experience. Seefeldt (1980) hypothesised that a “proficiency barrier” exists between the fundamental and transitional levels of motor skill development, in early childhood. They suggested that children who can achieve competency above the proficiency barrier will continue to engage in PA throughout their life, and those who do not exceed the proficiency barrier are less likely to remain physically active. An advantage of Seefeldt’s (1980) “proficiency barrier” hypothesis is that it recognises that there may not be a liner relationship between motor competence and PA, rather that PA is influenced when a specific level of motor competence is not achieved, and below the proficiency barrier there will be considerable difference in children’s motor competence and engagement in PA. If this is the case, then the children in this study who are in the higher centile for FMS competency will be more active throughout their lifespan. This differs slightly to Stodden, Goodway, and Langendorfer (2008) as they believe that the relationship between motor competency and PA is a dynamic process that changes over time, and that motor skill development promotes engagement in PA, therefore, representing a reciprocal relationship. As previously mentioned this reciprocal relationship is weak in early childhood such that motor skill competency, as seen in this study, will not strongly influence PA

(Stodden, Goodway, and Langendorfer 2008). This hypothesis is supported due to the reported low to moderate correlations between motor skill competency and PA previously reported in preschool children (Cliff et al. 2009a; Sääkslahti et al. 1999; Williams et al. 2008).

Stodden, Goodway, and Langendorfer (2008) believed that as children age those with intermediate to high levels of motor competence and greater PA levels will demonstrate higher performance scores (FMS). The conceptual model created by Stodden, Goodway, and Langendorfer (2008) asserts that children with less developed FMS will enter a negative spiral of disengagement, by which they will potentially develop lower levels of PA and therefore have a greater chance of becoming obese during later childhood and into adulthood. These children with lower FMS competency link to Seefeldt's (1980) proficiency barrier, in that they have not reached a certain level of maturity/competency, therefore they will not continue to engage in PA and they are less likely to remain physically active. Equally, the inability to reach the proficiency barrier could be linked to a lack of practice in the preschool children. In this study, there were no significant differences between those children possessing lower or greater developed FMS skills, in their PA or weight status. However, Stodden and colleagues' model (2008) would suggest that interventions should be used to ensure that preschool children's FMS remains as highly developed as possible to prevent their PA levels decreasing and them becoming obese as they progress into adulthood.

The current study demonstrated that there was no significant difference in BMI and WC when the preschool children were split by FMS competence; this contradicts a vast array of literature. Goodway and Suminski (2003) stated that overweight children, due to their increased mass have greater difficulty when performing motor skills, especially locomotor skills. Therefore, higher mass results in lower motor competence (Stodden, Goodway, and Langendorfer 2008) and they are less likely to be physically active (Berkey et al. 2003). The Stodden, Goodway, and Langendorfer (2008) model demonstrates a dynamic and reciprocal relationship between obesity and PA, motor skill competence, perceived motor competence and physical fitness. This model proposes that as a child enters middle childhood their perceived motor skills competency starts to change as they compare themselves to their peers (Stodden, Goodway, and Langendorfer 2008). A less competent child will possess lower perceived competency and this in middle childhood reflects their actual motor competency, unlike early childhood, such that these children will then start to opt out of PA and enter a negative spiral of disengagement in PA, whereby motor skill competence, physical fitness and PA are all low, leading to increased weight and obesity. Over time the aim is to counteract this and gain a positive spiral, with all factors being increased, with the aim of promoting a healthy weight status. Therefore, interventions increasing motor skill competence could be essential in promoting a heathy weight status for preschool children.

The current data shows that a substantial proportion of each day is spent in sedentary behaviour in British preschool children. This may explain the lack of any significant differences in PA levels between tertiles of FMS competency, as the majority of the participants in this study participated in sedentary behaviour (545 ± 85 mins and 94.2 ± 2.8%) on both the week and weekend days (overall PA). If there was more variability across the sample in how much time was spent in MVPA, possibly via the use of a different sample of children or through a specific intervention, then there is the possibility that significant differences in PA levels and weight status between tertiles of FMS competency occur; this therefore requires further investigation.

This study was novel as it looked for a link between weight status and FMS in a specific population of preschool children, from a deprived area in the UK. The study was unique in that it used objective PA monitoring using specific cut-points calibrated for use with preschool children in a UK sample. No significant relationship between FMS competency and the percentage of time spent in sedentary, light, moderate or vigorous PA was reported in the current study. Significant relationships have been reported between FMS and PA in older children (Barnett et al. 2009). However, studies that have examined the preschool age group, similarly report no association, or a weak relationship (Fisher et al. 2005; Okely, Booth, and Patterson 2001), with variation in FMS proficiency, only explaining 3% of the variation in PA levels in preschool children (Okely, Booth, and Patterson 2001). These findings are likely related to the age of the preschool children and because PA and FMS may not be fully established and consequently not strongly linked at the ages of 3-4 years. Minimal studies have investigated the relationship between FMS and PA in preschool children and further studies are needed to support this assertion.

The girls in the present study, were predominantly better at the locomotor skills, which are associated with more coordinated movements; such a suggestion is congruent with prior research (Cliff et al. 2009a). The boys were predominantly better at the object control skills, which is also consistent with existing literature (Foweather et al. 2015). Gender differences during the preschool years can not solely be explained by biological factors, as socialisation can explain variations between genders in FMS competency, due to different levels of practice of skills (Hardy et al. 2010a). When promoting PA during preschool time, staff need to be aware that girls' overall PA level may be more affected by each other and the environment they are in, when compared to the boys (Olesen et al. 2014). This highlights the necessity for a variety of more structured activities, to be promoted for the girls throughout the preschool day. Research by Bryant, Duncan, and Birch (2014) supported the findings of the present study, as they reported primary school aged boys to be significantly better at kicking and girls significantly better at balancing and jumping. FMS competency is linked with children spending significantly more time in MVPA and less time in sedentary behaviours (Williams et al. 2008; Wrotniak et al. 2006); therefore, supporting future interventions to improve competency of a variety of FMS, to ensure preschool children are physically active and develop/maintain a healthy weight status.

The running, sliding and jumping skills were performed with more competency than other FMS skills. This may be because they are performed on a regular basis and the children are familiar with these. Running does involve a 'brief period where both feet are off the ground' (Ulrich 2000), however, this is minimal exertion when compared to the leap, where the child needs to 'take off on one foot and land on the opposite' (Ulrich 2000), or hopping which requires the 'foot of the non-support leg [to be] bent and carried in back of the body, [whilst] the non-support leg swings in a pendular fashion to produce force' (Ulrich 2000). It would be appropriate to ensure there are increased activities that further promote competency of all FMS skills in preschools. It was reported that there was no correlation between the FMS subsets of locomotor and object control FMS and MVPA during week day and weekend days. Equally there was no correlation between these FMS subsets and BMI and WC. This could be supporting Stodden, Goodway, and Langendorfer's (2008) model which acknowledged that the association between motor competency and PA, differs in the developmental stage from that evidenced in older children. As previously mentioned, the importance of preschool children receiving further practice and instruction to reach mature patterns of movement required for primary school is essential. This would ensure they gain FMS competency and future research could identify if this then results in greater PA levels and improved weight status (Foulkes et al. 2015).

6.4.1 Practical Considerations

Using wrist worn accelerometers can be logistically and practically challenging with preschool children (Cliff et al. 2009a), where the accelerometer can sometimes be regarded as uncomfortable or an annoyance when worn for long periods of time. However, in the current study, although a cut-off of 6 hours per day was employed for inclusion in the data analysis, generally the participants far exceeded this value with mean wear times being over 600min/day for both weekdays and weekends

(696 min for weekend day's vs 692 min for weekdays). In the case of the present study, we took this to be indicative that the children in this study were comfortable wearing the accelerometers.

Although the current study successfully used accelerometry as an objective monitoring tool in preschool children, some limitations should also be considered. The preschool children that were monitored were drawn from a deprived part of the UK. This may have resulted in differences in PA levels and FMS competency rate in the study compared to an area of higher SES in the UK and research comparing both high and low SES groups would be welcome. That said, the focus on low SES children in the present study is important as these children face greater barriers to becoming physically active and in older age groups it is the low SES individuals that have higher rates of obesity and associated comorbidities (NOO 2014). Understanding the levels of PA and FMS in this group of preschool children is therefore useful in planning early intervention to improve future health. A further limitation in this study design was that none of the preschool children met the UK recommended PA guidelines, therefore, there was no differentiation in their PA levels. Further research is needed to see if this is a true reflection of preschool children from an area of low SES and whether these findings can be truly reflective of this population. It could be suggested that the preschool children in this study were mainly of a healthy weight status and not enough overweight/obese children made up the sample, this may have affected the outcomes of this study.

6.5 Conclusions

The current study assessed PA levels, FMS and weight status in preschool children from a deprived area in the UK. The results of this study suggest that none of the preschool children in this sample achieved the UK recommended guidelines of PA for health. There were no significant differences in the level of PA or weight status between tertiles of FMS competency. This information suggests that at the preschool age FMS does not influence PA or weight status in this group of preschool children from an UK area of low SES. This is potentially because PA and FMS may not be fully established and consequently not strongly linked at the ages of 3-4 years in this sample. Further investigation with children, using a FMS and PA intervention, would help to see if with increased FMS competency a relationship does form between FMS competency and PA levels and/or weight status. This would allow analysis of whether those children in a higher FMS competency group will have higher PA levels.

Thesis Study Map: Study Four

<table>
<tr><td>Study</td><td>Objectives</td></tr>
<tr><td>Study One: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children PA.</td><td>Objectives: To determine GENEActiv calibration cut-points for the accelerometers when worn at the non-dominant and dominant wrist, of children aged 4-5 years (preschool children), for assessment of the intensity of preschool children’s PA.

Key Findings:
Cut points were developed for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years.
The newly developed cut-points, were lower than, but broadly comparable to the cut-points previously validated in 8-14 year olds.
The cut points for GENEActiv accelerometers when worn at the non-dominant and dominant wrist for pre-schoolers (4-5-year olds) are the following: Sedentary (non-dominant: <5.3; dominant:<8.1), light (non-dominant: 5.3-8.6; dominant: 8.1-9.3) and moderate and above (dominant: >8.6; dominant: >9.3).
These cut-points have the potential to be used in future research with preschool children to help increase their compliance rates with PA.</td></tr>
<tr><td>Study Two: Accelerometer based physical activity levels differ between week and weekend days in British preschool children.</td><td>Objectives: To determine the intensity and duration of PA levels during the week and weekend days, in preschool children from a deprived area.

Key Findings:

One of the first studies to objectively compare PA levels between weekdays and weekend days in preschool children in the UK, from deprived areas in the UK.
None of the preschool children in this sample achieved the UK recommended guidelines of PA for health.
Preschool children participate in more MVPA during the weekdays, when compared to the weekend days; however, participation in MVPA is minimal for both days.
This study’s findings can help to promote future interventions which focus on enhancing PA and encouraging participation in MVPA in both the week and weekend days to improve physical development and a healthy weight status in preschool children.</td></tr>
<tr><td>Study Three: Accelerometer based physical activity levels and fundamental movement skills in British preschool children.</td><td>Objectives: To investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low socioeconomic status.

Key findings:
None of the preschool children in this sample achieved the UK recommended guidelines of PA for health.
There were no significant differences in the level of PA or weight status between tertiles of FMS competency.
Findings suggest, that at preschool age, FMS is not associated with PA or weight status in preschool children from an area of low socioeconomic status.
These findings are potentially because PA and FMS may not be fully established and consequently not strongly linked at the ages of 3-4 years.</td></tr>
<tr><td>Study Four: Preschool staff and parents’ perceptions of preschool children’s physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.</td><td>Objectives: To investigate preschool staff and parents’ perceptions of preschool children’s PA and FMS, from a qualitative perspective, considering the environment, facilities, play, socio-economic status and barriers to PA.</td></tr>
</table>

Chapter 7

Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study

7.1 Introduction

Understanding barriers and opportunities to PA in preschool children, in their preschool environment and at home is essential, in terms of their current and future health.

7.1.1 What is the daily recommended physical activity a preschool child should participate in?

Preschool children should engage in at least 180 minutes of moderate to vigorous physical activity (MVPA) per day, through challenging indoor or outdoor activities, to facilitate motor development (NASPE, 2009; Reilly et al. 2012). Preschool children should minimise extended sedentary periods of time, to improve cardiovascular health and contribute to a healthy weight (Department of Health 2011a). Of children aged between 2-4 years in England, only 9% of boys and 10% of girls meet the UK recommended 180 minutes of MVPA per day (Health and Social Care Information Centre 2012). In England, there is a growing number of children attending preschools due to the government allocating 15 hours for 38 weeks, for all 3 year olds (Institute for Fiscal Studies 2014); placing emphasis on preschools to impact on the PA of their preschool children. Preschool children with parents who have a low SES background and a high body mass index, are also at a greater risk of being overweight/obese (van Stralen et al. 2012).

7.1.2 What factors affect preschool children participating in PA?

PA levels of children vary, partly due to the different characteristics of the preschool setting (Pate et al. 2004) and home setting. Multiple factors determine PA behaviours and these include physiological, psychological, social, environmental and demographic (Giles-Corti et al. 2011). Settings with greater space and more opportunities for outdoor play and PA are required, as a lack of space is a major cause of being overweight for 10-40% of children in developed countries (Blair, Wood, and Sallis 1994). It has since been found that areas of higher greenness were associated with lower odds of increasing BMI (OR: 0.87; 95% CI: 0.79-0.97), suggesting that children should get outside and engage in healthy behaviours as one way of combating childhood obesity (Bell, Wilson, and Liu 2008). Spacious environments should be part of a preschool's layout as this could be influential in promoting PA in the form of independent mobility (Boldemann et al. 2006). Therefore, given their influence in shaping the habits/development of preschool children, parents and staff require a greater understanding of the importance of and barriers to PA, and the impact these barriers have on preschool children's health.

It is important to understand staff and parents' perceptions of preschool children's involvement with PA, including their interaction with the environment and consideration of their SES. A qualitative study researched PA in 7-9 year olds and identified the safety of the children being a barrier to PA outdoors, whilst parental constraints relating to the weather and equipment also affected their PA levels (Eyre et al. 2015). Therefore, understanding barriers that exist and prevent preschool children participating in PA in their preschool and home environment, could be influential in helping to inform future interventions around increasing PA levels in preschool children.

7.1.3 Is there a link between FMS and PA?

Good fundamental movement skills (FMS)/motor development, positively influence PA participation (Cliff et al. 2009a) and if opportunities are provided by the environment of the preschool to engage in motor tasks, then motor skill competence will develop (Barnett et al. 2013). Preschool (3-4-year olds) and 8-10-year-old children with better developed motor skills, spend significantly more time in MVPA and vigorous physical activity (VPA) and significantly less time in sedentary behaviours, when compared to children with less developed motor skills (Williams et al. 2008; Wrotniak et al. 2006). Previous FMS are reported as being better predictors of current PA levels in children aged 6-11 years (Bryant, Duncan, and Birch 2014). Therefore, learning and practicing FMS in primary age children will lead to future success in both participation and maintenance of PA (Bryant, Duncan, and Birch 2014). National data on adolescent physical inactivity mirrors the data on early childhood FMS delays (Stodden, Goodway, and Langendorfer 2008), supporting the assumption that different levels of motor skill development in children, may be an influencing factor in being physically active. This appears to suggest that FMS and PA track each other, therefore, understanding how FMS affects preschool children’s daily PA is imperative.

PA and motor development are important, as they both develop in the preschool years and they are precursors for future PA and development of FMS, which are relevant for lifelong daily living and sport specific movements (Gallahue 1982). However, the majority of studies that have examined this issue have taken a quantitative approach, directly measuring preschool children's PA patterns (Jackson et al. 2003; Penpraze et al. 2006; Trost et al. 2000). Whilst this approach is useful, it is of key importance to understand the perceptions and experiences of parents and preschool staff, regarding the PA of preschool children. This is crucial to build the foundations for a physically literate life and to inform future interventions to enhance PA and motor development in this age group. Qualitative data can provide contextual information and at the same time a rich insight into human behaviour (Guba and Lincoln 1994).

To the author's knowledge, no study to date has provided such information on preschool children from a deprived area of England. Therefore, the aim of this study is to investigate preschool staff and parents' perceptions of preschool children's PA and FMS, from a qualitative perspective, considering the environment, facilities, play, SES and barriers to PA.

7.2 Method

7.2.1 Study design

Research was approached with an interpretivist qualitative study design that included semi-structured focus group interviews. An interpretivist approach aims to understand the actions and perceptions of individuals through their own view and in their own social context (Bryman, Teevan, Bell 2009). Given the goal of this study, this lens was ideal as it allowed for the examination of the participants experiences and perceptions of PA in preschool children (Brydges, Denton, Agarwal 2016). This approach ensures that appropriate dialogue between the researchers and participants occurs to collaboratively construct a meaningful reality.

7.2.2 Participants

Following institutional ethics approval and informed consent (appendix 7), a purposive sample of parents and staff of 2-4-year-old preschool children attending four of the 11 preschools used in Chapter 5 and 6, who were from different part-time and full-time nurseries/pre-schools in North Warwickshire, England, participated in this study (n = 17, this consisted of: staff = 7, parents = 10). North Warwickshire was chosen as it incorporates preschools in areas that are considered to have the highest levels of socio-economic deprivation in the County. The focus groups consisted of four to five in each group. They were homogenous in terms of gender (all female), socioeconomic background and predominately ethnic background (16 = Caucasian, 1 = South Asian). The characteristics of the focus group, were representative of the parents and workers at the preschools. Morgan

(1988) stated that the goal is to have a homogenous group in background, yet not in attitude. As homogeneous groups know each other, there is the hope they are more comfortable to be open with each other. Within Warwickshire, there are nine Super Output Areas (SOA) that are in the top 10% of the most deprived in England (Warwickshire Government 2010); the preschools used in this study were all in such an SOA.

7.2.3 Instrument

Data for the study was collected via semi-structured focus group interviews. Focus groups are important due to promoting interaction between participants; they allow individuals to explore and clarify their views efficiently (Kitzinger 1995). They facilitate discussion on a topic through the application of clearly formulated questions (Stewart and Shamdasani 1990). These were used to gain an in-depth understanding of preschool children's PA levels, both in the preschools and at home. Each focus group consisted of four or five participants, as recommended by King and Horrocks (2010), with each focus group containing a mixture of staff and parents. The focus groups were heterogeneous in their nature, as they were mixed with parents and staff, yet homogeneous in terms of the participant's gender, socioeconomic background and the predominant ethnic background. This was to enable both parents and staff to voice their views and to also allow them to interact, to further the focus group discussions. Focus groups were chosen as they provide a more naturalistic data collection method in comparison to questionnaires and interviews (Wilkinson 2004). They are advantageous as they allow participants the opportunity to contribute answers based on other people's responses; this can promote free flow of a discussion and allow the language and responses of participants to be heard (Wilkinson 2004).

7.2.4 Researchers

The focus group interviews were conducted by a single trained interviewer (the first author). The interviewer has previous experience of conducting qualitative research, has a background in PA promotion and sport and exercise science. The interviewer has been involved with preschool children, staff and parents for 8 years and she is a mother of two children (one who was preschool age at the time the interviews were conducted).

7.2.5 Procedures

Six main topic areas were used in the focus groups for questioning parents and staff, they were: 1) knowledge, beliefs and sources of PA; 2) knowledge and beliefs about obesity; 3) knowledge of the environment and facilities for PA; 4) barriers and facilitators to preschool children's PA; 5) knowledge and beliefs of FMS linked with PA; and 6) staff training on PA. The topic areas and questions (see Appendix 8) were adapted primarily from Pate et al. (2013) and their views of research questions related to PA in preschool children. Pate et al. (2013) suggested that these questions/topic areas will allow practitioners to gain information to provide a more robust understanding of PA and its health implications for preschool children; whilst supplying knowledge to inform what effective strategies could be implemented to ensure preschool children are provided with appropriate PA to keep them healthy. The questions asked were open ended to allow for greater depth in the responses. The chosen topics were important, because they covered a variety of areas previously shown to influence PA. This approach allowed the participants to freely discuss PA levels of the preschool children. Given the importance surrounding obesity prevention through PA in preschools, it was important to examine staff and parents' knowledge and beliefs about obesity/fatness. Such information is key in targeting future interventions and ensuring any approaches taken to increase PA or reduce unhealthy weight are viable.

The interviews were conducted, during preschool hours, in the preschool settings that staff and parents were connected with. Familiar settings provide comfort and are beneficial for focus group data collection methods (King and Horrocks 2010). The interviews lasted between 45 and 65 minutes per group in accordance with the maximum two hours as stated by Krueger and Casey (2009). This time window was sufficient for conversations to occur and for the participants to be engaged and not lose concentration.

The researcher in this study maximised trustworthiness of the data through various means, one of them involving ensuring the credibility of the data. Credibility is stated as contributing towards the belief in trustworthiness of data through prolonged engagement, persistent observations and triangulation (De Vault 2017), all of which were performed in this study. Triangulation was achieved by asking the same questions of different participants, collecting data from different sources and using different methods to answer research questions (De Vault 2017). This study used a purposive sample, which was beneficial in that specific and varied information was maximised, in relation to the perspective in which the data was collected. In relation to maximising trustworthiness, the process of refining the data is crucial and must be systematically performed. The data was organised into themes according to similar attributes, and then into further sub-themes. This process involved taking notes about the emerging patterns associated with the themes. This process was essential and required the main researcher to be attentive to the data and tentative in their conceptualisation of the themes (Dey 1993).

7.2.6 Analysis of qualitative data

The focus groups were digitally recorded (Olympus DS-2400, digital voice recorder, Beijing, China), anonymised and transcribed verbatim. A facilitator verified the transcripts; this person was additional to the person interviewing/analysing. This took the form of using two analysts to review the recordings and compare their findings; this is known as analyst triangulation (Patton 2000). This extra analyst provided an important check in terms of selective attention and blind interpretative bias, whilst ensuring the verification and validation of qualitative analysis (Patton 2000). The data from the focus group interviews were analysed using thematic analysis, where patterns within the sample were found, according to guidelines proposed by Braun and Clarke (2006). Thematic analysis is a widely used mechanism which is used to identify, analyse and report patterns within qualitative data; it is considered to reflect reality and determine themes (Braun and Clarke 2006), allowing key themes and subthemes to be identified from the transcripts. The results reported were agreed by all analysers. This takes the view of a phenomenological approach which focuses on the personal knowledge and subjectivity of an individual, whilst emphasising the importance of personal perspective and interpretation (Lester 1999).

7.3 Results and Discussion

This study has provided a qualitative overview of perceptions of environmental influences on PA and the development of FMS of preschool children, from the view of both parents and preschool staff. No study, to date, appears to have done this and as such, the current study makes a novel contribution to the literature. The use of a qualitative approach was significant as it explored the thoughts and actions of the parents and preschool staff and importantly the reasons for these behaviours. Such a standpoint appears to have been neglected in the literature relating to the facilitators and barriers to PA in children in the early years. The study aimed to consider the environment, facilities, play, and barriers to PA and FMS development.

Results are presented in relation to each of the six main topic areas and quotes are referenced as the individual setting identified by Se, followed by the preschool staff and parents as S and P, respectively. The main themes from the focus group interviews were related to promoting PA and FMS development, and they were: the outdoor environment is influential, time and cost are a barrier for parents, more parental involvement is required and staff training on how to implement PA and FMS in preschool settings is needed.

7.3 1 Knowledge, beliefs and sources of PA

Participants' knowledge of PA and their beliefs and opinions of PA can be seen in Table 7.1.

7.3.1.1 What is PA?

Regardless of the setting all parents and staff had a good knowledge of PA. The results highlight that both parents and preschool staff had a good understanding of PA, as they linked it to movement, an increased heart rate and the outdoors. The emerging themes all related to movement, where running, jumping, using the tricycles and the outdoor space were all mentioned. Participants reported that '*PA is anything that increases heart rate, for example running'* (Se1, S1; Se2, S1).

7.3.1.2 What are the benefits of PA?

There were numerous benefits of PA that were mentioned, and these were categorised under physiological, psychological and sociable (Table 7.1). That said, the main benefits of PA were associated with the physiological and psychological changes as PA was viewed as 'burning fat and energy' and it makes the children 'physically better'. However, the physiological benefits of burning energy, were continuously linked with the psychological benefits of the preschool children having 'better concentration' levels, being 'more attentive' and generally 'more focused'.

Table 7.1 Knowledge, beliefs and sources of PA, individual settings are identified first as Se, followed by staff and parents as S and P respectively

Benefits of PA		
Physiological	Weight loss	*'PA helps to burn off fat, it prevents the children from being overweight'* (Se1, S1).
		'PA involves movement, it generally happens outside for example running and jumping. I believe PA helps to keep [child's name] at a healthy weight' (Se1, P1).
		'[Childs name] plays football, rugby and swims, he keeps himself very active, I believe this is essential in ensuring he keeps healthy and doesn't get too big' (Se2, P2).
	Burn energy	*'PA is beneficial as the children burn energy and they are then less wild'* (Se1, S2).
		'Uses up a lot of excess energy, wears them out, it tires them out' (Se3, P1).
	Outside environment	'*They are calmer if they have had opportunities for exercise outside. Then calmer and more attentive, as they have burned off their energy'* (Se2, P1).
		'*Calmer when they come back inside, it helps with their learning'* (Se4, S1).
		'*Tires them out, when been on the climbing frame due to their movement'* (Se3, S2).
Psychological	Concentration/ Focused	'*When been on the climbing frame and go back inside they are more focused'* (Se3, S2).
	Happy	'*PA makes them happy and tires them out*' (Se2, P3).

	Behaviour	'*They burn off energy; get fresh air and it affects their behaviour as it makes them behave better*' (Se2, P3). '*They burn off excess energy, which improves behaviour. You see a difference if they did not get the activity'* (Se4, S2). Behaviour and concentration was viewed as reliant on the burning of energy (physiological), therefore the physiological and psychological benefits were synonymous with PA participation.
	Outside environment	'*Calmer when they come back inside'* (Se4, S1). '*They are calmer if they have had opportunities for exercise outside…calmer and more attentive'* (Se2, P1).
Sociable	Meet other children	'*PA allows children to meet each other…they become socially better'* (Se2, P1).

7.3.1.3 Perceptions of Play

Play was seen as key to contributing to PA by both parents and staff. 'Play' was described as '*being physical*' (Se1, S2), participating in '*anything that the children enjoy and is fun, like jumping and role play'* (Se2, P3), it '*could involve anything from doing a jigsaw to being imaginative super heroes*' (Se1, S1). This supports Pellegrini (2009) who described play as something a child engages in voluntarily and that it can be a social, locomotor, fantasy or object directed PA which is considered not directionally functional. Play was summarised as '*learning through mainly outdoor activities like playing on climbing frames and running around*' (Se4, S2). '*Our* *children do a drama group, this also promotes play as they tend to be giants and very physical, this is where play and PA interlink*' (Se1, S1). This supports work by Hesketh, Lakshman, and van Sluijs (2017), as they stated that play and PA are used interchangeably. It was added that '*children don't view PA and play as different, which is positive, as children just exercise and enjoy it, whereas adults sometimes see it as a chore'* (Se2, P3). '*When outside the children are actively moving around and pretending to be different characters*' (Se3, S2), '*they never sit down, a game always evolves someway, whether it is playing aeroplanes or running around'* (Se4, S1). The outdoor environment was viewed as the main instigator in allowing play to occur, which in accordance with the parents and staff' opinions, is also where PA is primarily initiated. Parents and staff felt that the preschool children play for '*the majority of the day'* (Se1, P1), '*they never stop*' (Se2, P2). With most participants acknowledging that '*play occurs most of the time, apart from food and stories'* (Se1, P2), potentially '*75% of the time'* (Se1, S1). This was a similar perspective shared by parents in a study conducted by De Craemer et al. (2013), where low SES parents compared to high SES, reported their preschool children as active and not needing any further activity in their days and they believed children should not be involved in too much organised PA, to ensure they have time for sufficient rest.

7.3.1.4 What/who are the key sources of PA in the children?

Parents and staff are key sources of PA for preschool children, with childcare settings being a strong predictor of PA levels (Pate et al. 2008). Participants from three of the settings agreed that both parents and preschool staff are the key sources of PA. One participant stated, '*it depends on how much time the child* *spends in a care setting, for example if most of their time is in nursery, then nursery should be responsible'* (Se3, P2). One participant stated the responsibility lies with the '*parents as they [preschool children] are at home more*' (Se2, P2). This was further supported as it was felt that '*parents did have a responsibility as well when they are with their child'* (Se3, S1; Se3, S2). Therefore, the role of the parents needs to be considered when designing interventions associated with PA for preschool children. Parents' need to be educated, informed and involved in promoting PA to their preschool children (De Craemer et al. 2013), especially as parents are considered to have the largest influence on their preschool child's PA behaviours as children observe and imitate significant others (Berge et al. 2010; Gustafson and Rhodes 2006; Walsh et al. 2017). A different view point was that one participant felt that her '*son instigates it [PA] and then as the parent I follow it. If it's a day when really wet and not able to get outside, then I know about it!*' (Se3, P1). This is implying that the outdoor environment is a key contributor to promoting PA for preschool children.

7.3.2 Knowledge and beliefs about obesity

Obesity was viewed as important by both parents and staff and they implicitly linked a lack of PA with obesity. Participants' believed preschool children become obese due to '*sitting on their backsides, playing computer games*' (Se2, P3), '*participating in sluggish behaviour*' (Se2, P1) and '*parents giving them process foods…to keep them quiet*' (Se2, S1), this was stated as being evidenced through the preschool children's lunch boxes, staff members own opinions and through links with media coverage (Table 7.2). Preschool children's' lifestyle, whether that is the past times they participate in or the foods they eat, both influence their weight status and potential to become obese. This was supported by Larson et al. (2011) who completed a review and identified that a lack of strong regulations in childcare settings exist in relation to PA and diet.

Participants' opinions of obese children were, it is '*not nice to see*' (Se1, S2), '*I feel sorry for the child*' (Se2, P3), '*it can be a negative judgemental view and opinion of them being fat*' (Se4, S2), '*it is not an opinion of the child…a judgement of the parents*' (Se2, P1), '*sometimes we take things for granted and others may not be able to be healthy*' (Se1, P1), we '*cannot judge as we do not know if the parents have money to buy healthy foods'* (Se1, S1). '*Personally, I feel if the parents are overweight then they are not doing the correct things at home regarding eating and PA, then the children see this and think it is normal, this goes to all generations*' (Se3, P2). When discussing what counts as obese, it was mentioned that '*staff do not know the weight of the children, so it's their appearance we go by and those children that are 'more chunky''* (Se1, S1). One setting said '*we have an obese boy, the boy's health is starting to suffer as he struggles to move as easily as the other children'* (Se4, S1), '*children are starting to pick on him, we have informed health visitors'* (Se4, S2). It was added that some participants were '*shocked that some preschool children are obese, I thought their metabolisms are faster. I thought their body's burn junk foods quicker*' (Se3, P3). The participants felt that this was a misconception by society and it was agreed that preschool children also need to participate in regular PA.

All participants stated that preschool children's weight is a responsibility of parents and settings. '*Preschools are not responsible for children's weight, but they are responsible for activities for when they are in settings*' (Se3, P1). '*Some children are only at the setting for 3 hours a day, some days a week*' (Se4, S2). We '*can't control what the children eat and do regarding activity at home and vice versa*' (Se1, S1). Children's weight status and PA levels '*has to involve the home setting as well*' (Se2, P1). '*Preschools are important in providing PA, in terms of time and space to burn off energy, yet they are not solely responsible* (Se2, S1). '*It must be considered that some children at the setting, are only active when in the setting, this informs the planning*' (Se4, S1). '*In the end it sometimes feels that the PA of these children are our responsibility as it is the only exercise they participate in*' (Se4, S2). These comments are crucial, because in respect to the preschool staffs' 'planning', they aim to provide the preschool children with appropriate time and activities for PA; this is helping to ensure they meet the requirements of 180 minutes of PA a day. The preschool environment was identified as the main place, where the majority of preschool children participate in MVPA, and for some children, the only place. The home environment did not appear to promote PA for all preschool children. One parent stated that she is '*tired when I get home from work so I don't always go outside and exercise with my son, sometimes putting the TV on is easier. I do try to exercise with him at the weekend and this does happen more than in the week. I know he exercises at nursery though*' (Se4, P1). This parent feels that her son gains the required PA levels at preschool and therefore she is happy if she does not participate in exercise with him during the week. A further parent stated that '*I use the weekends to catch up on household chores as I work in the week, this can* *prevent my child from being as active as maybe he should'* (Se2, P2). It has been suggested that lower income households have greater access to technology, increasing sedentary behaviour, as opposed to MVPA (Tandon et al. 2012b). Engaging and educating preschool children to eat healthy food and exercise more were the key findings. This emphasises the relevance of preschools maintaining the MVPA levels that they deliver. It also suggests that future interventions with preschool children need to involve parental engagement more (Summerbell et al. 2012), particularly for PA interventions in the home environment and combining this with training the parents to understand FMS and PA levels and to be confident in improving them in their preschool children. This is important as habitual PA is associated with many health benefits in children, with greater health benefits being associated with higher levels of PA (Janssen and LeBlanc 2010). Participants mentioned, '*in deprived areas more walking is needed, yet parents do not…there is the need for more free facilities for children*' (Se2, P3). Also, the involvement of '*family incentive exercise is imperative*' (Se2, P1) and ideally there should be '*more active…and free activities*' (Se2, P1) '*for all of the family*' (Se4, S1). A mixture of free swimming and team activities for all the family were mentioned as ways of improving participation in PA, to prevent obesity for preschool children and their parents.

The suggestions made by the parents and staff regarding changes that can be made to resolve the obesity epidemic all focused on educating and promoting, not just the children but, the whole family to eat healthily and be physically active. The '*family incentive with exercise is imperative*' (Se2, P1; Se, P2), however the cost of family exercise was raised and it was stated that more activities need to be free. The safe walk to nursery and cycle schemes were favourably looked at, however the concern around time to complete these activities was raised by some parents. In relation to 'eating' the incentive for lower income families to receive fresh fruit and vegetable vouchers was commended and so was a 'fat tax', as the aim was this would encourage families to eat healthier. Parents and staff agreed that interventions to prevent obesity were required and these should be a combined effort in terms of promotion from the government, local government and individuals.

Table 7.2 Knowledge and beliefs about obesity, individual settings are identified first as Se, followed by staff and parents as S and P respectively

Reasons preschool children become obese			What can be done to resolve the obesity epidemic
Lifestyle	Lack of exercise	'*Links to an unhealthy lifestyle with no exercise*' (Se3, S2). '*The children are more sedentary'* (Se3, S1).	Keep promoting exercise '*the local swimming centre has been taken over and it is promoting being active 5 times a week*' (Se1, P1).
		'*Children follow their parents, so if they [parents] are overweight and do not exercise, then the children are probably overweight and do not exercise...it is due to a lack of education'* (Se3, P2). '*It is a mixture of lack of exercise, unhealthy*	'*More government exercise campaigns e.g. exercise at least 5 times a week and 180 hours a day for preschool children would be good*' (Se1, S1; Se, P1; Se, P2). '*If people don't visit gyms and swimming pools, would they be aware of some campaigns?*' (Se1, P2). Therefore, publicity not just in sporty places is required.

	eating and parents working' (Se4, S2). '*Parents lifestyles affect children's obesity as parents have to work, they have chores to complete around the house and it is easier to put a child in front of the television as opposed to spend time exercising with them'* (Se1, P2).	Emphasis needs to be on '*engaging the children not eating correctly and not being physically active, yet hard to educate children*' (Se2, S1). '*I would love to mirror what happens in Holland with bikes*' (Se2, P1). '*Family incentive with exercise is imperative*' (Se2, P1; Se, P2). '*We need to be more active and have free activities*' (Se3, S2). '*Exercise should be free for all of the family*' (Se4, S1). '*There is a need to target the parents more as they are the instigators at home*' (Se3, S2).

	Modern lifestyle	'*[Child's name] will play with older siblings on computer games, yet we (parent) try to get him out'* (Se1, P1). '*Some children play x-box and do not go out to play*' (Se3, S1). '*I move children on from computers, as some would spend all day on them'* (Se4, S2). '*Lifestyle plays a part as parents drive to nursery*' (Se2, S1). '*Poor parenting skills*' (Se4, P1). '*Grandparents looking after grandchildren, tend to give more treats'* (Se4, S2).	Safe walk to nursery schemes were considered good. However, '*some people use the nursery as it is on their way to work, therefore, it is very hard to adopt these schemes for all parents and children*' (Se1, S2). Promotion of cycle schemes was seen as a good idea, however they are '*very hard to do as I leave the house at 7.30 a.m. and collect my daughter and home for 5.45p.m., therefore, hard to fit the walking and cycling in every day. When possible I take the dog for a walk and go on nature walks. My husband tried it once and it took 1 hour and 20 minutes to get to nursery and the*

			second child to school, that involved a short cut down the canal, unfortunately cannot do this every day' (Se2, P3).
Foods	Convenience foods	'*Some parents that can't cook*' (Se2, P3). '*Some parents can't be bothered to cook a proper meal*' (Se2, P1). '*Convenience foods are easier to get and cheaper'* (Se1, P1; Se1, P2). '*Due to using frozen foods and convenience meals and not having time and money to cook'* (Se2, P1). '*Preschool is more aware of healthier and nutritious food; give the children*	Having a 'fat tax' '*would be a benefit as it would allow children to eat healthier, as it is dear currently to feed a family*' (Se1, S1). '*Would ensure parents provide a healthy snack for their children when at nursery*' (Se4, S1). '*My children love fresh fruit and vegetables yet £20 gets you a few bits, but lots of junk foods, so making fruits cheaper would be brilliant*' (Se2, P3). '*Don't ban junk foods, because it will have the*

		healthier foods in preschool, yet not happening at home' (Se1, S1). '*I saw a documentary where Mc Donald's add in all additives, so their foods will last for ever, it put me off these foods totally*' (Se1, P2).	*opposite effect and children will rebel*' (Se2, P3). '*A recent incentive for low income families in the nursery where they could pick up a voucher and get fresh fruit and vegetables from a local farm was an excellent idea*' (Se2, P1). '*Fruit is promoted well, but vegetables need to be promoted more*' (Se3, P1).
Genetics	Medical conditions	'*You do not always know if they have any underlying medical conditions*' (Se1, S1). '*Genetics could be important'* (Se1, S2). '*Genetics plays a factor, yet not whole excuse…they have found a gene it could*	*'Children could be screened at birth if certain genetics are known to cause obesity, we would know to definitely exercise with these children or monitor them closely'* (Se1, P1). *'Information of a Childs screening at birth could be shared with nurseries and*

	be related to, but lifestyle 50 years ago was also different' (Se2, P3). '*Could be genetics from my own experience, because I ate the same as my siblings and was as active as them, yet I was always bigger*' (Se3, P3).	*schools if needed? We would then know which children would need to focus on PA more so'* (Se2, S1).

7.3.3. Knowledge of the environment and facilities for PA

The indoor and outdoor space are both important in promoting PA in preschool children, because '*in this country we don't have the weather so the children are active in both environments*' (Se1, P1; Se1 S1) (Table 7.3). However, this was contradicted slightly, as one parent said that '*the outside is very important due to getting fresh air, it is important to get outside in as much weather as possible*' (Se3, P3). De Craemer et al. (2013) reported that the majority of parents cited the weather as the most important factor in determining if their child can play outside or not. These findings could therefore impact on the PA levels that preschool children participate in. Staff at one setting stated that '*free flow for the children happens, they play outside when they want, within a set time, this excludes registration, snack and lunch times*' (Se3, S2). When it came to specifying the facilities and equipment being used in the settings, it was the outdoor space that was always mentioned, with '*the outdoors [being] more important as it is larger*' (Se4, S1; Se4 S2). Parents did infer that when their children are active at home it is always the outside environment that they promote PA in. Parents stated that they are happy for their children '*to be active on trampolines, kicking a football, doing somersaults*' (Se2, P1), however, they do not promote PA of this nature inside '*because it would involve the children breaking something or injuring themselves'* (Se3, P1).

This study highlighted that the outdoors is considered a key environment for PA. This includes the key features of space, within the outdoor environment to run around in and also climbing frames to play on. Studies have noticed that play space has been significantly negatively associated with sedentary activity and positively associated with vigorous activity (Ridgers, Fairclough, and Stratton 2010), and children are more active in spacious areas, compared to restrictive areas (Pellegrini and Smith 1993); with outdoor play being associated with a lower risk of being overweight (Velduis et al. 2012). Similarly, environmental factors that encourage children to be physically active are, living in a rural area (more outdoor space), a playground near to their house, having a garden and living near forest areas for walking, conversely, environmental barriers to children's PA were a television and having large streets that need crossing to access a park (De Craemer et al. 2013). Being outside was considered imperative, as it provides a large area that could be accessed in all weathers; although indoor areas were viewed as important, as the English weather is temperamental.

The present study is key in that it has captured the thoughts of both parents and staff on PA and FMS levels and discovered that they both agree that it is vitally important to improve PA and FMS. They stated that this is achieved primarily through participation in PA and FMS in a spacious outdoor environment, where the preschool children can run around, or in an outdoor area with a climbing frame, in which they can climb and be active. This is supported by Pate et al. (2008) as they stated that being in the outdoors is one of the most powerful correlates of PA in children. Equally, the time a preschool child spends outside has a positive association with PA (Hinkley et al. 2008). The outdoor equipment that was referred to in this current study was climbing frames, bikes and balls;

when compared to the indoors there was more concern for health and safety. Research shows that children engage in vigorous PA when equipment such as balls and jump ropes are provided (Wilenberg et al. 2010). Facilities that were linked with PA and FMS development were the outside area, school fields and playgrounds, with one preschool using an adjacent school hall. The positive influence of preschools as key instigators in promoting preschool children’s PA levels, FMS and health was evident, as all of the preschools promoted PA and FMS through different projects such as daily games, involvement of external companies and staff running ‘Forest School’ sessions.

The staff from a variety of settings stated that in order to see improvements in the preschool children’s PA levels they would ideally like to see the outdoor area extended, the grass area utilised more (Se3) and additional climbing equipment to be added outdoors as well. Similarly, the use of the playground, hallway or dining area have been mentioned as being used to increase children’s PA levels (De Craemer et al. 2013). One setting also stated that if they were trained in football, for example, then they could run sessions and facilitate improvements in PA. This links to previous research, which has identified the importance of providing parents with ideas to utilise their available environmental resources, such as parks more productively, to increase PA levels and allow greater interaction between parents and their preschool children (Hesketh et al. 2014). The key message here is that all suggested improvements regarding equipment and facilities to improve PA, were all centred on the outdoor environment.

Table 7.3 Knowledge of the environment and facilities for PA – promoters of PA, individual settings are identified first as Se, followed by staff and parents as S and P respectively.

Promoters of PA	Currently in settings	How settings could be adapted
Equipment	'*We have a slide, climbing frame and soft area with matting (outside)*' (Se1, S2). '*Bicycles, scooters, trikes*' (Se2, P2). '*Slide, climbing activities*' (Se2, P3). '*Outdoors area for the trikes, climbing area*' (Se3, P1). '*Slides, hoops, bean bags, climbing frame. Shaded area where they can move, yet slower movements happen under there*' (Se4, S2). All of the equipment mentioned in relation to promoting PA was linked with the outdoors.	'*We could have more climbing equipment. Inside more equipment is needed, however we tried soft play inside and it created more accidents as children went over the top of each*' (Se1, S1). '*Extend the outdoor area so the children can use the climbing frame and bikes at the same time*' (Se3, S1).
Facilities	'*The outside area for running, the climbing frame and slide*' (Se1, S1).	'*I would like to extend the outdoor area and use more grass area*' (Se3, S2).

	'*We have room to roam and be active*' (Se1, S2). '*Indoors is not a rigid environment, they do have free play and movement. They are not cooped up and sedentary, they can use building blocks and develop their exercise and motor skills*' (Se2, P3). '*Get to use the school hall on occasions for PE*' (Se3, P1). '*We use the school fields more in the summer*' (Se3, S1). '*We have room to play outdoors. Indoors is a calm area due to 40 children. Door is open so the children are free flowing*' (Se4, S1).	'*Work around the school next door to use the playground more*' (Se3, P2). '*We could use the school fields as we are joined with the schools. They are not used currently due to safety reasons and we do not want a child to walk off*' (Se4, S1).
Projects	'*A company delivers drama one day a week and football one day a week'* (Se1, S1). '*We have participated in sport relief and a sport relief, sponsored bounce*' (Se2, P2). '*The children have been involved with a sponsored walk. June is a be fit and healthy month, this includes sports day, walk to*	'*If we had more training we could run the football*' (Se1, S1).

nursery, even if you park a street away and then walk in as effort made, [cooks name] the cook is sending menus to parents to look at healthy foods at home and how to cook them' (Se2, S1).

'*The children have the opportunity for walks, challenges for PA, paths to follow for balance, games such as chasing, traffic lights, parachute games, duck and goose. Movement opportunities also exist inside for example 'wake up shake up' in the morning, which links to growing and being the seed and growing into trees*' (Se2, S1).

'*Healthy eating week which promotes exercise, sponsored trundle'* (Se3, S1).

'*Forest schools, get to climb, there are 6/7 sessions per child for this, sometimes they get to do the course two times*' (Se3, S2).

'*The 'ladder man' comes in, he uses ladders and children move in and out of the ladders*' (Se4, S2).

PA: Physical Activity PE: Physical Education

7.3.4 Barriers and facilitators to PA

Time, cost, parent's lifestyle, the need for larger outdoor areas, too many barriers inside and health and safety concerns of specific staff, were considered as barriers to PA by all participants (Table 7.4). The impact barriers have on the preschool children is '*when they are not active… the children are crankier and irritated as they have not burnt their energy*' (Se3, P3). Time was identified as a key barrier to PA, as this was associated with parents having busy lifestyles and having little time to dedicate to PA with their children; as supported by numerous studies (Hesketh, Hinkley, and Campbell 2012; Pagnini et al. 2009; Stenhammar et al. 2011). *'Parents have chores to complete, so sometimes the children are put in front of the television*' (Se2, P1); this prevents PA from taking place. This was similar to findings by Hesketh, Lakshman, and van Sluijs (2017) who also reported that parents allowed their children to engage in sedentary behaviours, as this 'downtime' has the benefit of providing them with time to complete chores and 'downtime' was perceived as having some educational value for the preschool children. This would suggest that more detail as to the sedentary behaviour being carried out is required. This is to distinguish between developmentally beneficial (e.g. reading and crafts) and non-beneficial sedentary behaviours (TV viewing) (Hesketh, Lakshman, and van Sluijs 2017). The American Academy of Pediatrics (2016) published guidelines stating that children aged 2-5 years old should be limited to one hour of screen time per day. Potentially, understanding the content of preschool children's sedentary time would be insightful. Although, it is well documented that screen time is a barrier to preschool children's PA levels (Bentley, Turner, and Jago 2016).

Cost was also identified as a barrier, as parents perceived that they needed more money to facilitate PA. '*When the weather is not good, it is costly for swimming, play pits and structured activities*' (Se3, P1). If parents had more disposable income, or if activities were cheaper/free, then parents stated they would promote PA and FMS development more with their preschool children. Equally, more training for parents could be provided to show them how they can be physically active with their children and develop their FMS, without spending any money. In preschool, some settings stated health and safety as an issue, as some staff members are more cautious of the children climbing on slides and being active. This risk aversion is commonly associated with policies around play and the requirements for safe environments that preschool children can be physically active in (van Zandvoort et al. 2010). It would be beneficial if staff could attend training on incorporating the use of the climbing equipment into a preschool child's day; this would promote more MVPA for the preschool children. Training would help some staff to break down the barriers they personally have with the children engaging in activities on the climbing equipment. Parents should also be made aware of the health and safety concerns of staff, as it could be that their child is not as active in the preschool setting as they believe. It was stated by one member of staff, that '*some children prefer to stay inside and not go outside, this is because the child is so active outside of the nursery they 'relax' at nursery*' (Se3, S1). This is positive in terms of this setting feeling that some of their children are active at home, but then a barrier for the setting as they struggle to involve some of the children in PA during preschool time.

Table 7.4 Barriers and facilitators to PA, individual settings are identified first as Se, followed by staff and parents as S and P respectively

	Barriers/Facilitators
Time	Time, was considered a barrier by all participants, as parents have busy lifestyles and need to work, therefore, there is very little time for PA at home.
Cost	A further barrier which was identified by parents was '*cost and the ability to drive to get my son places for exercise*' (Se1, P2).
	Cost was considered a problem because '*when the weather is not good, it is costly for swimming, play pits and structured activities*' (Se3, P1).
Lifestyle	'*Parents have chores to complete, so sometimes the children are put in front of the television*' (Se2, P1), this prevents PA from taking place.
	A preschool child's day was described as, '*some are picked up from nursery at 5.30pm, they are taken home in a car, they have something to eat and then bed; they have no time for being active*' (Se1, S1).
	'*There is a lack of being able to walk a child to nursery*' (Se2, S1), this was attributed to parents having a lack of time for their child to participate in PA.
	When the children '*are not active, potentially due to cost and time, the children are crankier and irritated as they have not burnt their energy*' (Se3, P3).
Outdoor space	'*The outside space could be larger*' (Se1, P1; Se3, P1).
	'*Having a larger outdoor area, would prevent not allowing children on the climbing frame due to health and safety reasons*' (Se3, S1).
Inside space	'*Inside is a barrier due to chairs, so children cannot run around*' (Se1, S1), '*on a safety point we have to stop them running inside*' (Se4, S2).
	'*Some children prefer to stay inside and not go outside, this is because the child is so active outside of the nursery they 'relax' at*

	nursery' (Se3, S1). This is positive in terms of this setting feeling that some of their children are active at home, but then a barrier for the setting as they struggle to involve some children in PA during preschool time.
Health and Safety	The barrier due to health and safety appears to '*depend on the member of staff, as I am happy for them [children] to climb and some staff members get nervous at this*' (Se4, S1), staff interpretation of health and safety can therefore be a key barrier.
Paperwork	We '*have a lot to try and fit in to assess the children*' (Se3, S2). We 'have *a lot more paperwork to complete on the children*' (Se3, S1). Lack of time spent devoted to PA was a problem in some settings as '*staff's time has to be spent devoted to learning as well*' (Se4, S2).

7.3.4.1 Measuring PA and FMS

Opinions differed on how you can measure PA. Responses ranged from 'o*bserving them [preschool children] taking part in running and jumping and how long they do it for*' (Se3, P1), to '*their behaviour, for example they are more conforming and their ability to learn*' (Se2, P1). The majority of the participants felt measuring PA was important, because '*if children are not active then it affects them physically and mentally'* (Se3, P3). It was considered a way of identifying who is obese and not, however, some individuals felt it is only necessary to measure PA if a child is overweight. This identified confusion in the staff and parents' opinions of PA and obesity, as PA is a health-related behaviour which is associated with obesity, not a measure of obesity.

Most parents and staff were supportive of measuring FMS as they felt it was essential in terms of developing PA levels in preschool children (Se1, P2; Se1, S1; Se2, P2; Se3, P1; Se4, S1). Some of the staff expressed interest in having an involvement in developing the children's FMS and PA levels; this was supported with positivity from the parents, as they were happy for the preschool staff to develop their children's FMS and PA levels. One parent did say it '*would take the pressure off of me having to ensure their levels [FMS and PA] were good enough*' (Se3, P1). However, some parents disagreed with measuring PA levels and FMS as they felt that measuring these was '*not really [important] unless my child was obese and I needed to do something about it*' (Se1, P1).

Measurement of FMS was therefore met with a divided opinion, as some participants felt that it was imperative, because if the preschool children are weak at any skills, then staff can practice specific skills and inform parents to work on them. Staff did say that they required more training in identifying the presence or absence of these FMS skills and if this happened, they were extremely willing to develop the skills with the preschool children. Such opinions align well with prior research showing that children with better developed FMS, spend significantly more time in MVPA and VPA and significantly less time in sedentary behaviours (Williams et al. 2008; Wrotniak et al. 2006). Conversely, some individuals felt that there needs to be a balance between testing and children enjoying themselves; they do not want 'over measuring'.

7.3.5 Knowledge of FMS

The participants' definition of motor skills was very good. '*Fine motor skills are manipulation, for example, control of pencil, putting Lego together. Gross or large movements involve coordination of arms and legs [and] being able to kick a ball*' (Se2, P3). The participants defined FMS as involving '*movements like running and jumping, which are fundamental to what the children do on a daily basis*' (Se4, S1; Se4 S2). Staff '*promote gross motor skills probably more so outside, where these can be assessed'* (Se4, S2). It was felt that measurements '*help improve parent's knowledge; they know what their child should be achieving at their age*' (Se3, P1). However, some people felt '*we need a balance between testing and letting the children move*' (Se1, P2). In terms of instigators for FMS, it was felt that the outdoor space promoted '*running around*' (Se1, P1; Se1 P2), '*climbing and drama, which involve big movements*' (Se1, S1). The *staff 'promote gross motor skills probably more so outside, where these can be assessed'* (Se4, S2). Most preschools said that they ensured that their children participated in outdoor activity daily regardless of the weather, as the children simply wore their coats. Equally one nursery had an outdoor area that was undercover and easier to participate in PA in all weather. Whenever development of FMS was considered, the outdoor space was always referred to; this was where PA and FMS were always promoted. The indoor environment was considered a place for more formal learning to occur and viewed as having more health and safety concerns, which prevented the promotion of FMS and PA occurring in it. '*We [staff] are always developing their running, jumping and holding a pen, so they concentrate on fine and gross skills*' (Se3, S2). This highlighted that the staff were knowledgeable on FMS, however they were honest and said that at times they felt they devoted more time to reading and writing in terms of ‘achieving academic targets’ than to FMS and PA levels. One parent stated that she has ‘*two children and my background knowledge is not that good on this area, I feel nursery staff need to help me promote this*’ (Se1, P1). This parent felt that the preschool that her child attends should take more responsibility for improving parent’s knowledge of FMS and PA levels. This would be placing further responsibility and involvement on preschool staff in developing preschool children’s’ FMS and PA levels. This opinion was not agreed with by many parents or staff because the staff (Se1, S1; Se4, S2) stated that their time was devoted to promoting PA to the preschool children within the setting. Additionally, some parents felt that it was ‘*the responsibility of the parents to improve their knowledge and get involved in PA more, parents should accept responsibility for their own child’s health and stop blaming others’* (S3, P1).

7.3.6 Staff training on PA

The majority of parents presumed that the staff ‘*have a basic, yet good understanding of PA*’ (Se1, P1). One parent believed that staff ‘*are all NVQ trained and some are working up to degree level’* (Se2, P3). Staff from one setting stated that ‘*two members are fully trained forest school leaders and two have completed shorter training to accompany colleagues for forest schools*’ (Se3, S1). Forest schools help to build independence, develop confidence, self-esteem and a positive attitude in preschool children; this happens through hands on learning exploring the outdoors. This differed between settings as staff from one setting said they ‘*are not trained, I feel there is no training available to participate in*’ (Se4, S1; Se4 S2). The staff are always '*willing to accept training, it comes down to money*' (Se4, S1), they considered training important '*to keep current and improve knowledge*' (Se2, P2). '*Training provides ideas of how to link the Early Years Foundation Stage (EYFS) framework into sessions, to ensure the children are more active*' (Se4, S2). Therefore, by attending relevant training, all preschool staff can improve the PA levels of preschool children. All staff did comment that they would like more training as this would ensure that they are all more competent at delivering PA and developing FMS, and this would help the preschools financially, as they would not need to hire in external companies. This is possible as childcare settings provide opportunities to improve time engaged in PA and allow staff to promote healthy behaviours (Kipping et al. 2016). Unfortunately, there is currently limited training available on PA, and all participants wanted further training for staff, covering how PA can be incorporated and delivered in a preschool setting; the cost of these courses was preventing training from occurring. Therefore, when considering future interventions, training on PA promotion for staff is a requirement.

7.3.7 Limitations

There are some limitations with this study. The four preschools were from a similar geographical area; therefore, it is hard to generalise to other areas. Equally, there were only four focus groups, which could be considered a small number and therefore a limitation in terms of applying the findings to all populations. The majority of the sample was Caucasian; whilst it would have been interesting to hear the viewpoints of other participants, they were not available in this area. Similarly, the whole of the sample was female, which was representative of the staff at all preschools but not the parents. Therefore, this prevented any male opinions being received. Greater engagement with men, in such studies, would be beneficial, as perceptions and influences on preschool children's PA may differ by carer gender (Hesketh, Lakshman, and van Sluijs 2017). A very limited number of studies have analysed male parent's perceptions of their preschool child's PA behaviours. However, those that have, reported that most fathers felt they lacked sufficient knowledge to match their child's PA needs, yet they desired a greater comprehension of PA, as they believed being physically active was important (Walsh et al. 2017). This could be crucial in supporting family focused interventions which incorporate father's involvement in promoting PA. This could be a relevant proposal, as previous research has noted that father's PA levels have a consistent positive correlation with PA levels in children, therefore, more active father's tend to have more active preschool children (Ferreira et al. 2007; Hinkley et al. 2008; Walsh et al. 2017). This sample was also from a low SES area and therefore this study lacks generalisation to the wider population of preschool children. Future research into children from different SES areas would be welcome. As this was a qualitative study, then the research is dependent on the individual skills and experience of the researcher. The researcher conducting the interviews was trained in the completion of focus group interviews and how to construct and perform these. As the researcher was present in the focus groups then this may have prevented the participants from making honest responses. This current study did not consider the impact that cultural differences had on this research area. Cultural differences may have influenced the focus group outcomes; this is potentially an area for further exploration.

This current study was, however, the first to consider the staff and parents' views of PA and FMS in a low socio-economic area, whilst considering environmental issues. This study was influential in showing that influences on preschool children's PA levels are multifactorial and multidimensional as found by Hinkley et al. (2011). Including parents and staff in the focus groups, allowed for incorporation of both of their opinions and a greater discussion of the preschool and home environment in terms of PA. Equally, having both parents and staff in the same focus group, could have prevented the parents from fully providing their opinion. The parents may have withheld from divulging negative opinions associated with PA in the preschool. It was considered that the key facilitator of PA and developing FMS is a spacious outdoor environment for the preschool children to move in and the inclusion of climbing frames for them to climb and be physically active on. This study has provided crucial data on preschool staff and parent's experiences and beliefs of PA levels, and what they believe are the key instigators for increasing PA and developing FMS for preschool children.

7.4 Conclusion

This study highlights that preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low socio-economic area. This implies that, to improve PA in preschool children, the preschool settings and the outside environment are key instigators in allowing the children to be active, therefore more resources, for example, time and money need to be inputted into these to ensure preschool children are participating in the required PA levels. The qualitative approach taken here, provides a much needed perspective from the key caregivers, as those best placed to make positive changes in the lives of children, as to ideal means and locations, where health enhancing PA could be promoted, specific to children in their early years of development. Future research, as previously suggested, would greatly benefit from gaining the perspectives of males involved in preschool children's lives, this would predominantly be fathers and any male care providers at preschools. This would allow for a greater insight from influential people involved in preschool children’s upbringing and help to present a more rounded viewpoint. This could be achieved through future research utilising more focus groups, from different preschools, and during this process ideally gaining more male participants.

The home environment was identified as needing to be more supportive in promoting PA and FMS. This is relevant, as the home environment has been identified as the most important place where preschool children can develop their PA behaviours (Pocock et al. 2010; Tucker et al. 2011). This could be achieved by parents being trained in activities that allow them to engage themselves and their preschool children in PA, which have no, or a minimal cost. Increasing children’s PA levels by involving both parents and preschool children in physical activities was supported by Tucker et al. (2011). Some parents have reported being motivated to complete PA with their child whilst at their preschool, therefore organised parent and child activities at preschools, could be a way of increasing preschool children’s PA levels (De Craemer et al. 2013). For future interventions, preschool settings should consider staff attending training, which focuses on receiving ideas on activities that will engage the children in PA and develop their FMS. Implementing these ideas would enable preschool children to be more physically active, increase their PA levels and develop their FMS, through both parental involvement and preschool staff training.

Thesis Study Map: Key Findings

Study	Objectives
Study One: Calibration of GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of preschool children's PA.	Objectives: To determine GENEActiv calibration cut-points for the accelerometers when worn at the non-dominant and dominant wrist, of children aged 4-5 years, for assessment of the intensity of preschool children's PA. Key Findings: • Cut points were developed for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years. • The newly developed cut-points, were lower than, but broadly comparable to the cut-points previously validated in 8-14 year olds. • The cut points for GENEActiv accelerometers when worn at the non-dominant and dominant wrist for pre-schoolers (4-5-year olds) are the following: Sedentary (non-dominant: <5.3; dominant:<8.1), light (non-dominant: 5.3-8.6; dominant: 8.1-9.3) and moderate and above (dominant: >8.6; dominant: >9.3). • These cut-points have the potential to be used in future research with preschool children to help increase their compliance rates with PA.
Study Two: Accelerometer based physical activity levels differ between week and weekend days in British preschool children.	Objectives: To determine the intensity and duration of PA levels during the week and weekend days, in preschool children from a deprived area. Key Findings: • One of the first studies to objectively compare PA levels between weekdays and weekend days in preschool children in the UK, from deprived areas in the UK. • None of the preschool children in this sample achieved the UK recommended guidelines of PA for health. • Preschool children participate in more MVPA during the weekdays, when compared to the weekend days; however, participation in MVPA is minimal for both days. • This study's findings can help to promote future interventions which focus on enhancing PA and encouraging participation in MVPA in both the week and weekend days to improve physical development and a healthy weight status in preschool children.
Study Three: Accelerometer based physical activity levels and fundamental movement skills in British preschool children.	Objectives: To investigate whether FMS competency influences PA levels and weight status in preschool children, in an area of low socioeconomic status. Key findings: • None of the preschool children in this sample achieved the UK recommended guidelines of PA for health. • There were no significant differences in the level of PA or weight status between tertiles of FMS competency. • Findings suggest, that at preschool age, FMS is not associated with PA or weight status in preschool children from an area of low socioeconomic status. • These findings are potentially because PA and FMS may not be fully established and consequently not strongly linked at the ages of 3-4 years.

Study Four: Preschool staff and parents' perceptions of preschool children's physical activity and fundamental movement skills from an area of high deprivation: A qualitative study.	Objectives: To investigate preschool staff and parents' perceptions of preschool children's PA and FMS, from a qualitative perspective, considering the environment, facilities, play, socio-economic status and barriers to PA. Key Findings: • Preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low socio-economic area. • More resources, for example, time and money need to be inputted into preschool settings and the outside environment to ensure preschool children are participating in the required PA levels. • The home environment was identified as needing to be more supportive in promoting PA and FMS. • Preschool settings should consider staff attending training, which focuses on receiving ideas on activities that will engage the children in PA and develop their FMS.

Chapter 8. Synthesis of Findings

8.1 Key Findings and Implications

The purpose of this Chapter is to discuss the overall results of the studies in this thesis and clarify the links between them. Thesis maps are provided and outline the aims of each of the individual Chapters and how they interconnect. This Chapter will start with a thesis recap of the aims of each individual study and provide a summary of the main findings of each study, whilst also clarifying the originality and significance of the work undertaken. As the studies in Chapters 4-7 included individual discussions, limitations and conclusions, this Chapter will reiterate and summarise their key findings. Finally, this Chapter will present the practical implications of the studies within the thesis and the direction for future research.

8.2 Thesis recap

This thesis aimed to investigate the current PA levels, FMS scores and weight status of preschool children (3-5-year olds), whilst gaining the opinions of both parents and staff, on the PA levels and activities that preschool children engage in. Specifically, the aims of the thesis were to: a) calibrate GENEActiv accelerometer wrist cut-points for children aged 4-5 years, for assessment of the intensity of pre-schoolers PA; b) investigate PA levels, via accelerometers, during week and weekend days in British preschool children from a deprived area; c) examine whether British preschool children, from a deprived area, show a correlation between their fundamental movement skills, weight status and PA levels; and d) determine preschool staff and parents' perceptions of preschool children's PA and FMS from an area of high deprivation, via a qualitative study.

8.3 Main Findings and Implications

The calibration study (Chapter 4), aimed to calibrate cut-points for the use of non-dominant and dominant wrist worn GENEActiv accelerometers of pre-schoolers (4 to 5-year olds), for assessment of the intensity of their PA levels. Previously, there were no cut points determined for preschool children using the GENEActiv accelerometers, with the closest validated for 8-14-year olds (Phillips, Parfitt, and Rowlands 2014). This study was therefore original as it was the first study to investigate, and consequently calibrate cut points for the wrist worn GENEActiv accelerometer in preschool children aged 4-5 years. The cut points for the pre-schoolers using the GENEActiv accelerometers when worn at the non-dominant and dominant wrist are as follows: sedentary (non-dominant: <5.3g·s; dominant:<8.1g·s), light (non-dominant: 5.3-8.6g·s; dominant: 8.1-9.3g·s) and moderate and above (non-dominant: >8.6g·s; dominant: >9.3g·s), these were lower than, but comparable to those determined for the 8-14-year olds. The significance of this work is that the newly calibrated cut-points are essential in that they can be used in future research to help classify PA; ultimately they can be utilised in forming public health policies associated with required PA levels. In relation to this thesis, the determination of these cut-points informed Chapter 5 and 6. This was because the calibrated cut-points allowed for PA levels to be determined, categorised and compared between weekdays and weekend days for preschool children (Chapter 5) and PA levels to be compared with FMS of preschool children (Chapter 6). When using the newly calibrated cut-points for the GENEActiv accelerometers for preschool children, none of the children in the North Warwickshire area met the UK recommended guidelines of 180 mins of PA a day (Department of Health 2011a).

Chapter 5 aimed to assess and compare PA levels in preschool children during the week and weekend days. This was the first study to objectively compare PA levels between weekdays and weekend days in preschool children in the UK, using the calibrated cut-points from Chapter 4 and was therefore, influential in making an original contribution to the literature in this area. This study was novel in that it applied preschool specific cut-points to free living PA, whereas most previous research had used non-specific cut-points and therefore they may not have accurately estimated PA in this population. It was also one of the first to report objectively monitored PA levels of preschool children from deprived areas in the UK. The significance of the results of Chapter 5 is that none of the preschool children in this sample achieved the UK recommended guidelines of 180 mins of LMVPA a day, which is required for health. This Chapter indicated that preschool children did participate in more MVPA during the weekdays, when compared to the weekend days; however, participation in MVPA was minimal for both days. During the week days, the children undertook significantly less sedentary behaviour (91.9% v 96.9%), when compared to weekend days. This information can help to promote future interventions which focus on enhancing PA and encouraging participation in MVPA in both the week and weekend days to improve physical development and a healthy weight status in preschool children. The findings of this research suggest that more prominence is placed on greater parental involvement in promoting PA levels during the weekend days, to 'catch up' those during the week days in preschool settings. This information would help in informing further research to concentrate on specific interventions focused on parental awareness of PA, how they can personally be involved in promoting it and how they can implement it into their children's daily lives.

It is vital that preschool children develop their FMS competency, to enable them to be active into their adolescent and adult years. Chapter 6 developed from Chapter 5 and assessed whether preschool children's FMS competency is associated with their PA levels and weight status. This study (Chapter 6) is one of very few to examine whether motor competence, as assessed via FMS, is associated with objectively assessed weight status and PA levels in preschool children from deprived areas in the UK. This study reported no significant differences in tertiles for preschool children's overall FMS competency, locomotive FMS or object control FMS, between children of different levels of PA and weight status. These findings are significant as they suggest that at preschool age FMS competency does not influence PA or weight status. This is most likely because FMS may not be fully established in the preschool years and consequently not strongly linked with PA levels. This does not mean that FMS competency is unimportant, because it still needs to be improved for older ages of children where it does restrict their PA levels. These findings align with the Stodden, Goodway, and Langendorfer et al. (2008) model, which acknowledges that the association between motor competency and PA, which leads to a healthy weight, is weak in the developmental stages.

The implications of these findings are that research should be performed with preschool children, to introduce interventions which allow them to receive further practice and instruction to reach mature patterns of movement required for primary school, to both develop their FMS competency to a higher level and to determine whether this results in greater PA levels and improved weight status, preventing obesity in adulthood (Foulkes et al. 2015; Stodden, Goodway, and Langendorfer 2008). This is furthermore supported by Seefeldt (1980) proficiency barrier, as they suggested that children who can achieve competency above the proficiency barrier will continue to engage in PA throughout their life, and those who do not exceed the barrier are less likely to remain physically active. Therefore, those children who are in a higher centile for FMS competency, will be more active throughout their lifespan; as supported by Cliff et al. (2009a); Sääkslahti et al. (1999); Williams et al. (2008). To counteract the homogenous nature of the participants in this Chapter, then assessing the FMS competency levels of preschool children from a different geographical and SES area would be advantageous, to determine any differences in FMS competency and PA levels.

The girls in Chapter 6, were predominantly better at the locomotor skills, and were significantly greater at the hop, leap and skip (locomotor skills), these skills are associated with more coordinated movements; such a suggestion is congruent with prior research (Cliff et al. 2009a). The boys were predominantly better at the object control skills (significantly higher at the kick), which is consistent with existing literature (Foweather et al. 2015). In this Chapter girls had a greater overall total FMS score than the boys (boys = 50.4 ± 15.6, girls = 52.9 ± 14.6), yet it was not significant. These gender differences in FMS competency in preschool children, can be a result of both biological factors and socialisation, due to different levels of practice of each of the skills (Hardy et al. 2010a). There was also no significant correlation between overall FMS and MVPA during weekdays or weekends. Significantly, this Chapter provides needed information examining the tenets of the Stodden theoretical model, linking FMS to PA, in British preschool children. To clarify, the findings of this thesis support the Stodden model, as preschool children's FMS are still at the developmental stage, and consequently a relationship with PA is weak. Such research is essential, to provide a solid foundation from which to target future interventions aimed at enhancing PA of preschool children, through the development of FMS.

The implications of these findings are crucial, because they suggest that parents and preschool staff need to be aware of what FMS the girls and boys are weaker at and promote these in an intervention. The dose and quality of PA independently and in combination could have important implications for FMS competency of preschool children. This said, Robinson et al. (2017) found no differences between treatment doses, yet did discover that preschool children do require high quality PA movement opportunities to support the development of their FMS. Therefore, further research to determine evidence-based interventions which provide high quality PA and promote development in FMS are required. The key take home message from the present findings is to ensure that future interventions aim to improve the competency of a variety of FMS for preschool children, increase their daily PA and develop/maintain a healthy weight status.

The final study in this thesis (Chapter 7) was qualitative in approach and aimed to assess preschool staff and parents' perceptions of preschool childrens' PA in relation to environment, facilities, play and barriers to PA. This Chapter was devised to provide an overview of perceptions of environmental influences on PA and the development of FMS of preschool children, and importantly the reasons for these behaviours from the view of both parents and preschool staff. This was a way of drawing together the thesis and providing much needed contextual information and a different lens with which to understand parents and preschool settings/staff's involvement, related to preschool childrens' PA levels and FMS competency. Such information is essential as a start point, to understand from the perspective of stakeholders/policy makers, the practical issues around enhancing preschool children's PA. No study to date, has completed this and as such, the current Chapter makes a novel contribution to the literature. Such a standpoint appears to have been neglected in the literature relating to the facilitators and barriers to PA in children in the preschool years. The Chapter considered the environment, facilities, play, and barriers to PA and FMS development.

Chapter 7 is significant in that it highlighted that preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low SES area. Therefore, interventions are required to improve PA in preschool children and the preschool settings and the outside environment are key instigators in allowing the children to be active. More resources, for example, time and money are needed to be inputted into settings, to ensure preschool children are participating in the UK required 180 mins of MVPA a day. Regardless of the setting all parents and staff had a good knowledge of PA and they linked it to movement, an increased heart rate and the outdoors. Opinions did differ on who was responsible for preschool children’s PA, however, the consensus was that parents have the main responsibility for their preschool children’s PA levels, yet staff are accountable for the activities the children participate in during the preschool environment. Opinions did differ between the staff and parent’s perspectives on whether children’s PA and FMS should be measured. The majority of the participants felt that measuring PA was important, as they were concerned about the physical and mental impact of physical inactivity on the children. Some participants deemed it important to test PA as it was a way of identifying who was overweight. This is a misconception of what PA measurements should be used for. Further education of both preschool parents and staff, around PA being associated with obesity and not a measure of it, could prove beneficial.

The qualitative approach was essential in providing a required perspective from the key caregivers, as they are best placed to make positive changes to the lives of children, as to ideal means and locations, where health enhancing PA could be promoted, specific to preschool children in their early years of development. The home environment was also identified as needing to be more supportive in promoting PA and FMS. This could be achieved through interventions which involve parents being trained in activities that allow them to engage themselves and their preschool children in PA and develop their FMS, whilst maintaining a healthy weight status, which have no, or a minimal cost. For future interventions, preschool settings should also consider staff attending training, which focuses on receiving ideas on activities that will engage the children in PA and develop their FMS. Implementing these ideas would enable preschool children to be more physically active, increase their PA levels and develop their FMS competency, through parental involvement, preschool staff training and utilising the outdoor environment. The implication of this is that future studies, local authorities and other policy makers should consider more resources, for example, time and money are needed to be inputted into preschools to ensure the children are participating in the required PA levels to improve health.

8.4 Generic Themes

8.4.1 Cohort

Chapter four was a laboratory based study requiring the use of an invasive procedure with the preschool children, so due to this a small sample size was recruited. This sample size allowed for the calibration of the GENEActiv accelerometers for preschool children and the sample recruited allowed for an appropriate power to be achieved. This Chapter consequently allowed for the determination of PA levels of preschool children during the week and weekend days for Chapter 5 and 6. The calibrated cut-points can also be used for future research to determine preschool children's PA levels. It could be suggested that this Chapter cannot be generalised to wider populations, as there could be cross cultural variation such that further calibration studies are therefore required. Therefore, care should be taken as these cut-points are specific to the geographical area and SES of the participants assessed and new cut-points should be determined for different populations.

All children who participated in the studies in this thesis were from the same deprived area in North Warwickshire. Participants recruited were reflective of ‘typical’ children in these preschools. In Chapter 5 and 6 none of the participants achieved the UK recommended 180 mins of PA. The sample therefore included inactive children, however, this is reflective of deprived children (NOO 2014; Public Health England 2013). Although the children were inactive, their PA levels were not associated with their FMS competency and it could be suggested that their lack of PA has not been affected by their FMS. On the other hand, if no children exhibit high levels of PA, it could be argued that there is not enough variation in PA in this sample for a correlation to be possible. Therefore, a different sample at this age with higher variation might show a correlation. Equally their lack of PA or FMS competency has not impacted on their weight status. The highly inactive participants should not be disregarded as the link between PA levels and FMS competency is reflective of Stodden, Goodway, and Langendorfer (2008) and Seefeldt (1980)’s research. Future research should consider targeting preschool children that meet the PA recommended guidelines to see if they have any association with FMS competency. This said, it could be hard to recruit these specific children, as they may not exist, or be accessible from a deprived area within a similar geographical location. Future studies may also consider recruiting children aged 3-8 years as this is the age where development of FMS exists. It would be appropriate to observe if any correlations between PA levels and FMS competency occur and at what specific age, particularly as this would support Seefeldt’s proficiency barrier hypothesis and Stodden’s model.

8.4.2 PA levels

The PA levels reported for the preschool children in this thesis were low during both the week and weekend days, with none of the children meeting the UK recommended 180 minutes of PA. Although this was the quantitative outcome (Chapter 5 and 6), parents and preschool staff (Chapter 7) did possess a good understanding of PA (qualitative outcome), as they linked it to movement, whether that was running, jumping, using the tricycles or being outdoors. They associated the main benefits of PA with the physiological and psychological changes such as 'burning fat and energy' and the children having 'better concentration' levels, and they implicitly linked a lack of PA with obesity. All participants stated that preschool children's weight is a responsibility of parents and that parents in the home environment need to be more proactive with engaging in PA, as the preschool environment was identified as the main place, where the majority of preschool children participate in MVPA, and for some children, the only place.

This research highlights that parents' and preschool staff who are key influential individuals in preschool children's lives are aware of PA, yet they do not promote it sufficiently. This would support the findings of Chapter 5 and 6, and emphasise the relevance of preschools increasing the MVPA levels that they deliver. It also suggests that future interventions with preschool children need to involve parental engagement more (Summerbell et al. 2012), particularly for PA interventions in the home environment and combining this with training the parents to understand and be confident to improve the PA levels in their preschool children. The findings from Chapter 7, imply that the role of both the parents and the outdoor environment needs to be considered when designing interventions. Participation in PA and FMS in a spacious outdoor environment, where the preschool children can run around is essential, as being in the outdoors is one of the most powerful correlates of PA in children (Pate et al. 2008); equally, the time a preschool child spends outside has a positive association with their PA levels (Hinkley et al. 2008).

Chapter 6 discovered that FMS competency did not influence PA levels in preschool children. In terms of supporting preschool children to engage in developing their FMS competency and PA levels, the results of this thesis would suggest that, involvement from parents during the weekend/home setting is required, as well as the need for preschool staff to increase the input around PA levels and FMS, during the week. The inclusion of more outdoor activities would allow PA levels to be enhanced and FMS competency levels to improve prior to entrance of the preschool children to school. This would have the advantage of ensuring preschool children's PA levels are promoted, to achieve the recommended 180 mins of PA a day, with the aim of their weight status not becoming a concern and obesity levels not rising.

8.4.3 FMS Competency

The children in this thesis were preschool age and going through the developmental stage in terms of improving their FMS competency. TGMD-2 is a process orientated test, as it assesses the components that make up the skill, that reflects the development of the skill not the physical growth and maturational levels of children (Barnet et al. 2013; Hardy et al. 2010a). Therefore, this test is better placed for the assessment of preschool children, hence it being used to assess FMS competency in Chapter 6. The findings from Chapter 6 are significant in that they support Seefeldts (1980) proficiency barrier, as there was no association between FMS competency and PA levels in the preschool children assessed in this thesis. The research in this thesis also supports the Stodden, Goodway, and Langendorfer (2008) model, that preschool children's skill level, is a primary underlying mechanism in promoting engagement in PA. At this age, the children are still developing and not able to make accurate judgments of their competence, something which is believed to improve with age.

Parents and preschool staff (Chapter 7) reported that FMS involves movements such as running and jumping and is what children do on a daily basis, with FMS, specifically gross motor skills, being promoted and performed more in an outside space. Therefore, the participants understanding of FMS was fairly good. Measurement of FMS was met with a divided opinion, as some participants felt that it was imperative, because if the preschool children are weak at any skills, then staff can practice specific skills and inform parents to work on them. Staff did say that they required more training in identifying the presence or absence of these FMS skills and if this happened, they were extremely willing to develop the skills with the preschool children. Further research would be appropriate to implement interventions whereby staff and parents are supported in delivering activities to improve preschool children's FMS. This could be achieved by parents being trained in activities that allow both them and their children to engage in FMS and PA, with no, or a minimal cost. Equally, it would be beneficial for staff to attend training which focuses on receiving ideas that will engage the children in PA and develop their FMS. This would have the added advantage of having a dual purpose, as the children's FMS competency would be improving and at the same time their daily minutes of PA increasing, through both parental involvement and preschool staff training.

8.4.4 Feasibility

These preschool based studies were implemented successfully with the support of preschool managers and staff. These studies were completed around the children's formal learning, so no additional pressure was placed on the staff. The planning of when the children were in preschool and when the studies could take place was kindly organised by the staff at the settings, because some preschool children only attended in the morning or afternoon and only on certain days. Therefore, logistically the access into the preschools was complex at times. Most of the children received the FMS assessment and wearing of the GENEActiv accelerometers very well. Gaining the interest of the preschools was the greatest challenge. However, once a manager of a setting was on board then usually this was an incentive for parents/guardians to agree for their child to participate in the studies. Children's assent was important and if any child did not want to participate in the studies then this was respected. Predominantly settings that participated in one study were happy to participate in more, however, this was not always the case.

Chapter 4 was laboratory based. As the children that were assessed in this Chapter were between the ages of 4 and 5 years, then testing had to work around their time in preschool/school. Therefore, most of this testing was completed during the summer holidays, so the children's education was not disrupted and the parents could get them into the University's laboratory. A great amount of time was spent familiarising the children with the treadmill and the metamax, as out of all the studies in this thesis, this was the most unfamiliar procedure used with the children.

During both studies 2 and 3, the children wore the GENEActiv accelerometers for long durations. This was a new concept to the children and one which both parents and preschool staff supported and helped to encourage the children to comply with. In Chapter 6, when the FMS assessments took place, sometimes more support was required from staff to assure the preschool children that their involvement in the testing was acceptable; at times, the researcher had to spend more time ‘winning over’ the trust of some children, prior to them participating. The number of parents agreeing for their child to participate in Chapter 5 and 6 was encouraging, and overall, their continued support throughout the weekend to wear the accelerometers was also positive. Finally, the uptake of parents and staff to participate in the focus groups (Chapter 7), was suitable. Initially the preschool settings were very supportive in allowing staff members to be involved in these questionnaires, they also helped in sending reminders to parents to ensure sufficient numbers were involved in the focus groups.

8.5 Limitations

In Chapter 4, a fixed order of activities was followed from sedentary to running. This may have been a limitation due to the more sporadic nature of preschool children’s daily movement patterns. Children are reported as having a higher oxygen cost during weight bearing activities, which is possibly a result of their ‘wasteful’ gait during walking and running (Spurr et al. 1984). Therefore, assessing different activities, for example weight bearing and free-living activities may have produced varied results. Additionally, there may have been the possibility, although unlikely, of an order effect where fatigue from earlier activities could have influenced later activities (Duncan et al. 2016). This could be addressed in future studies by assigning the order of tests in a randomised block design. Finally, as the preschool children moved from one station to another, it may be appropriate to readdress the 'transition' time for future research to prevent any carry-over effect in the oxygen uptake between activities. However, as this present Chapter measured VO_2 by removing the first 2.5 minutes of data and averaging the remaining data of an activity (Mackintosh et al. 2016), it is likely that the measurements of EE reflected steady-state conditions in the various activities involved.

Also, in Chapter 4, recruiting 4-5-year-old children, and subsequently using indirect calorimetry whilst exercising, was challenging and more time consuming than if older children or adults were the population being assessed. This resulted in a relatively small sample size for the calibration of the new cut-points. Secondly, the data did not show a greater skew towards either the non-dominant or dominant hand, as the non-dominant was more accurate in determining sedentary and moderate and above PA and the dominant light PA. In this current Chapter, none of the activities required the use of one hand more than the other, however it was not noted if the children did favour one hand more than the other in the activities. Handedness could be investigated in future studies.

Although Chapter 5 successfully used accelerometry as an objective monitoring tool in preschool children, some of the accelerometers did fail to record data. This manufacturer problem caused no data to be recorded for seven participants.

The preschool children that were monitored were drawn from a deprived part of the UK. Low SES children face greater barriers to becoming physically active and as they age low SES individuals have higher rates of obesity and associated comorbidities (NOO 2014). Additionally, people from lower SES groups predominantly live in areas that do not support walking and cycling (The Marmot Review Team 2010). This viewpoint would suggest that deprived areas do not facilitate PA as effectively as other areas and as such, people living in deprived areas may not participate in PA as frequently.

Limitations reported in Chapter 6 were related to the sample being drawn from a deprived part of the UK. This potentially resulted in differences in PA levels and FMS competency rate in the preschool children, when compared to an area of higher SES in the UK. Therefore, this Chapter welcomes future research to compare both high and low SES groups. Although this was reported as a potential limitation, the focus on low SES children was important, as these children face greater barriers to becoming physically active (NOO 2014). Hence, understanding the levels of PA and FMS in preschool children is useful in planning early intervention to improve future health.

In Chapter 7, the four preschools that participated were from a similar geographical area; therefore, it is hard to generalise the results to other areas. The majority of the sample was Caucasian; whilst it would have been interesting to hear the viewpoints of other participants, they were not available in this area. This sample was from a low SES area and therefore this Chapter lacks generalisation to the wider population of preschool children. Including parents and staff in the focus groups allowed for both of their opinions and a greater discussion of the preschool and home environment in terms of PA. Equally, having both parents and staff in the same focus group could have prevented the parents from fully providing their opinion. The parents may have withheld from divulging negative opinions associated with PA in the preschool. Also, as the researcher was present in the focus groups then this may have prevented the participants from making more open responses. However, it was necessary that the researcher was present to lead the focus group.

8.6 Future Research

The results of Chapter 4 showed relatively poor performance for the light cut-points when compared with other PA intensities. This may be because there is greater 'noise' in light PA intensity levels for younger children, making it difficult to differentiate from sedentary activities (Vale et al. 2015). Therefore, it is essential that future research is completed to better classify light intensity using the GENEActiv accelerometers to avoid any misreporting of PA intensities; this is supported by Duncan et al (2016). Assessing different activities, for example weight bearing and free-living activities may provide varied results to the activities tested in Chapter 4. This would assess any concerns regarding reports that weight bearing activities have a higher oxygen cost, which possibly results in their ‘wasteful’ gait during walking and running (Spurr et al. 1984). It would also be beneficial for future research to cross validate the cut-points reported here, with an independent sample and evaluate their efficacy in a free-living environment, rather than the laboratory based, predominantly ambulatory activities used in this Chapter. Finally, in relation to the activities performed, it would be appropriate to readdress the ‘transition’ time for future research, to prevent any carry-over effect in the oxygen uptake between activities. This would fully ensure that the measurements of EE reflected steady-state conditions in the various activities involved.

If further calibration studies are performed on pre-schoolers, then researchers should aim for a larger sample size and to assess the effect of different variables on the data, to allow greater generalisability of the findings, albeit this may prove to be difficult due to the age of the children. Future research could look at a similar study but emphasise activities which require the use of one hand more than the other, to see if this relates to the non-dominant and dominant cut-points.

Chapter 5’s and 7’s findings imply that parental influence on PA during the weekend days needs improving; this could be a result of parents lacking an understanding of appropriate PA to deliver to their children, or a lack of time. To develop appropriate interventions, future research needs to examine the parental influence on PA levels of preschool children at the weekend, to fully understand their current involvement and improve their teaching of PA. Understanding these factors would enable the refinement of future interventions whereby parents are more involved in promoting

MVPA levels with their preschool children, allowing for improvements in physical development and a healthy weight status.

The participants recruited in both Chapter 5 and 7 were drawn from a deprived part of the UK. This may have resulted in a lower participation rate in the study compared to an area of higher SES in the UK and may have resulted in a lack of potential generalisation to the wider population of preschool children. Therefore, research comparing both high and low SES groups would be welcome to extend the literature in preschool children. Chapter 7 also had a sample that was from a similar geographical area and was predominantly Caucasian. Future research could focus on gaining a sample that is from both a different geographical area and ethnic background. Cultural differences may have influenced the focus group outcomes; this is potentially an area for further exploration. Understanding the levels of PA in both low and high SES groups, and different cultural and geographical areas would be useful in planning early interventions to improve future health of the preschool children.

Chapter 6 reported that British preschool children spent a substantial proportion of each day in sedentary behaviour during both the week and weekend days. As preschool children are inactive then this may explain the lack of any significant differences in PA levels between tertiles of FMS competency. Therefore, future research would be best focused around assessing a more varied sample in terms of children from a different geographical area and SES group, and establishing how much time they spend in MVPA. This would be beneficial as it would determine whether a different sample of preschool children show any significant differences in

PA levels and weight status between tertiles of FMS competency. This information could then be utilised to create a specific intervention to improve any FMS weaknesses, with the intention of improving FMS competency, increasing PA levels and promoting a healthier lifestyle due to lower levels of obesity.

This thesis reported no significant relationship between FMS competency and the percentage of time spent in sedentary, light, moderate or vigorous PA, in a deprived population of preschool children, using objective PA monitoring specific cut-points calibrated on a UK sample. Similarly, Fisher et al. (2005) and Okely, Booth, and Patterson (2001) reported no association, or a weak relationship between FMS and PA levels, yet significant relationships have been reported between FMS and PA in older children (Barnett et al. 2009). Minimal studies have investigated the relationship between FMS and PA in preschool children and further studies are required to ascertain if PA and FMS are simply not fully established and consequently not strongly linked at preschool ages.

Research into motor proficiency among family members could lead to understanding familial factors that may influence PA in youth. Further examination of the relationship between motor proficiency and PA is required through longitudinal and intervention studies (Wrotniak et al. 2006), with community-based and preschool interventions targeting FMS as a strategy to promote long-term activity (Barnett et al. 2009). This will allow any associations between FMS and PA to be identified and strategies to be implemented more widely which involve movement skills and promotion of PA, which will have a positive influence on preschool children's physical development, health, motor proficiency and wellbeing in preschool settings. Practitioners in preschool settings need to be aware of how they can increase PA levels and what are considered to be appropriate forms of PA. If further research is performed, then accelerometers are a valid tool, with Trost et al. (2000) recommending measurements over both weekdays and weekend days, to allow for overall PA to be accounted for. Such research will help to determine what is classed as optimal MVPA with respect to duration and type of activity (dose-response) for preschool PA guidelines (Raustorp et al. 2012; Reilly et al. 2012) and should be influential in creating an evidence-based model to make changes to practice for preschool staff and children.

Socialisation can explain variations between genders in FMS competency, due to different levels of practice of skills (Hardy et al. 2010a). Researchers need to be aware that girls' overall PA level may be more affected by each other and the environment they are in, when compared to boys (Olesen et al. 2014). This highlights the necessity for interventions to be implemented using a variety of structured activities, for girls throughout the preschool day; with the aim of future interventions improving FMS competency, to ensure preschool children are physically active and develop/maintain a healthy weight status. Regardless of gender, it would be appropriate to ensure that activities are promoted in preschools that further promote competency in all FMS skills.

This Chapter highlights that preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low SES area. This implies that to improve PA in preschool children, the preschool settings and the outside environment are key instigators in allowing the children to be active, therefore more resources, for example, time and money need to be inputted into these to ensure preschool children are participating in the required PA levels. Future research should focus on: interventions to reduce barriers to PA indoors; promoting more outdoor time; a wider variety of activities and encouraging overall activity play (Howie et al. 2012). Comparisons of objectively measured indoor and outdoor PA is required during preschool time (Raustrop et al. 2011), in a variety of different settings with regards to space, equipment and environmental characteristics in both indoor and outdoor activities that preschool staff deliver. The home environment was identified as needing to be more supportive in promoting PA and FMS; even though PA was no better in preschools. This could be achieved by parents being trained in activities that allow them to engage themselves and their preschool children in PA, which have no, or a minimal cost. For future interventions, preschool settings should consider staff attending training, which focuses on receiving ideas on activities that will engage the children in PA and develop their FMS. Implementing these ideas would enable preschool children to be more physically active, increase their PA intensity levels and develop their FMS, through both parental involvement at the weekends and preschool staff training; whilst incorporating the outdoor environment (Foweather et al. 2015).

8.7 Conclusion

In conclusion, this thesis aimed to enhance understanding of preschool children's PA levels and FMS competency from a deprived area. Findings from the thesis have extended the evidence and understanding of research in this area. This thesis has four novel studies, the calibration study which was unique in that it has produced calibrated cut-points for the wrist worn GENEActiv accelerometers for preschool children, two measurement studies (PA during the week and weekend days and FMS competency compared with PA levels and weight status) and a qualitative study.

The thesis has found the following key findings: preschool children do not participate in the UK required 180 mins of MVPA on a daily basis; they are significantly more sedentary on the weekend days; their PA levels and weight status do not significantly differ depending on their FMS competency; preschool parents and staff believe that preschool settings and the outside environment are major influences in terms of promoting PA for preschool children from a low SES area and that the home environment needs to be more supportive in promoting PA and FMS. Knowledge of preschool children's objective PA measurement is now improved through the newly determined cut-points. Levels of MVPA were found to be extremely low during both the week and weekend days, with them being slightly higher in the weekdays whilst in preschool. Therefore, future interventions are required to improve the MVPA levels in preschool children both in the preschool settings and at home. Equally, sedentary behaviour is required to be decreased during the weekends days; this combined with the qualitative feedback suggests that interventions are specifically required to improve PA levels and FMS competency in the home environment and parents may require training to achieve this. When implementing new interventions, it would be of benefit to use both objective measures (accelerometry) and qualitative methods (focus groups), to assess PA levels and FMS competency of the preschool children. This would strengthen the findings and provide supporting evidence of any improvements in these variables due to interventions introduced. If employing a group randomised design, then increasing the number of preschools participating, would help to avoid cluster randomisation and finally, assessing after 12 months post-intervention would determine the long-term effects of the programmes.

FMS competency was similar regardless of PA levels and weight status of the children, therefore, interventions could introduce meaningful FMS sessions that focus on the skills that children are weaker at (boys were significantly weaker at the hop, leap and skip (locomotor skills), girls were predominantly weaker at the object control skills (significantly weaker at the kick)), to enable them to participate in MVPA and gain a healthy weight status. The research conducted within this thesis is important in informing future research/interventions and public health policies to improve the PA levels, FMS competency and weight status of preschool aged children, particularly those living in deprived areas. The implications for policy and practice, are that preschool children living in deprived areas are not physically active enough to meet the UK PA guidelines of 180 minutes a day. This needs to be addressed, and appropriate training of parents and staff undertaken, to increase the preschool children's PA levels during the week and weekend days. The ultimate aim would be to train the parents and staff to improve the FMS competency of the preschool children at the same time as increasing their PA levels. In terms of policy, the implications are that it would be appropriate to embed PA and FMS training, into mandatory training for all staff involved in working with preschool children. This would ensure that preschool staff possess knowledge, skills and confidence associated with PA and FMS. This would address one of the pillars of the Early Years Foundation Stage (EYFS) statutory framework. Preschool staff would understand the UK PA guidelines, they would learn what FMS is and how it influences preschool children's lives and impacts on their PA levels.

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Appendices

Appendix 1 – Participant Information Sheet and Informed Consent - Chapter 4

Dear Parent/Guardian,

The Department of Applied Sciences and Health at Coventry University are conducting a research study assessing the physical activity habits of preschool age (3-5 years) children. We are investigating how valid accelerometers are in their measurement of children's physical activity. Accelerometers are a type of activity monitor, usually worn on the wrist, which are used to assess physical activity levels. However, we are not sure how well these work with young children and are looking to examine their accuracy. We would therefore like to ask permission for your child to participate. The children involved in the study would be asked to attend our laboratory for approximately 2 hours at a time convenient to yourself/your child. We would like to measure physical activity using an accelerometer (a watch) which they wear on their wrist when they perform a range of different tasks. This includes: Lying down, playing with Lego, running at a light and a moderate intensity. Each section would last for 5 minutes. At the same time we would like to measure how much carbon dioxide your child breathes out. This would require your child to wear a small 'mask' over their nose and mouth so we can capture the gas they breathe out. We do this to calculate how much energy each child uses in each activity so we then can work out how accurate the accelerometers are. You would be present at all times during the visit and we hope to make this a fun and interesting experience for the children who take part.

All the procedures used are safe, will be conducted by trained personnel. The data will be anonymous, treated in confidence and solely used for the purposes of the research study. Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time. Participation in this project will help our scientific understanding of the accurate measurement of physical activity in 3-5 year olds. We hope you will be interested in allowing your child to participate in this project and should you have any queries please do not hesitate to get in touch.

I am more than happy to expand on this information further.

Yours Faithfully,

Clare Roscoe
PhD Student
Department of Biomolecular and Sport Sciences,
Coventry University
07815 073524

Other information that you may find useful

Withdrawal
If at any time during the testing your child would like to withdraw (or you would like to withdraw them), you are free to do so without any recourse

What are the benefits?
We cannot promise the study will help you personally but the information we get from this study will help improve our understanding of the accurate measurement of physical activity in 3-5 year olds and is importance in helping develop more effective physical activity programmes that can be used to enhance children's health. This is because understanding activity and lifestyle habits may assist us in developing programmes to increase physical activity and reduce disease risk in future.

What are the risks?
The risks that your child may encounter during the testing are minimal and no more than encountered during their day to day physical activities.

What happens to the information?
Procedures for handling, processing, storage and destruction of their data match the Caldicott principles and the Data Protection Act 1998. All data gathered will be anonymous and treated in strictest confidence. It will only be used for the purposes described above and only the principal researcher will have access to the data.

Who has reviewed this study?
This study has been reviewed and approved by the Ethics Committee at Coventry University and the procedures in place in the study adhere to the Code of Conduct of the British Association of Sport and Exercise Sciences

What if I have more questions?
If you have any further questions please get in touch with the principal researcher for the study, Prof. Mike Duncan, Department of Biomolecular and Sports Sciences, James Starley Building, Coventry, CV1 5FB, Telephone: 02476 888613 or e-mail: michael.duncan@coventry.ac.uk

Further relevant information can also be gained from the British Association of Sport and Exercise Sciences on their website www.bases.org.uk should you feel that your child's participation in the study has raised any issues

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I give permission for my son/daughter ________________________ (insert name) to participate in the above mentioned study. I understand that the data will remain anonymous and will only be used for the purposes described above, that I have the right to withdraw and that participation is entirely voluntary.

Signed: ________________________ (Parent/Guardian) ____________ (Date)

Signed: ________________________ (Witness) ____________ (Date)

Appendix 2 – Participant Information Sheet and Informed Consent - Chapter 5 and 6

Dear Parent/Guardian,

The Department of Biomolecular and Sport Science at Coventry University are conducting a research study assessing the physical activity habits of preschool children in North Warwickshire. XXXXXXX, has kindly agreed to participate. We would therefore like to ask permission for your child to participate. The children involved in the study would be asked to continue with their normal day-to-day routines. We would like to measure physical activity using an accelerometer (a watch) which they wear on their arm for four days. We would also like to measure their height and weight and waist circumference and complete some fundamental motor skill activities e.g. jumping, skipping and hoping with them; this would be videoed. The videos would be used to slow the movement down to analyse and then destroyed.

All the procedures used are safe, will be conducted by trained personnel and do not require you/your child to do anything extra in your day-to-day routine. The data will be anonymous, treated in confidence and solely used for the purposes of the research study. Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time. Participation in this project will not influence your child's nursery/preschool sessions in any way and could help our scientific understanding of the activity habits of preschool children. We hope you will be interested in allowing your child to participate in this project and should you have any queries please do not hesitate to get in touch.

I am happy to attend the nursery/preschool, where I will bring the equipment for you to view, see how it works and what will be required of your children.

Yours Faithfully,

Clare Roscoe
PhD Student
Department of Biomolecular and Sport Sciences,
Coventry University
07815 073524

Other information that you may find useful

Withdrawal
If at any time during the testing your child would like to withdraw (or you would like to withdraw them), you are free to do so without any recourse

What are the benefits?
We cannot promise the study will help you personally but the information we get from this study will help improve our understanding of the influence of physical activity on health and is importance in helping develop more effective physical activity programmes that can

be used to enhance children's health. This is because understanding activity and lifestyle habits may assist us in developing programmes to increase physical activity and reduce disease risk in future.

What are the risks?
The risks that your child may encounter during the testing are minimal and no more than encountered during their day to day physical activities.

What happens to the information?
Procedures for handling, processing, storage and destruction of their data match the Caldicott principles and the Data Protection Act 1998. All data gathered will be anonymous and treated in strictest confidence. It will only be used for the purposes described above and only the principal researcher will have access to the data.

Who has reviewed this study?
This study has been reviewed and approved by the Ethics Committee at Coventry University and the procedures in place in the study adhere to the Code of Conduct of the British Association of Sport and Exercise Sciences

What if I have more questions?
If you have any further questions please get in touch with the principal researcher for the study, Dr. Mike Duncan, Department of Biomolecular and Sports Sciences, James Starely Building, Coventry, CV1 5FB, Telephone: 02476 888613 or e-mail: michael.duncan@coventry.ac.uk

Further relevant information can also be gained from the British Association of Sport and Exercise Sciences on their website www.bases.org.uk should you feel that your child's participation in the study has raised any issues

---

I give permission for my son/daughter ________________________ (insert name) to participate in the above mentioned study. I understand that the data will remain anonymous and will only be used for the purposes described above, that I have the right to withdraw and that participation is entirely voluntary.

Signed: ________________________ (Parent/Guardian) ____________ (Date)

Signed: ________________________ (Witness) ____________ (Date)

Appendix 3 – Information Sheet for Parents - Chapter 5 and 6

Information leaflet

Body Measurements

- Height and weight will be measured; this will allow Body Mass Index (BMI kg/m^2) to be calculated.
- Waist Circumference will also be measured (see below).

Measurement of Physical Activity

- Physical activity will be measured using an accelerometer (GENEActiv) (wrist watch). This will tell us what activity the children participate in, in their normal everyday life.

- The accelerometers will be set-up and ready to use, therefore no time will be required by parents to set them up.
- They are small and lightweight and will be worn on the right wrist.
- These will be worn in the day and removed when sleeping.
- These will be reattached to the right wrist by the parents in the mornings.
- The accelerometers are waterproof but should **not** be worn in the bath.
- The participants will be asked to wear the accelerometers for four consecutive days (ideally Friday, Saturday, Sunday and Monday).

Fundamental Motor Skills (FMS)

- FMS provides information on how children learn to coordinate their bodies and learn the skills necessary for healthy physical activity in primary and secondary school.
- The following motor skills will be assessed using the Test of Gross Motor Development-2 (TGMD-2).

    - **Locomotor skills** (run, gallop, hop, horizontal jump).
    - **Object control skills** (striking a stationary ball, catch, kick, overhand throw).
- Each skill is made up of 3-5 performance criteria which are rated as present or absent.
- FMS would be videoed outside with one child assessed at a time.

All data will be treated **anonymously** and the video evidence will be **destroyed** in accordance with Coventry University's stipulations once the evidence has been analysed.

Appendix 4 – Information Sheet for Children - Chapter 5 and 6

Child Information leaflet

Body Measurements

- Your height and weight will be measured.
- Your Waist Circumference will also be measured (see below).

Measurement of Physical Activity

- You will wear a wrist watch on your right arm which will measure the activity you are completing.
- You can wear this for all activities apart from swimming, bath time and sleeping.
- The watch will be collected after the four days and provide details of the activities you have completed.

Fundamental Motor Skills (FMS)

- FMS provides information on how you learn to coordinate your body.
- You will be videoed performing the following:
    - Running, galloping, hopping and side wards jumping.
    - Striking a stationary ball, catching, kicking and overhand throwing.

Appendix 5 – Information Sheet to go home with the GENEActiv

Accelerometers - Chapter 5 and 6

Dear Parents/Guardians,

Your son/daughter has been provided with an accelerometer (watch) as part of the research study, which you kindly agreed for them to participate in. If your child could wear the watch all day Thursday, Friday and both Saturday and Sunday please. Could you return the watch on Monday XXXXX to a nursery member of staff (or when your child is next in nursery). Your child can wear the watch at all times! If they could be positioned on the right wrist, with the gold pin facing up the arm (so you could read the serial number if your child went to read it like a normal watch).

Thank you again for your cooperation in this study.

Yours Faithfully,

Some

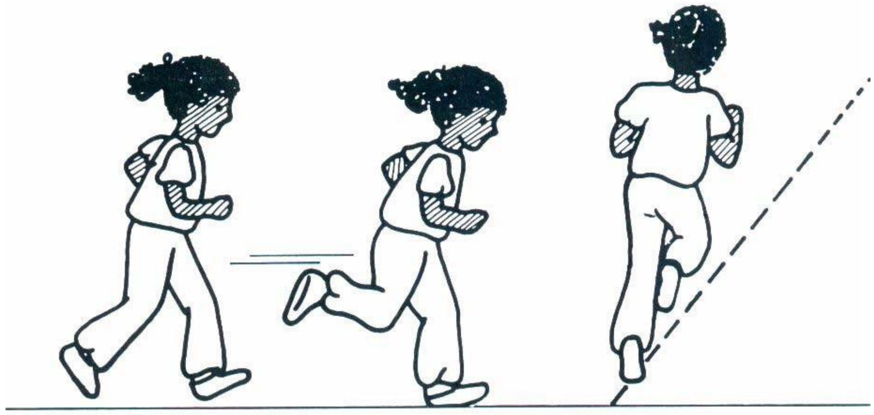
Clare Roscoe
PhD Student,
Coventry University,
07815073524

Appendix 6 – Test of Gross Motor Development

Subtest 1. Locomotor Skills

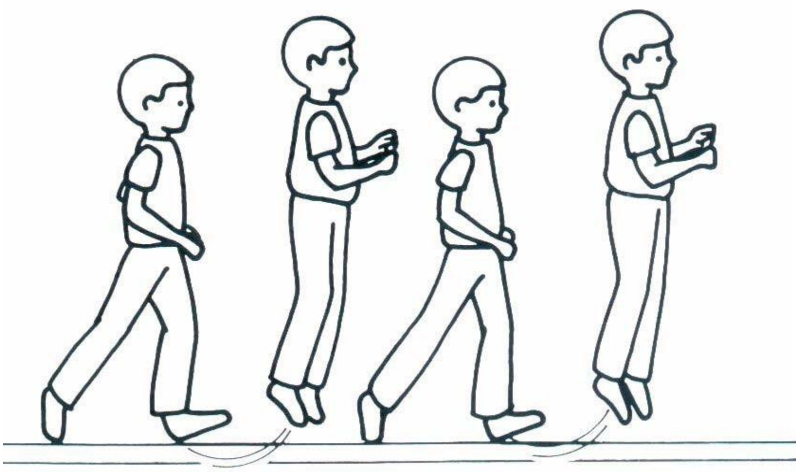
SKILL: Run
EQUIPMENT/CONDITIONS: A minimum of 50 feet of clear space and masking tape, chalk, or other marking device.
DIRECTIONS: Mark off two lines 50 feet apart. Instruct student to “run fast” from one line to the other.

PERFORMANCE CRITERIA:	1st	2nd
*Brief period where both feet are off the ground.		
*Arms in opposition to legs, elbows bent.		
*Foot placement near or on line (not flat footed).		
*Nonsupport leg bent approximately 90 degrees (close to buttocks).		

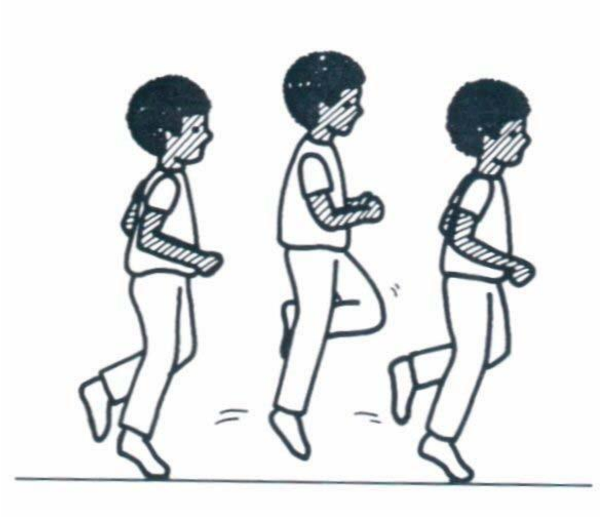


SKILL: Gallop
EQUIPMENT/CONDITIONS: A minimum of 30 feet by a of clear space.
DIRECTIONS: Mark off two lines 30 feet apart. Tell student to gallop from one line to the other three times. Tell student to gallop leading with one foot and then the other.

PERFORMANCE CRITERIA:	1st	2nd
*A step forward with the lead foot followed step with the trailing foot to a position adjacent to or behind the led foot.		
*Brief period where both feet are off the ground.		
*Arms bent and lifted to waist level.		
*Able to lead with right and left foot.		

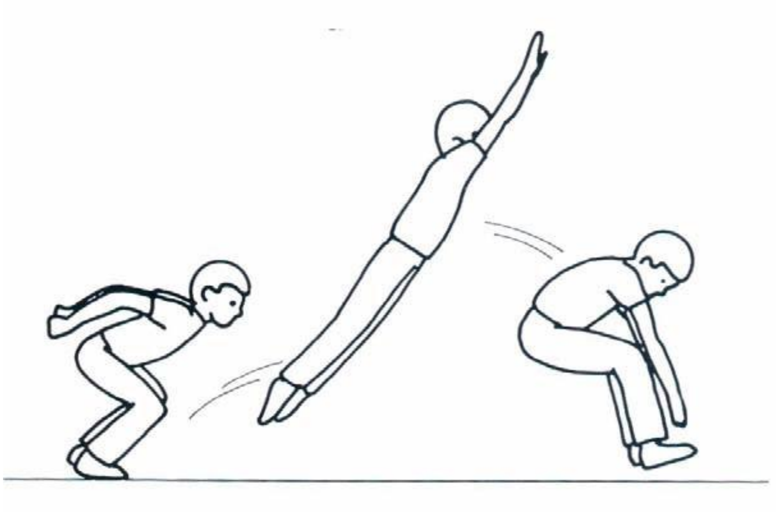


SKILL / EQUIPMENT / DIRECTIONS	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Hop **EQUIPMENT/CONDITIONS:** A minimum of 15 feet of clear space. **DIRECTIONS:** Ask the student to hop three times, first on one foot and then on the other. **This criteria does not require the performance of the other three.	*Foot of nonsupport leg is bent and carried in back of the body.		
	*Nonsupport leg swings in pendular fashion to produce force.		
	*Arms bent at elbows and swing forward on take off.		
	*Able to hop on the right and left foot.**		

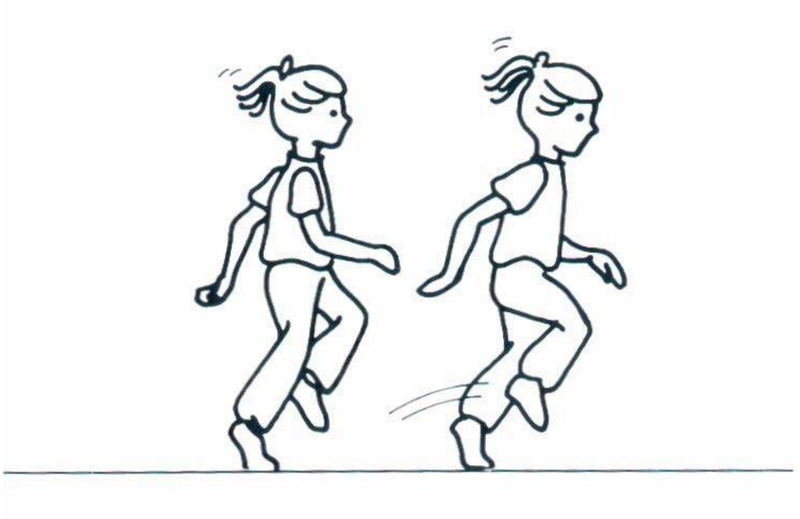


SKILL / EQUIPMENT / DIRECTIONS	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Leap **EQUIPMENT/CONDITIONS:** A minimum of 30 feet of clear space. **DIRECTIONS:** Ask the student to leap. Tell the student to take large steps by leaping from one foot to the other.	*Take off on one foot and land on the opposite foot.		
	*A period where both feet are off the ground (longer than running).		
	*Forward reach with arm opposite the lead foot.		

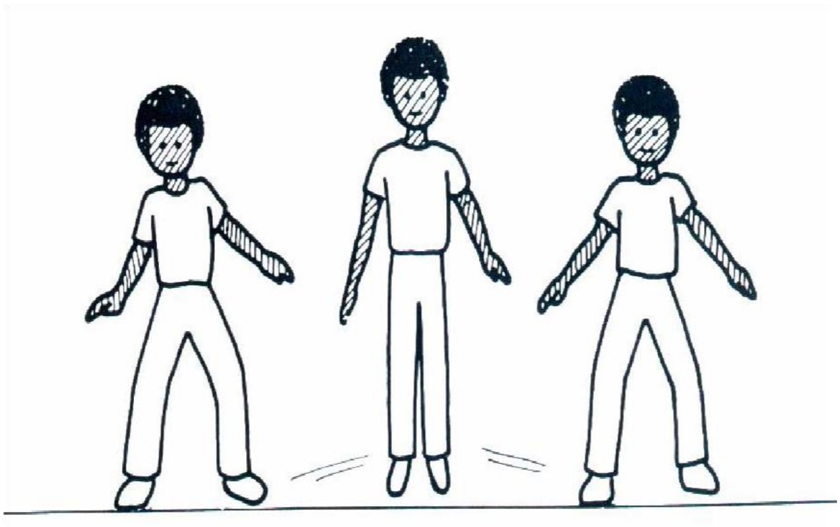
SKILL / EQUIPMENT / DIRECTIONS	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Horizontal Jump **EQUIPMENT/CONDITIONS:** A minimum of 10 feet of clear space and masking tape, or other marking device. **DIRECTIONS:** Mark off a starting line on the floor, mat, or carpet. Have the student start behind the line. Tell the student to "jump far."	*Preparatory movement includes flexion of both knees with arms extended behind the body.		
	*Arms extend forcefully forward and upward, reaching full extension above head.		
	*Take off and land on both feet simultaneously.		
	*Arms are brought downward during landing.		



SKILL / EQUIPMENT / DIRECTIONS	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Skip **EQUIPMENT/CONDITIONS:** A minimum of 30 feet of clear space and masking tape, or other marking device. **DIRECTIONS:** Mark off two lines 30 feet apart. Tell the student to skip from one line to the other three times.	*A rhythmical repetition of the step-hop on alternate feet.		
	*Foot of nonsupport leg carried near surface during hop phase.		
	*Arms alternately moving in opposition to legs at about waist level.		

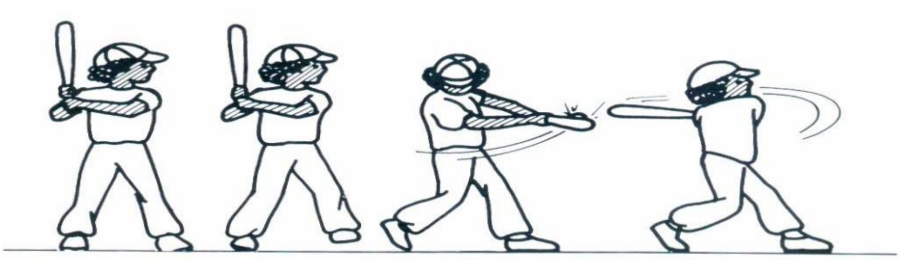


SKILL: / EQUIPMENT/CONDITIONS: / DIRECTIONS:	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Slide **EQUIPMENT/CONDITIONS:** A minimum of 30 feet of clear space and masking tape, or other marking device. **DIRECTIONS:** Mark off two lines 30 feet apart. Tell the student to slide from one line to the other line three times facing the same direction. **This criteria does not require the performance of the other three.	*Body turned sideways to desired direction of travel.		
	*A step sideways followed by a slide of the trailing foot to a point next to the lead foot.		
	*A short period where both feet are off the floor.		
	*Able to slide to the right and to the left side.**		

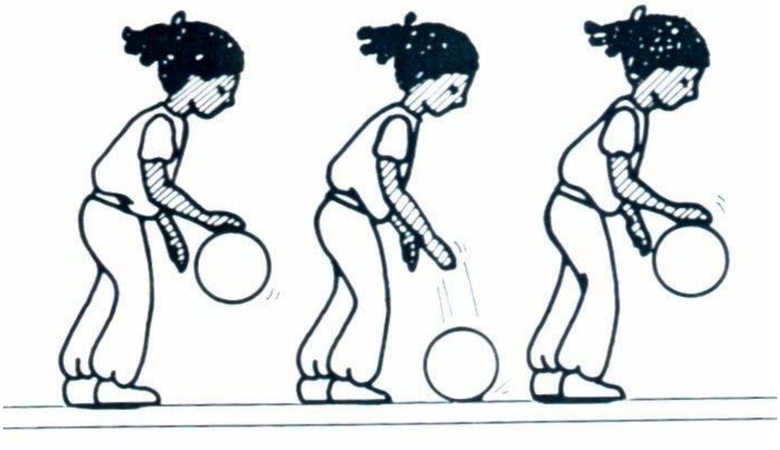


Subtest 2. Object Control Skill

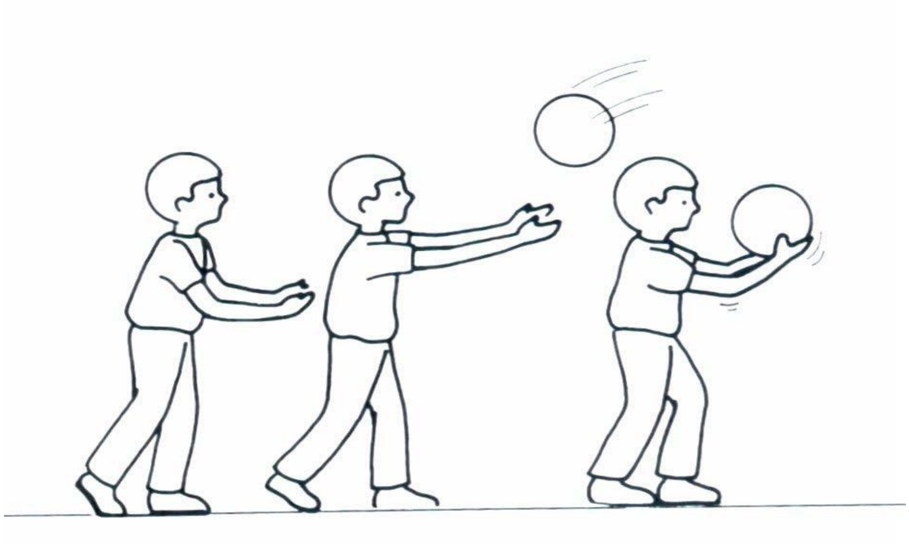
	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Two-Hand Strike **EQUIPMENT/CONDITIONS:** A 4-6 inch lightweight ball and plastic bat. **DIRECTIONS:** Toss the ball softly to the student at about waist level. Tell the student to hit the ball "hard." Count only those tosses that are between the student's waist and shoulders.	*Dominant hand grips bat above nondominant hand.		
	*Nondominant side of body faces the tosser (feet parallel).		
	*Hip and spine rotation.		
	*Weight is transferred by stepping with front foot.		



	PERFORMANCE CRITERIA:	1st	2nd
SKILL: Stationary Bounce **EQUIPMENT/CONDITIONS:** An 8-10 inch playground ball and a flat hard surface. **DIRECTIONS:** Tell the student to bounce the ball three times using one hand. Make sure the ball is not underinflated. Repeat three separate trials.	*Contact ball with one hand at about hip height.		
	*Pushes ball with fingers (not a slap).		
	*Ball contacts floor in front of (or to the outside of) foot on the side of the hand being used.		



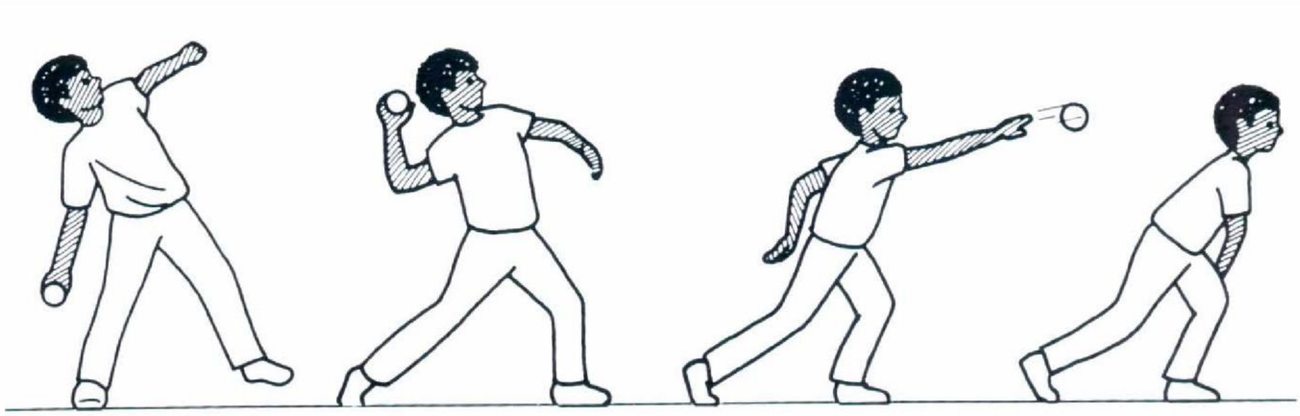
SKILL: Catch **EQUIPMENT/CONDITIONS:** A 6-8 inch sponge ball, flexed 15 feet of clear space, masking tape or other marking device. **DIRECTIONS:** Mark off two lines 15 feet apart. Student stands on one line and the tosser on the other. Toss the ball underhand directly to student with a slight arc, saying "catch it with your hands." Only count those tosses that are between student's shoulders and waist.	**PERFORMANCE CRITERIA:** *Preparation phase where elbows are and hands are in front of body. *Arms extend in preparation for ball contact. *Ball is caught and controlled by hands only. *Elbows bend to absorb force.	**1st**	**2nd**



SKILL: Kick **EQUIPMENT/CONDITIONS:** An 8-10 inch plastic or slightly deflated playground ball, 30 feet of clear space, masking tape or other marking device. **DIRECTIONS:** Mark off one line 30 feet away from a wall and one that is 20 feet from the wall. Place the ball on the line nearest the wall and tell the student to stand on the other line. Tell the student to kick the ball "hard" toward the wall.	**PERFORMANCE CRITERIA:** *Rapid continuous approach to the ball. *The trunk is inclined backward during ball contact. *Forward swing of the arm opposite kicking leg. *Follow-through by hopping on nonkicking foot.	**1st**	**2nd**

SKILL: Overhand Throw
EQUIPMENT/CONDITIONS: A tennis ball, a wall, and 25 feet of clear space.
DIRECTIONS: Tell the student to throw the ball "hard" at the wall.

PERFORMANCE CRITERIA:	**1st**	**2nd**
*A downward arc of the throwing arm initiates the windup.		
*Rotation of hip and shoulder to a point where the nondominant side faces an imaginary target.		
*Weight is transferred by stepping with the foot opposite the throwing hand.		
*Follow-through beyond ball release diagonally across body toward side opposite throwing arm.		



Appendix 7 – Participant Information Sheet and Informed Consent - Chapter 7

Dear Parent/Guardian/Staff,

The Department of Biomolecular and Sport Science at Coventry University are conducting a research study assessing parents and preschool staff's perceptions of physical activity in preschool children in Atherstone, Bedworth and Nuneaton. XXXXXXX has kindly agreed to participate. We would therefore like to ask permission for you to participate. Your children may have previously participated in Study 1 which assessed physical activity carried out in their normal day-to-day routines, using an accelerometer (a watch), which they wore on their arm for four days. Also fundamental motor skills activities were assessed.

The procedure will involve an interview of a focus group from your preschool/nursery setting and the group will be made up of parents and staff. The interview will be recorded using a digital tape recorder and transcribed. The data will be anonymous, treated in confidence and solely used for the purposes of the research study. Participation in the study is entirely voluntary and you have the right to withdraw from the study at any time. Participation in this project will not influence your child's nursery/preschool sessions in any way and could help our scientific understanding of the activity habits of preschool children. We hope you will be interested in participating in this project and should you have any queries please do not hesitate to get in touch.

I am happy to attend the nursery/preschool to discuss the focus group interviews with you in more detail.

Yours Faithfully,

Some materials
have been removed
from this thesis due
to Third Party

Clare Roscoe
PhD Student
Department of Biomolecular and Sport Sciences,
Coventry University
07815 073524

Other information that you may find useful

Withdrawal
If at any time during the testing you would like to withdraw you are free to do so without any recourse

What are the benefits?
We cannot promise the study will help you personally but the information we get from this study will help improve our understanding of the influence of physical activity on health and is importance in helping develop more effective physical activity programmes that can be used to enhance children's health. This is because understanding activity and lifestyle

habits may assist us in developing programmes to increase physical activity and reduce disease risk in future.

What are the risks?
The risks that you may encounter during the interview are minimal and no more than encountered during your normal day-to-day life.

What happens to the information?
Procedures for handling, processing, storage and destruction of their data match the Caldicott principles and the Data Protection Act 1998. All data gathered will be anonymous and treated in strictest confidence. It will only be used for the purposes described above and only the principal researcher will have access to the data.

Who has reviewed this study?
This study has been reviewed and approved by the Ethics Committee at Coventry University and the procedures in place in the study adhere to the Code of Conduct of the British Association of Sport and Exercise Sciences

What if I have more questions?
If you have any further questions please get in touch with the principal researcher for the study, Dr. Mike Duncan, Department of Biomolecular and Sports Sciences, James Starely Building, Coventry, CV1 5FB, Telephone: 02476 888613 or e-mail: michael.duncan@coventry.ac.uk

Further relevant information can also be gained from the British Association of Sport and Exercise Sciences on their website www.bases.org.uk should you feel that your child's participation in the study has raised any issues

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I give permission for myself ________________________ (insert name) to participate in the above mentioned study. I understand that the data will remain anonymous and will only be used for the purposes described above, that I have the right to withdraw and that participation is entirely voluntary.

Signed: ________________________ ____________ (Date)

Signed: ________________________ (Witness) ____________ (Date)

Appendix 8 – Focus Group Script – Chapter 7

Focus Group Script

State: We are looking to seek *your* thoughts and opinions, nothing is right or wrong and you are welcome to talk about but not required to talk about personal experiences.

Some questions asked will be about real issues and some will be speculative.

Stem Questions – Physical Activity

- What is the first thing that you think about when I say the words 'physical activity'?
- What are the benefits of PA?
- What/who are the key sources of PA in the children?
- What is the first thing you think about when I say 'obesity'?
- Who counts as obese?

Obesity and weight

- Why do you think preschool children become fat or obese?
    - Lack of exercise?
    - Eating (healthy/unhealthy? Junk food? Quantity?)
    - Compulsive over eating?
    - Modern lifestyles?
    - Genetics?
- Do you think children can be fat and fit?

Physical Activity and the Environment and Facilities

- What equipment and facilities are there at the nursery that allows the children to be involved in PA, both indoor and outdoor?
- Do you feel that indoor or outdoor space is more important to promote PA in children, or do you consider both important?
- Do any projects occur that promote PA?
- How do you feel the environment/facilities could be adapted to promote PA more?

Physical Activity and Play

- What do you consider 'play' to be?
- How often do you feel the children 'play' per day at nursery?
- Does play and PA interlink?

Barriers to Physical Activity

- What barriers to you feel exist to PA in everyday society?
- What impact do you feel these have on adults and children?
- What barriers do you feel exist to PA at the nursery?

Obesity

- Do you feel the obesity epidemic is happening in children of preschool age?
- What do you think could be done to resolve the obesity epidemic?
- What level of intervention do you feel is necessary to resolve an obesity epidemic e.g. Government, Local Government, Industry and Individuals?

Weight and Responsibility

- Do you think society should be held responsible for preschool children's weight? If so what could society do?
    - Do you have any ideas of social-level interventions?
- Do you think preschool settings should be held responsible for children's PA and weight status? If so what can preschool settings do?

Physical Activity and Fundamental Movement Skills

- Do you know how PA can be measured?
- Do you feel it is important to measure PA levels of preschool children?
- What do you believe 'motor skills' to be?
- Do you understand what FMS is?
- Do you feel it is important to measure FMS in preschool children?
- What involvement with the development of FMS do you feel the nursery has?

Training on Physical Activity

- To what extent do you feel all preschool staff are trained in PA, what it involves and how it can be implemented in preschool settings?
- How would you feel if staff had more training on PA and how it is incorporated into preschool children's day?

Closing

- Do you have any other thoughts or views you would like to share?
- Can you tell me why you decided to participate in this focus group?
- What has it felt like to participate in a focus group? Is it what you expected? (If not, what did you expect?)