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Kaiseree Dias

A dissertation submitted to the University of Bristol in accordance with the requirements for award of the degree of Doctor of Philosophy in the Faculty of Health Sciences

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Abstract

Physical activity is associated with improved physical and mental health in preschool-aged children. Physical activity behaviours established in early childhood track into adulthood. This mixed methods thesis comprises three studies which explored physical activity and sedentary time in 2-4-year-old children.

An epidemiological study of data from the International Children's Accelerometry Database found that 30.0% and 21.2% of 3-4-year-old children from four high-income countries did not engage in internationally-recommended daily total physical activity (≥180 minutes) and moderate-to-vigorous physical activity (≥60 minutes). Variations in activity levels were observed in relation to 10 potential correlates (age, gender, country, season, ethnicity, parental education, day of the week, time of sunrise, time of sunset and hours of daylight).

Next, codebook thematic analysis was used to qualitatively explore mothers' and fathers' perspectives on the barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-old children. A broad range of barriers and facilitators were identified across parents' social and structural environments, which highlighted socioeconomic and racial inequalities in access to activity opportunities. Themes included: children's characteristics and circumstances; interactions with other children; parents' priorities and circumstances; parents' social networks and information sharing; home and childcare environments; organisation-run activities; local authority, council and community-run opportunities; and accessibility and the environment. Mothers were observed to have the main role in children's activity behaviours compared to fathers due to an unequal division in work and childcare.

In the final study, quantitative analyses on acceptability and reliability found that two newly developed questionnaires were appropriate for measuring key parental and nursery staff mediating factors (self-efficacy, motivation and knowledge) towards changing 2-4-year-olds' activity behaviours.

This thesis suggests that 2-4-year-old children may not have equal access to a wide range of physical activity opportunities. Policy, practice and research responses need to promote physical activity through enhanced surveillance, public health interventions and systems-based approaches.

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Author’s Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the *University's Regulations and Code of Practice for Research Degree Programmes* and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: DATE: 03/08/2022

Publications and Conferences

The following two publications were published from the research conducted in this thesis[1, 2]. I am the first author, undertook the analyses and wrote the first drafts of both publications. The contribution of my co-authors is gratefully acknowledged.

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Publications

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List of Abbreviations

α	Alpha Coefficient
A-levels	Advanced Levels
β	Beta Coefficient
BMI	Body Mass Index
CHAMPS	Children's Health and Activity Monitoring Programme
CI	Confidence Interval
COREQ	Consolidated Criteria for Reporting Qualitative Research
cRCT	Cluster Randomised Controlled Trial
DF	Degrees of Freedom
ECC	Early Childhood Caries
EPAO	Environment and Policy Assessment and Observation
EYPS	Early Years Professional Status
EYTS	Early Years Teacher Status
GCE	General Certificate of Education
GCSE	General Certificate of Secondary Education
GNVQ	General National Vocational Qualification
HNC	Higher National Certificate
HND	Higher National Diploma
IBDS	Iowa Bone Development Study

ICAD	International Children's Accelerometry Database
ICC	Intraclass Correlation Coefficient
IMD	Index of Multiple Deprivation
JUMP	Join Us Play More
κ	Kappa Coefficient
LPA	Light Physical Activity
MAGIC	Movement and Activity Glasgow Intervention in Children
METs	Metabolic Equivalent
MPA	Moderate Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
N	Number
NAP SACC	Nutrition and Physical Activity Self-Assessment for Child Care
NCT	National Childbirth Trust
NHS	National Health Service
NVQ	National Vocational Qualification
O-levels	Ordinary Levels
PA	Physical Activity
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QTS	Qualified Teacher Status

R^2	R-squared Values
RCT	Randomised Controlled Trial
ROBIS	Risk Of Bias in Systematic Reviews
SB	Sedentary Behaviour
SCT	Social Cognitive Theory
SD	Standard Deviation
SEF/SEM	Socioecological Framework/Socioecological Model
SEM	Standard Error of Measurement
SES	Socioeconomic Status
ST	Sedentary Time
T	T-value
TPA	Total Physical Activity
TV	Television
UK	United Kingdom
USA	United States of America
VO_2	Oxygen Consumption
VPA	Vigorous Physical Activity
WHO	World Health Organisation
zBMI	Standardised Body Mass Index Score

CHAPTER 1. INTRODUCTION

1.1. Overview

This chapter sets the scene for the thesis and introduces the international and national public health context of preschool-aged children (section 1.2) and discusses the definitions (section 1.3) and influences of physical activity and sedentary time in young children's health and development (section 1.4). In sections 1.5 and 1.6, I provide a summary of how physical activity and sedentary behaviours are measured and the levels of physical activity and sedentary behaviours currently displayed by preschool-aged children. I present how global and local policy contexts relate to reducing inactivity in section 1.7. I conclude this chapter by outlining the thesis aims and research questions (section 1.8) and the mixed methods approach used (section 1.9).

1.2. Public health context for preschool-aged children

According to the World Health Organisation (WHO), 39% of adults aged over 18 years-old were overweight (body mass index (BMI) ≥ 25) and 13% of adults were obese (BMI ≥ 30) in 2016[3]. This reflects a three-fold increase in global obesity rates since 1975[3]. In England, 35% of adults were overweight and 28% obese in 2018[4]. The risk of developing non-communicable diseases such as type 2 diabetes, cardiovascular diseases, musculoskeletal disorders and some cancers is raised with increases in BMI[3]. One analysis has estimated that obesity costs the United Kingdom (UK) £58 billion annually[5]. This figure includes: National Health Service (NHS) costs (e.g. primary care, hospitalisations, medications and antidepressants); individual costs (i.e. loss of quality of life); wider costs (e.g. loss of workplace productivity and social care costs); and COVID-19 costs (i.e. higher probability of hospitalisation and death)[5]. Alongside improvements in dietary patterns, overweight/obesity and related non-communicable diseases can be prevented in part by engaging in regular physical activity and reducing physical inactivity[3].

For children under the age of five, overweight and obesity are defined as having a standardised BMI (zBMI) score that is two and three deviations higher than the WHO Child Growth Standards median, respectively[3]. Globally, the number of overweight and obese children under the age of five was estimated at 39 million in 2020[3]. In England, the National Child Measurement Programme survey calculated that 13.3% of 4-5-year-old children were overweight and a further 14.4% obese in the 2020/2021 school year, which has increased from 13.1% and 9.9% respectively, in 2019/2020[6]. Children living with obesity are at greater risk of conditions such as hypertension, breathing difficulties, fractures, insulin resistance and psychological effects[3]. Childhood obesity is also a predictor of obesity, disability and premature death in adulthood[3, 7]. Conversely, being physically active in early childhood is positively associated with several health indicators[8-12] (see section 1.4), including psychosocial health[13], cognitive development[14], fundamental motor skills[15] and motor development[16].

In combination with maintaining a healthy diet, increasing physical activity and decreasing time spent being sedentary plays a key role in the primary and secondary prevention of overweight and obesity[17, 18]. Being physically active and reducing inactivity in preschool-aged children is also beneficial to young children's health and development (see section 1.4)[8-12]. It is therefore imperative that promoting physical activity in this age group is considered a public health priority. Evidence suggests that physical activity and sedentary behaviour patterns track from early childhood (0-5-years-old) into adolescence, making the early years a key time to promote beneficial physical activity behaviours[19]. When referring to preschool-aged children throughout this thesis, I will be discussing 2-4-year-old children, which is in line with international and UK physical activity guidelines and research (see section 1.6). This is to ensure that the thesis findings are relevant to this age group, where it is assumed that able-bodied children can fully engage with physical activities, and before these children have begun formal schooling in the UK.

1.3. Defining physical activity and sedentary behaviour

Physical activity (PA) can be defined as any bodily movement produced by skeletal muscles that results in energy expenditure (>1.5 metabolic equivalent (METs))[20]. Physical fitness refers to a set of attributes that individuals must achieve which are either health- or skill-related and can be measured with specific tests[20]. Exercise is a subcategory of physical activity involving planned, structured and repetitive bodily movement, done to improve or maintain physical fitness components[20]. Although children under the age of five can exercise, they are more likely to engage in physical activity through play, which can be described as being voluntary, enjoyable, imaginative and without having a specific goal in mind[21]. Unstructured play is primarily child-led, and has no particular outcome or rules, allowing children to work on decision-making and discovery on their own, whereas structured play has a set outcome in mind and is often adult-led[22]. In contrast to physical activity, sedentary behaviours (SB) consist of any waking behaviours which are characterized by an energy expenditure ≤1.5 METs while in a sitting, reclining or lying position[23]. Sedentary time (ST) refers to periods spent sitting, which for children under five-years-old could include sitting in high-chairs, buggies or listening to a story[21]. Sedentary screen time refers to passive engagement with screen-based entertainment[21].

1.4. Importance of physical activity for health and development

Two systematic reviews by Timmons et al[8] and Carson et al[9] found beneficial associations between physical activity and a wide range of health indicators in 0-4-year-olds, which included: adiposity; bone and skeletal health; motor skill development; psychosocial health; cognitive development; cardiometabolic health; and physical fitness. The authors of the more recent review[9] consistently found that more physical activity in terms of frequency and duration was better for young children's health indicators and highlighted the importance of children in the early years being physically active. A systematic review by LeBlanc et al[10] found that increased television (TV) viewing was unfavourably associated with adiposity, psychosocial health and cognitive development scores. A more recent systematic review by Poitras et al[11] also found that increased screen time was positively associated with adiposity measures and negatively associated with measures of psychosocial health, motor and cognitive development. The authors however observed that some included studies showed null associations[11]. Associations between objectively measured sedentary time and adiposity and motor development were either unfavourable or null whereas time spent reading/storytelling showed beneficial or null associations[11]. Dose-response relationships were evident in terms of increased television watching and decreased cognitive development and psychosocial health[11]. However, the authors highlighted that further data is needed to look at the appropriate types, patterns and durations of sedentary behaviour needed to promote optimal health outcomes[10, 11]. None of the included studies reported on associations between sedentary behaviours and bone and skeletal health or cardiometabolic health indicators[10, 11].

A systematic review by Rollo et al[12] assessed adherence to 24-hour movement guidelines (which is a compositional mix of physical activity, sedentary behaviour and sleep recommendations) and health indicators across the lifespan. The findings showed that adherence to the 24-hour movement guidelines was beneficially associated with social-cognitive development, health-related quality of life and behavioural and emotional problems among preschool-aged (3-4-years-old) children but not associated with adiposity among toddlers (1-2-years-old)[12]. Favourable associations were also found between the composition of 24-hour movement behaviours with adiposity, bone and skeletal health among preschoolers[12]. All the reviews[8-12] identified a few important limitations with including many low-quality evidence studies and the need to carry out narrative syntheses instead of quantitative meta-analyses, due to the heterogeneity in outcome measurements across the included studies. The evidence therefore signals the need for higher quality studies to be conducted with stronger study designs (e.g. longitudinal) and standardised outcome measurement protocols, to assess the associations between physical activity, sedentary time and health indicators in preschool-aged children.

1.5. Measurement of physical activity and sedentary behaviours

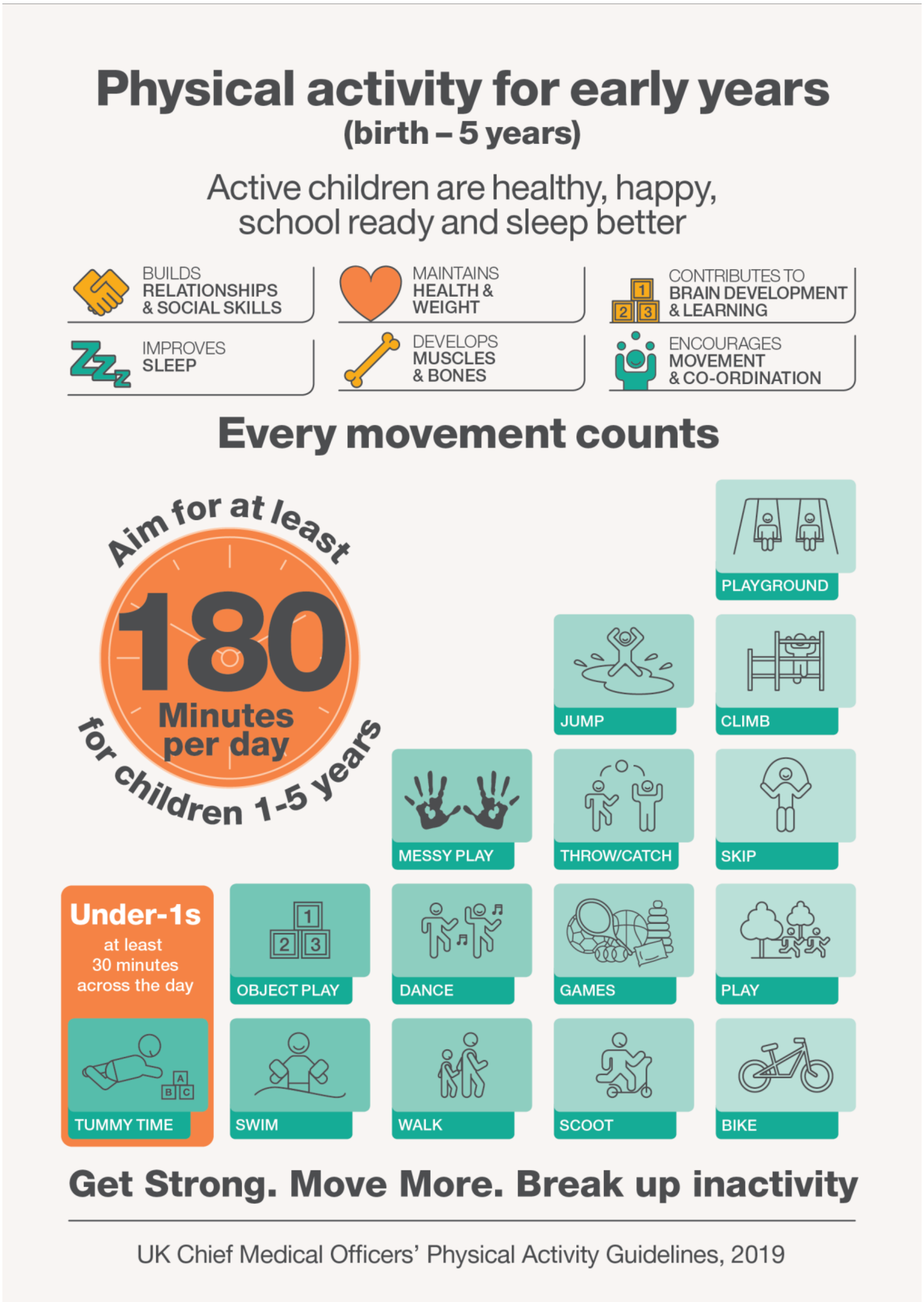
It is essential to measure physical activity/sedentary time and sedentary behaviours in preschool-aged children for: surveillance; guideline adherence; to inform policy and intervention development; and to establish the effectiveness of interventions and policies designed to target these behaviours[24, 25]. Physical activity and sedentary behaviours can be measured using a variety of different tools: proxy self-report measures (e.g. diaries, parent questionnaires); device-based measurement tools (e.g. accelerometers, heart rate monitors); energy expenditure measures (e.g. whole room calorimetry, doubly labelled water); and direct observation[26]. To be appropriate for the preschool-aged population, the choice of measurement tool needs to reflect: their reduced cognitive abilities[27] and inability to self-report their own behaviours; their sporadic movement patterns[28]; and their increased likelihood of interfering with device-based measurement tools[29].

A recent review by Phillips et al[26] examined the reliability, validity and feasibility of measurement tools used to assess physical activity and sedentary behaviour in preschool-aged children. The authors concluded that based on the available evidence, accelerometers (Actigraph, Actical and ActivPAL) have the best measurement properties for physical activity and sedentary time in preschoolers and should be the tool of choice when possible; ideally used with proxy reported measurement tools for contextual information, which is not collected by device-measurement tools[26]. The authors also found that Fitbits (Flex and Zip) may be appropriate for physical activity measurement, and that proxy measurements can provide valid data when budgets are limited[26].

1.6. Levels of physical activity and sedentary time in preschool-aged children

The WHO recommend that able-bodied children aged 1-4-years-old should spend at least 180 minutes per day in a variety of types of physical activities, with 3-4-year-olds spending at least 60 minutes of this time engaging with moderate-to-vigorous activity (active play)[21]. The WHO also recommend that 1-4-year-olds should not be sedentary for more than 60 minutes at a time, with 2-4-year-olds having sedentary screen time limited to a maximum of one hour per day[21]. The UK Chief Medical Officers have the same physical activity recommendations as the WHO for healthy, typically developed toddlers (1-2-years-old) and preschoolers (3-4-years-old) but do not have specific sedentary or screen time guidelines[30] (see Figure 1). The only available, and most nationally representative physical activity and sedentary time data in England is from the Health Survey for England, which found that 9% of 2-4-year-olds were classified as meeting the guidelines of 180 minutes of physical activity per day in 2015[31]. Approximately 4% and 9% of 2-4-year-olds spent six hours or more in sedentary time on weekdays and weekends respectively[31]. Further, 83% of 2-4-year-olds did less than one hour of physical activity either on all or some days of the week[31]. It is important to recognise however, that while these data were collected from a representative sample of children, the survey used a parent-reported assessment of physical activity which is a less accurate method of measuring physical activity and sedentary time[26, 31].

Figure 1: Infographic of the UK physical activity guidelines for early years[30]



Individual studies[32-37] have assessed adherence to nationally recommended guidelines[38-40] in their study populations using objectively measured physical activity and proxy self-reported screen time. Internationally, the percentage of preschool-aged children meeting recommended guidelines of 180 minutes of physical activity per day ranged from 5.1%[34] (Australia) to 100%[32, 33] (UK), with one study[35] (Canada) finding that 13.7% spent at least 60 minutes in moderate-to-vigorous physical activity (MVPA) per day. Other studies have found that 17.3%[37] (Australia) to 24.4%[36] (Canada) of preschool-aged children met screen time guidelines of less than one hour per day. However, it is not possible to compare these study findings due to differences in the accelerometry processing protocols and self-report measures which were applied in each study.

A systematic review by Pereira et al[41] conducted a meta-analysis of accelerometry-measured sedentary time in early childhood. The meta-analysis found that a sample of 14,598 2-5-year-olds from 50 studies spent 51.4% of their waking time in sedentary time[41]. As mentioned earlier, the authors discussed the need for higher quality evidence involving the use of age-appropriate measurement devices, validated accelerometry cut points and accelerometry wear time criteria[41]. A recent systematic review by Tapia-Serrano et al[42] conducted a meta-analysis to assess the proportion of children who met 24-hour movement guidelines[21]. In the sample of 11,768 3-5-year-olds from 26 studies in 14 countries, the authors found that 11.3% met all three movement guidelines and 8.81% did not meet any of the 24-hour movement recommendations[42]. The inclusion of studies with different self-report and device-based physical activity and sedentary behaviour measurements introduced some limitations regarding the validity and reliability of the analyses[42]. The authors also discussed that bias may have arisen from the 24-hour movement guidelines that were implemented in Canada, Australia, New Zealand, South Africa and Asia-Pacific between 2016 – 2021[42].

1.7. Physical activity and sedentary behaviour policies for preschool-aged children

In 2018, the WHO released a global action plan which provided updated guidance and a framework of feasible and effective policy actions that countries could implement to promote physical activity at all levels using a systems-based approach[43]. The WHO's goal is to globally reduce inactivity by 10% by 2025 and by 15% by 2030[43]. The plan outlines four objectives: create active societies – social norms and attitudes; create active environments – spaces and places; create active people – programmes and opportunities; and create active systems – governance and policy enablers[43]. It also presents 20 policy actions that are universally applicable to all countries in considering individual, cultural and environmental factors of inactivity[43]. Implementation of effective whole systems-based approaches requires dedicated leadership and the WHO have stated that they will logistically and financially support countries to co-ordinate multisectoral and cross-government partnerships to reduce inactivity across all ages and abilities[43]. One of the first barriers to implementing policy changes and systems-based approaches is that this requires a high degree of political and governmental agency. It also requires that these bodies acknowledge the public health priority of increasing physical activity and decreasing sedentary time in under-fives. This highlights the important role of academic researchers in providing evidence and recommendations to appropriate stakeholders.

In the UK, the government's 'Childhood Obesity: A Plan for Action' report was published in 2016, which outlined strategies to reduce rates of childhood obesity over the following 10 years[44]. The report was condemned by several stakeholders, who criticised its lack of accountability and mandatory recommendations, and for the removal of strategies before publication relating to restricting junk food advertising and promotions[45, 46]. The report's only reference to physical activity in the early years was the updating of the Early Years Foundation Stage Framework to include the UK guidelines for physical activity[30, 44]. In the second report which was published in 2018, it stated that Ofsted would be conducting research into what curriculum best supports physical development in the early years, which is limited as teaching 2-4-year-olds about healthy behaviours is unlikely to lead to behaviour change[47].

Ensuring that children have the best start in life was identified as a priority within Public Health England's five-year strategy, which runs from 2020 to 2025[48]. At the local authority level in England, public health teams are responsible for commissioning the Healthy Child Programme, which aims to help establish a healthy life for all children[49, 50]. The 'Pregnancy and first five years of life' part of the programme is run by health visitors, who offer families a programme of immunisations, screening tests, developmental reviews and information and guidance to help support parents to make healthy choices[49, 50]. This includes the identification of early risk factors for obesity and supporting parents to promote healthy physical activity behaviours to reduce the risk of obesity[49, 50].

1.8. Thesis aims and research questions

The overall aim of the PhD is to build on the work and challenges identified above by using a mixed methods approach to explore physical activity and sedentary time in preschool-aged children. I will be exploring the levels, factors, barriers and facilitators associated with physical activity and sedentary time in preschool-aged children. The findings from the thesis may be used to inform the design of interventions and policies to decrease sedentary time and increase physical activity levels in under-fives in the UK. The PhD components aim to address the research questions and gaps in the literature that have been identified in the Introduction (Chapter 1) and Literature Review (Chapter 2). The thesis research questions are summarised below:

1. What are the levels and potential correlates of sedentary time and physical activity in preschool-aged children (Chapter 3)?
2. What does the most methodologically robust evidence show in terms of factors associated with changes in physical activity and sedentary time in preschool-aged children (Chapter 2)?
3. What are the barriers and facilitators of increasing physical activity and decreasing sedentary time in preschool-aged children (Chapter 4)?
4. What self-report measures could be used to assess mediating factors relating to parents' and nursery staff's self-efficacy, motivation and knowledge towards preschoolers' activity behaviours (Chapter 5)?

The thesis is organised into six chapters. In Chapter 2, I summarise existing systematic review findings on the correlates and determinants of physical activity and sedentary time, to explore potential behaviour change intervention targets. Chapter 3 is a quantitative study which aims to demonstrate this public health priority by determining the levels of objectively measured physical activity and sedentary time in preschool-aged children internationally. Chapter 3 also aims to assess correlates of physical activity and sedentary time in under-fives, to identify factors which may enable or limit physical activity. The qualitative study I report in Chapter 4 aims to identify parents' views of barriers and facilitators to preschoolers' activity. In Chapter 5, I present a quantitative study to evaluate the reliability of questionnaires which measure mediating factors associated with physical activity and sedentary behaviours in 2-4-year-olds. Chapter 6 provides an overall discussion of the thesis findings and the implications that arise from the work.

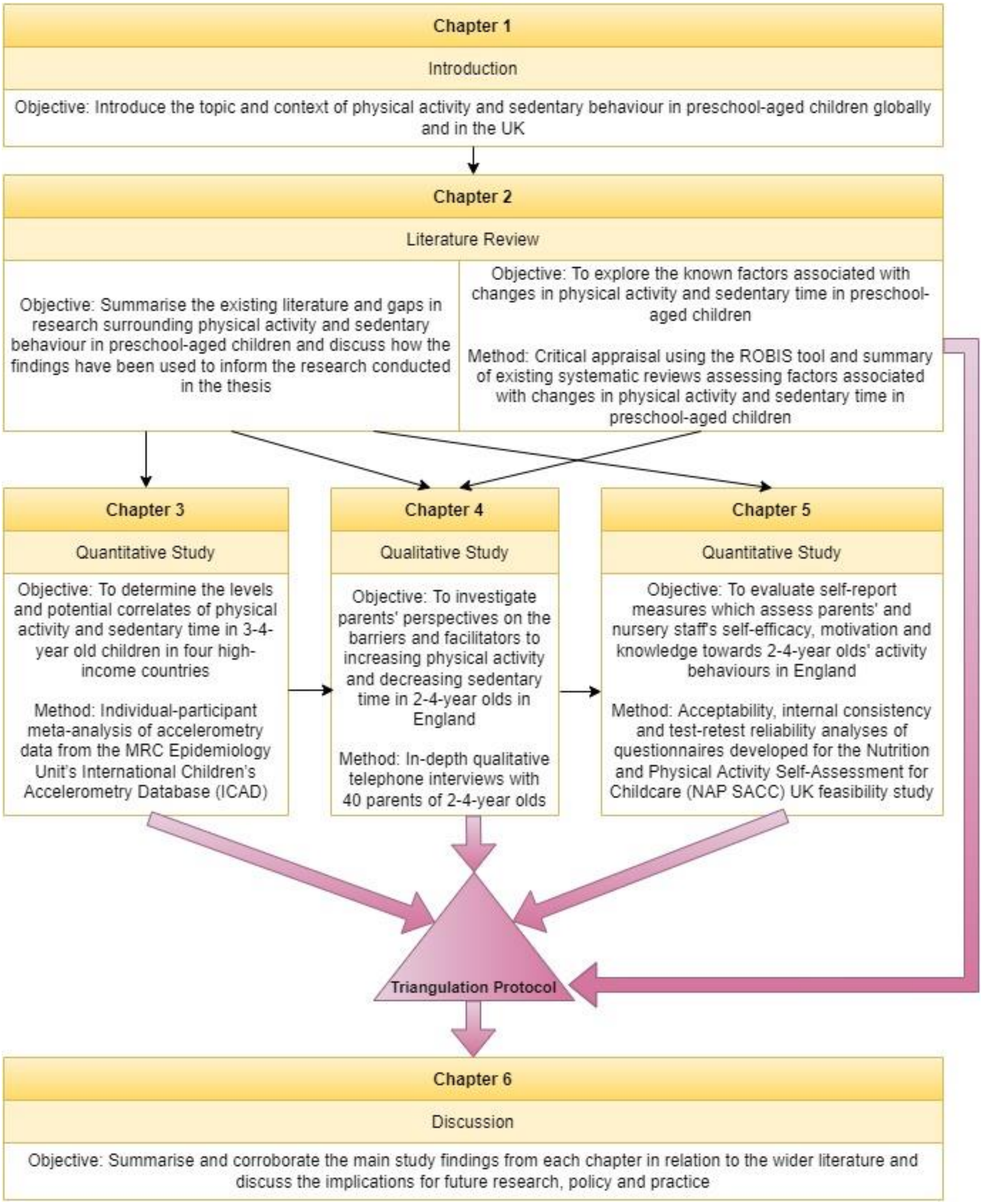
1.9. Mixed methods research in the context of the thesis

Mixed methods can be described as a third research paradigm where a combination of quantitative and qualitative methods are used in a single study to analyse data and integrate findings[51]. Mixed methods research is commonly used in health services research and is guided by pragmatism rather than principle. A key concept is that no single approach (such as quantitative methods) can provide a complete understanding of complex health care research questions, which require multiple ways of looking at them[52]. 'Pragmatists' argue that there is a false dichotomy between quantitative and qualitative research and encourage the use of both methods[53]. Quantitative methods can be used to address the 'what' research questions whereas qualitative methods address the 'why' of different but related research questions[54]. Using mixed method approaches allows for the strengths of one method to counterbalance the limitations of another method, for example, qualitative methods can be used to explain findings identified from quantitative methods[55]. O'Cathain[56] et al refer to three analytical techniques for integrating data from quantitative and qualitative studies in mixed methods research:

- *Triangulation protocol*[56] is when separate quantitative and qualitative studies are conducted to address different objectives within an overarching research question. The study findings are combined at the interpretation stage to observe convergence, discrepancy and complementarity between the study findings. This method also looks for 'silences' where findings or themes identified in one method are not found in another.
- *Following a thread*[56] describes themes or research questions which are identified at the initial analysis stage of each component; then the theme or question from one component is investigated further across other components.
- The *mixed methods matrix*[56] approach involves conducting quantitative and qualitative methods on the same cases within a study, therefore allowing cases to be studied at the analysis stage of the mixed methods study.

The thesis will use a *triangulation protocol*[56] analytical approach (see Figure 2) to address the overall aim of the thesis through conducting separate quantitative and qualitative studies and corroborating study findings in the discussion chapter (Chapter 6). Another possible view is that the thesis could be described as a multimethod study, which can be defined as the collection of data from different sources using different research methods, to produce results which will help explain human and social behaviour[57]. The terms 'mixed methods' and ‘multimethods’ have been used synonymously amongst researchers, making it more difficult to differentiate between the two definitions[58]. However, the integration of findings from the different studies is a key part of mixed methods research, which is not required in multimethods research[58]. As I have employed a *triangulation protocol* approach to analyse the study findings in the discussion chapter of the thesis, my PhD can be described as mixed methods research[56]. Figure 2 provides an overview of the thesis structure by chapter, research objective and methods.

Figure 2: Structure of the thesis within the context of mixed methods research



Note: Black arrows indicate where findings have been used to inform aspects of the study/chapter. Pink arrows indicate the triangulation protocol approach in corroborating the study findings to address the overall aim of the thesis.

CHAPTER 2. LITERATURE REVIEW

2.1. Overview

In Chapter 1, I introduced the public health context of the need to increase physical activity and decrease sedentary time in 2-4-year-old children in the UK, and listed the four research questions that this thesis aims to address. This literature review chapter provides a critical summary of the existing literature related to the focus of the PhD and provides a rationale for conducting the different components of the thesis. Throughout the chapter, I discuss how the findings from the literature have been used to inform the research that has been conducted as part of the PhD.

The first section of this chapter (section 2.2) critically appraises key systematic reviews which have assessed factors associated with physical activity and sedentary time in preschool-aged children. I outline how the research gaps I identified across these reviews are addressed in the study I present in Chapter 3 and throughout the thesis. To inform Chapter 4, I critically evaluate existing qualitative literature and research on physical activity and sedentary time in preschoolers (section 2.3). Finally, in section 2.4, I outline physical activity interventions and introduce the importance of assessing mediating factors relating to the activity behaviours of 2-4-year-olds, to support the work presented in Chapter 5.

2.2. Summary of existing literature relating to factors associated with physical activity and sedentary time in preschool-aged children

2.2.1. Critical appraisal of quantitative reviews assessing factors associated with physical activity and sedentary time in preschool-aged children

In this section (2.2.1) I describe how I identified and critically appraised systematic reviews which assessed factors associated with physical activity and sedentary time in preschool-aged children. In section 2.2.2 I discuss the limitations highlighted by these reviews in terms of assessing the levels and correlates of activity measures and how I will address these limitations in Chapter 3. In section 2.2.3 I summarise the findings from these reviews and answer Research Question 2 of the thesis: *'What does the most methodologically robust evidence show in terms of factors associated with changes in physical activity and sedentary time in preschool-aged children?'*. In section 2.2.4 I describe the overarching limitations and gaps in the research and how I intend to address them with the thesis.

At the start of my PhD, I used a systematic approach to identify and critically appraise relevant systematic reviews, to inform the direction of the thesis. The aim of the initial literature search was to identify systematic reviews relating to factors that are associated with physical activity and sedentary time in preschool-aged children. I focussed on reviews as they can provide more reliable conclusions compared to looking at individual studies and can be used to identify gaps in the literature[59]. Appendix 1 shows the search strategy that was used to identify the relevant reviews. The following databases were searched in 2018: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present, Cochrane Library and PROSPERO. I chose these databases as they are suitable for finding internationally published and prospective reviews in the field of medicine and healthcare. Results from the literature searches were exported into EndNote X9. Titles, abstracts and full texts were screened in line with the PECO eligibility criteria: preschool-aged children; sedentary time and/or physical activity; correlates, determinants; and reviews. Reference lists of identified papers were checked for additional reviews.

Appendix 2 summarises the content of the identified systematic and narrative reviews (n = 6) of quantitative studies which have assessed factors associated with sedentary time and physical activity in preschool-aged children. Across the reviews, factors are referred to as either correlates or determinants. Correlates can be described as cross-sectional statistical associations or correlations between measured variables and activity outcomes[60]. Determinants are longitudinal factors in which temporal associations may be observed over time and variations in these factors lead to systematic variations in physical activity and sedentary behaviours[60]. The information in Appendix 2 has been presented in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist[61]. The reviews by Bingham et al[62] and Hesketh et al[63] adhered to the PRISMA reporting guidelines in full whereas the other reviews did not report some aspects. The reviews were published between 2008 and 2017. Four[62-65] were named as systematic reviews in their titles, whereas the other two[66, 67] were not described as systematic reviews.

I critically appraised the identified systematic reviews to judge the quality of their evidence and whether it was appropriate to use their conclusions to inform the various components of the thesis. I used the Risk Of Bias in Systematic Reviews (ROBIS)[68] to assess the risk of bias in the identified systematic reviews, as this can be tailored to assess reviews which have synthesised evidence using different study designs. Table 1 provides a summary of these risk of bias assessments where I adhered to the guidance featured on www.robis-tool.info in performing these assessments. Phase one (not included in Table 1) involved determining whether the identified reviews were relevant to addressing the research question i.e. whether they quantitatively assessed factors associated with activity measures in preschool-aged children. Phase two involved four domains relating to concerns regarding bias: 1) study eligibility criteria; 2) identification and selection of studies; 3) data collection and study appraisal; and 4) synthesis and findings. Each domain requires a rating of low, high or unclear concern. Phase three considers the findings from Phase two in summarising the overall risk of bias of the review, categorised as low, high or unclear risk of bias.

Table 1: Assessment of the risk of bias of reviews exploring factors associated with sedentary time and physical activity in preschool-aged children using the ROBIS tool (Phase 2 and Phase 3)

PHASE 2						
DOMAIN 1: STUDY ELIGIBILITY CRITERIA						
	Bingham et al[62]	De Craemer et al[64]	Hesketh et al[63]	Hinkley et al[66]	Hinkley et al[67]	Li et al[65]
1.1 Did the review adhere to pre-defined objectives and eligibility criteria?	PY	PY	Y	PY	PY	PY
1.2 Were the eligibility criteria appropriate for the review question?	Y	Y	Y	Y	Y	Y
1.3 Were eligibility criteria unambiguous?	Y	Y	Y	Y	Y	Y
1.4 Were all restrictions in eligibility criteria based on study characteristics appropriate?	Y	Y	Y	Y	Y	Y
1.5 Were any restrictions in eligibility criteria based on sources of information appropriate?	PN	PN	PY	PN	PN	PN
Concern for specification of study eligibility criteria	High concern	High concern	Low concern	High concern	High concern	High concern

Rationale for concern	No study protocol but objectives and eligibility criteria appear to be pre-defined. Only included published, peer-reviewed studies which can be justified given the narrative synthesis method used. Unjustified in restricting to English language studies only.	No study protocol but objectives and eligibility criteria appear to be pre-defined. Only included full-text studies which can be justified given the narrative synthesis method used. Unjustified in restricting to English language studies only.	Only full-text studies included which can be justified given the narrative synthesis method used.	No study protocol but objectives and eligibility criteria appear to be pre-defined. Only included published, peer-reviewed studies which can be justified given the narrative synthesis method used. Unjustified in restricting to English language studies only.	No study protocol but objectives and eligibility criteria appear to be pre-defined. Only included published, peer-reviewed studies which can be justified given the narrative synthesis method used. Unjustified in restricting to English language studies only.	No study protocol but objectives and eligibility criteria appear to be pre-defined. Unjustified in restricting to English language studies only.
DOMAIN 2: IDENTIFICATION AND SELECTION OF STUDIES						
	Bingham et al[62]	De Craemer et al[64]	Hesketh et al[63]	Hinkley et al[66]	Hinkley et al[67]	Li et al[65]
2.1 Did the search include an appropriate range of databases/electronic sources for published and unpublished reports?	Y	PN	Y	Y	Y	Y
2.2 Were methods additional to database searching used to identify relevant reports?	Y	Y	Y	Y	Y	Y

2.3 Were the terms and structure of the search strategy likely to retrieve as many eligible studies as possible?	PN	PN	Y	PN	PN	PN
2.4 Were restrictions based on date, publication format, or language appropriate?	Y	Y	Y	Y	Y	Y
2.5 Were efforts made to minimise error in selection of studies?	Y	Y	Y	NI	NI	Y
Concern regarding methods used to identify and/or select studies	Low concern	High concern	Low concern	High concern	High concern	Low concern
Rationale for concern	Inadequate search terms and combinations.	Inadequate search terms and combinations. PubMed search only but appropriate for the type of literature.		Inadequate search terms and combinations. No information on screening abstracts and titles or full-text assessment.	Inadequate search terms and combinations. No information on screening abstracts and titles or full-text assessment.	Inadequate search terms and combinations.
DOMAIN 3: DATA COLLECTION AND STUDY APPRAISAL						
	Bingham et al[62]	De Craemer et al[64]	Hesketh et al[63]	Hinkley et al[66]	Hinkley et al[67]	Li et al[65]
3.1 Were efforts made to minimise error in data collection?	Y	NI	Y	NI	NI	NI

3.2 Were sufficient study characteristics available for both review authors and readers to be able to interpret the results?	Y	Y	Y	Y	Y	Y
3.3 Were all relevant study results collected for use in the synthesis?	Y	Y	Y	Y	Y	NI
3.4 Was risk of bias (or methodological quality) formally assessed using appropriate criteria?	Y	N	Y	N	N	Y
3.5 Were efforts made to minimise error in risk of bias assessment?	Y	N	NI	N	N	Y
Concern regarding methods used to collect data and appraise studies	Low concern	High concern	Low concern	High concern	High concern	Unclear concern
Rationale for concern		No information regarding data extraction. Risk of bias not formally assessed.	Not clear whether risk of bias assessment was conducted by two independent reviewers.	No information regarding data extraction. Risk of bias not formally assessed.	No information regarding data extraction. Risk of bias not formally assessed.	No information regarding data extraction or results collected.
DOMAIN 4: SYNTHESIS AND FINDINGS						
	Bingham et al[62]	De Craemer et al[64]	Hesketh et al[63]	Hinkley et al[66]	Hinkley et al[67]	Li et al[65]

4.1 Did the synthesis include all studies that it should?	Y	Y	Y	NI	NI	Y
4.2 Were all pre-defined analyses reported or departures explained?	NI	NI	Y	NI	NI	NI
4.3 Was the synthesis appropriate given the nature and similarity in the research questions, study designs and outcomes across included studies?	PY	PY	PY	PY	PY	Y
4.4 Was between-study variation (heterogeneity) minimal or addressed in the synthesis?	Y	Y	Y	Y	Y	Y
4.5 Were the findings robust, e.g. as demonstrated through funnel plot or sensitivity analyses?	PN	PN	PN	PN	PN	Y
4.6 Were biases in primary studies minimal or addressed in the synthesis?	Y	N	N	N	N	N
Concern regarding the synthesis and findings	High concern	High concern	High concern	High concern	High concern	High concern
Rationale for concern	Narrative synthesis method appropriate, but	Narrative synthesis method appropriate but	Narrative synthesis method appropriate but	No information/ flow chart available to assess	No information/ flow chart available to assess	Risk of bias assessment results not

	not the quantitative element not due to heterogeneity in outcomes. A different approach could lead to different conclusions, but justified due to limited literature.	quantitative element not due to heterogeneity in outcomes. Different approach could lead to different conclusions but justified due to limited literature. Risk of bias not assessed.	quantitative element not due to heterogeneity in outcomes. Different approach could lead to different conclusions but justified due to limited literature. Risk of bias assessment results not incorporated in synthesis.	numbers. Narrative synthesis method appropriate but quantitative element not due to heterogeneity in outcomes. Different approach could lead to different conclusions but justified due to limited literature. Risk of bias not assessed.	numbers. Narrative synthesis method appropriate but quantitative element not due to heterogeneity in outcomes. Different approach could lead to different conclusions but justified due to limited literature. Risk of bias not assessed.	incorporated in synthesis.
PHASE 3: RISK OF BIAS IN THE REVIEW						
	Bingham et al[62]	De Craemer et al[64]	Hesketh et al[63]	Hinkley et al[66]	Hinkley et al[67]	Li et al[65]
A. Did the interpretation of findings address all of the concerns identified in Domains 1 to 4?	PY	N	PY	N	N	N
B. Was the relevance of identified studies to the review's research question appropriately considered?	Y	Y	Y	Y	Y	Y

C. Did the reviewers avoid emphasizing results on the basis of their statistical significance?	Y	Y	Y	PY	PY	Y
Risk of bias in the review	Low risk of bias	High risk of bias	Low risk of bias	High risk of bias	High risk of bias	High risk of bias
Rationale for risk	Exclusion of non-English publications and inclusion of low-quality studies stated as limitations.	Limitations in synthesis method discussed. The remaining concerns identified in Phase two were not addressed in the review discussion or conclusions.	Inclusion of published studies only stated as publication bias. Risk of bias scores not incorporated or justified but may be due to a lack of literature.	Concerns identified in Phase 2 were not addressed in the review discussion or conclusions.	Concerns identified in Phase 2 were not addressed in the review discussion or conclusions.	Concerns identified in Phase 2 were not addressed in the review discussion or conclusions.

Note: Y=Yes, PY=Probably Yes, PN=Probably No, N=No, NI=No Information

Using the ROBIS tool, the systematic reviews by Bingham et al[62] and Hesketh et al[63] were rated as having a relatively low risk of bias whereas the other four reviews[64-67] had a relatively high risk of bias. The rationale sections in Table 1 provide a more detailed description of the concerns and bias risk. In general, the reviews had the following issues: no study protocols; the inclusion criteria were limited to English language studies only; inadequate search terms and combinations to identify all relevant studies; limited or no information on data extraction methods; no form of risk of bias assessment or description of how these assessments have been reflected in the analysis; and the use of narrative synthesis methods. Although the reviews by Bingham et al[62] and Hesketh et al[63] had their limitations, the authors appropriately discussed these limitations and the impacts on the findings and therefore these two systematic reviews[62, 63] were deemed to be of low risk of bias.

The findings from this assessment highlight the limitations with using the ROBIS tool. For example, differentiations between the levels of concerns and overall risk of bias in Phases two and three were limited to just three categories: low, high or unclear. There is a subjective element to judging the concerns and risk of bias which may lead to different conclusions if undertaken by someone else. Similarly, judgements may have been based on comparisons between the different reviews and therefore, different conclusions may have been reached if different reviews were critiqued. The ROBIS tool provides a framework which allows researchers to systematically and thoroughly assess where biases may have been introduced in the design and conduct of systematic reviews[68]. One of the strengths of using the ROBIS tool in the early stages of the PhD is that it made me appreciate the importance of designing and conducting high quality studies and reducing the introduction of bias where possible. The ROBIS tool influenced my use of other reporting checklists (e.g. Consolidated Criteria for Reporting Qualitative Research (COREQ)[69]) when designing and writing up the studies from my PhD. Where the introduction of bias was unavoidable, I made sure to discuss the implications of bias on the study findings, which some of the reviews I assessed with the ROBIS tool failed to do so appropriately. Whilst it is important to acknowledge that the risk of bias assessments have these limitations, their use in directing the next stages of the thesis can still be considered appropriate.

2.2.2. Assessing the levels and correlates of physical activity and sedentary time in preschool-aged children

Establishing the proportion of preschool-aged children reaching recommended physical activity and sedentary time guidelines is important for informing public health research and funding priorities[70, 71] (as discussed in Chapter 1). Most of the reviews[62-64, 66, 67] discussed in section 2.2.1, which assessed factors associated with physical activity and sedentary time in preschoolers, struggled to synthesise the study findings or to conduct meta-analyses due to study variability in the: a) measures of physical activity and sedentary time; b) measures of associated factors; c) accelerometer cut points; and d) covariates used in the regression models. The authors of one review[64] mentioned that some of the included studies stratified their analyses (e.g. by gender), which may have affected the results relative to looking at the whole sample. Future studies need to consider how they can consistently measure and report factors, physical activity and sedentary behaviours in a way that allows a comparison of findings between studies, particularly regarding the use of statistical meta-analytical techniques. An example of where it would be possible to conduct a cross-study comparison and meta-analysis is the International Children's Accelerometry Database (ICAD), which is a pooled database of raw accelerometer data files reduced using standardised techniques[72].

The identified reviews[62-64, 66, 67] mostly included studies which had measured sedentary time and physical activity with less valid subjective assessment methods (e.g. parental proxy self-report measures). These subjective assessments may not have accurately measured sedentary time and physical activity as they are more prone to measurement error and bias (e.g. social desirability, recall)[26]. This could have affected the strength and precision of the associations reported. Both subjectively and objectively measured sedentary behaviours were under-researched compared to physical activity and therefore need to be assessed in future studies[67]. Li et al[65] tried to address these limitations by only including longitudinal and prospective studies which used objective measures of sedentary time and physical activity; however, this meant that only nine studies were included in the review. This had implications for the review's results synthesis[65]. I aim to address some of these limitations in Chapter 3 through conducting a meta-analysis of objectively measured accelerometry data from the ICAD pertaining to physical activity and sedentary time in preschool-aged children, and further add to the literature by identifying potential correlates of these factors. In Chapter 3, I address Research Question 1 of the thesis: *'What are the levels and potential correlates of sedentary time and physical activity in preschool-aged children?'*.

2.2.3. Summary of factors associated with physical activity and sedentary time in preschoolers

To inform the design of more targeted public health interventions and policies, it is necessary to identify factors associated with preschool-aged children's sedentary time and physical activity levels[71, 73]. Identifying these correlates (i.e. cross-sectional factors) is important in determining factors which may facilitate or restrict physical activity and can therefore inform the design of behaviour change interventions and policies[73, 74]. Positively associated correlates of total physical activity (TPA) identified by Bingham et al[62] included being male (42/77 studies), parental support (5/5 studies - subjectively measured outcomes), parental physical activity (4/5 studies - subjectively measured outcomes), childcare attendance (6/6 studies) and time spent outdoors (7/8 studies). Being male (33/54 studies) and childcare attendance (3/4 studies) were found to be positively associated correlates of moderate-to-vigorous physical activity[62]. Although subjective measures of activity are less reliable than objective measurements, the authors found few differences between the correlates of subjectively and objectively measured physical activity across the ecological model[62].

The inclusion of cross-sectional studies and the lack of prospective or longitudinal physical activity studies were stated as limitations across the reviews[62-67]. Using cross-sectional data limits the ability to capture habitual sedentary time and physical activity patterns across a range of times, locations and contexts. There is a need for more longitudinal studies to be conducted in preschool-aged children, as they have stronger study designs compared to cross-sectional studies and can better estimate factors associated with temporal changes in sedentary time and physical activity behaviours[62, 63, 65]. It would not be feasible to carry out a longitudinal study within the timescale and budget of the PhD. Until more longitudinal studies are conducted, there is a lack of additional literature to justify updating the relatively recent reviews conducted by Bingham et al[62], Hesketh et al[63] and Li et al[65]. A systematic review was therefore not conducted as part of this thesis.

Once the determinants (longitudinal factors) of risk behaviours have been identified, they can be transformed into intervention targets and behaviour change strategies[71]. In section 2.2.1, I deemed the two reviews by Bingham et al[62] and Hesketh et al[63] to have a relatively low risk of bias. The findings from the two reviews thus represent the best evidence to date regarding factors associated with changes in physical activity in preschool-aged children. Therefore, the findings of these two reviews[62, 63] were used to address Research Question 2 of the thesis: *'What does the most methodologically robust evidence show in terms of factors associated with changes in physical activity and sedentary time in preschool-aged children?'*. Bingham et al[62] found that male sex (2/3 studies) and time spent playing with parents (3/4 studies) were positively associated with total physical activity. Maternal depressive symptoms were also found to be negatively associated with subjectively measured total physical activity in one study[62]. No determinants of light or moderate-to-vigorous physical activity were identified[62]. Based on findings from Hesketh et al's review[63], parental monitoring and childcare provider training were positively associated with physical activity and moderate-to-vigorous physical activity respectively (≥4 studies). There was some evidence (<4 studies) to suggest that maternal role modelling, sibling co-participation, opportunities for play, additional childcare providers, structured physical activity and playground density were also positively associated with physical activity.

2.2.4. Addressing the research gaps in the thesis

Assessing study limitations helps researchers determine the credibility of study findings as well as highlighting gaps in the literature which need to be addressed with future research. Where possible, I have aimed to address the gaps in the research identified across the relevant reviews[62-67] when conducting the PhD studies, which I have highlighted in the rationale and discussion sections of each study chapter. Most of the reviews mentioned their inclusion of low-quality studies which sometimes had small sample sizes and potentially non-generalisable populations as limitations[62-64, 66, 67]. The authors suggested that future studies need to be conducted in larger sample sizes to provide findings which are more representative of the general population to assess yet undetected associations. Two of the reviews[66, 67] highlighted that some of the included studies did not use or report the use of measurement tools which were reliable or validated for preschool-aged children. The divergence in practices in processing accelerometer data and classifying physical activity intensities were other cited limitations in the reviews[62-67]. In section 3.3 of Chapter 3 I assess the most appropriate accelerometry wear time practices to apply to preschool-aged children data, which I use when conducting the ICAD analyses. I also conduct reliability analyses on questionnaires which measured mediating factors relating to preschool-aged children's activity behaviours in Chapter 5.

Study samples included in the reviews were limited in that they mainly consisted of white participants in high-income countries who came from middle to higher socioeconomic backgrounds with highly educated parents[62, 63]. Data on the factors of sedentary time and physical activity were typically provided by mothers and other female caregivers meaning that there was a lack of data collected from male caregivers[63]. Taking these generalisability limitations into consideration, more studies need to be conducted:

a) With more ethnically and culturally diverse populations;
b) In low- and middle-income countries;
c) In populations with lower socioeconomic statuses (SES); and,
d) With male caregivers.

The authors of the reviews encountered difficulties in synthesising study findings due to the lack of research carried out looking at certain factors. Specific under-researched variables stated across the reviews[62, 63, 65-67] included: community, environmental and policy level factors; interacting biopsychosocial factors (e.g. potentially greater social interactions through active play in childcare settings); paternal factors; socioeconomic status; cultural factors; child growth and maturation; child/parent goal setting; childcare provider monitoring; and social support. Li et al[65] mentioned that none of their included studies explicitly stated a theoretical framework that their examined determinants were based upon. Theory is arguably important to consider when choosing influences of interest in future sedentary time and physical activity research. Some of these under-researched variables will be explored in the quantitative analyses carried out in Chapter 3 and the qualitative study conducted for Chapter 4 of the thesis.

2.3. Exploring parents' perceptions of factors which influence physical activity and sedentary time in preschool-aged children

2.3.1. Parental influences

Through conducting the literature search in section 2.2.1, I identified one key qualitative systematic review by Hesketh et al[75] which informed the qualitative component of the thesis. In this section (2.3.1), I summarise the findings from this systematic review[75]. I will then examine some of the included studies in more depth, where these are of relevance to the context of the thesis (i.e. studies which include parents of 2-4-year-old children). I will also examine relevant qualitative studies which have been published since 2016, which is when the literature search was conducted by Hesketh et al's systematic review[75]. In section 2.3.2, I summarise the identified gaps in the qualitative literature, and discuss how these will be addressed in Chapter 4 of the thesis.

Identifying influences on behaviour change can help optimise the implementation and effectiveness of interventions and policies which aim to increase activity in preschool-aged children[76]. The quantitative reviews discussed in section 2.2 identified factors which have been less frequently investigated, particularly community- and policy-related influences, relative to child, family and environmental factors[75]. Qualitative research provides an alternative avenue for exploring factors which influence young children's activity and sedentary time, but like the quantitative research in the field, there is a paucity of qualitative studies which have explored physical activity and sedentary time in 2-4-year-old children. Parents are key gatekeepers to young children's activity behaviours. Children who receive greater parental support for activity[77], are exposed to positive parental role-modelling behaviours[78] and have appropriate restrictions on television viewing and outdoor play in their home environments[79], have been found to engage with higher levels of activity and lower levels of television viewing. Therefore, investigating parents' perceptions of what influences their children's health behaviours is important to inform the development of interventions and policies to increase physical activity and decrease sedentary time in preschool-aged children.

Qualitative systematic review

The review by Hesketh et al[75] aimed to systematically synthesise qualitative literature which explored perceived barriers and facilitators to physical activity and sedentary behaviours in 0-6-year-old children. Data was extracted and synthesised from 43 included articles, involving 35 study samples, using thematic content analysis. The synthesis was underpinned by the socioecological model[75]. Most of the included studies conducted semi-structured one-to-one interviews and focus groups and used thematic/content and inductive data analysis techniques[75]. As discussed in section 2.2.1, it is useful to assess the quality of evidence when interpreting study findings. Using the ROBIS tool[68], I found the qualitative systematic review to have a low risk of bias (Table 2).

Table 2: Assessment of the risk of bias of the qualitative systematic review by Hesketh et al[75] using the ROBIS tool

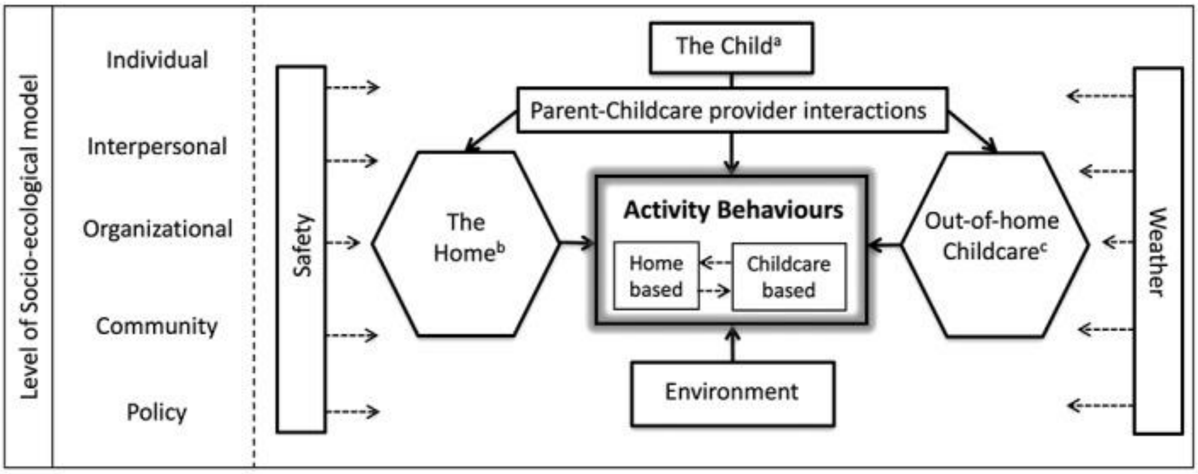
PHASE 2	
DOMAIN 1: STUDY ELIGIBILITY CRITERIA	
1.1 Did the review adhere to pre-defined objectives and eligibility criteria?	Y
1.2 Were the eligibility criteria appropriate for the review question?	Y
1.3 Were eligibility criteria unambiguous?	Y
1.4 Were all restrictions in eligibility criteria based on study characteristics appropriate?	Y
1.5 Were any restrictions in eligibility criteria based on sources of information appropriate?	PY
Concern for specification of study eligibility criteria	Low concern
Rationale for concern	Only published full-text studies were included, which can be justified given the qualitative synthesis method used.
DOMAIN 2: IDENTIFICATION AND SELECTION OF STUDIES	
2.1 Did the search include an appropriate range of databases/electronic sources for published and unpublished reports?	Y
2.2 Were methods additional to database searching used to identify relevant reports?	NI
2.3 Were the terms and structure of the search strategy likely to retrieve as many eligible studies as possible?	Y
2.4 Were restrictions based on date, publication format, or language appropriate?	Y
2.5 Were efforts made to minimise error in selection of studies?	Y
Concern regarding methods used to identify and/or select studies	Low concern
Rationale for concern	No information on additional methods used to identify relevant literature.
DOMAIN 3: DATA COLLECTION AND STUDY APPRAISAL	
3.1 Were efforts made to minimise error in data collection?	Y
3.2 Were sufficient study characteristics available for both review authors and readers to be able to interpret the results?	Y

3.3 Were all relevant study results collected for use in the synthesis?	Y
3.4 Was risk of bias (or methodological quality) formally assessed using appropriate criteria?	Y
3.5 Were efforts made to minimise error in risk of bias assessment?	NI
Concern regarding methods used to collect data and appraise studies	Low concern
Rationale for concern	Not clear whether risk of bias assessment was carried out by two independent reviewers.
DOMAIN 4: SYNTHESIS AND FINDINGS	
4.1 Did the synthesis include all studies that it should?	Y
4.2 Were all pre-defined analyses reported or departures explained?	Y
4.3 Was the synthesis appropriate given the nature and similarity in the research questions, study designs and outcomes across included studies?	Y
4.4 Was between-study variation (heterogeneity) minimal or addressed in the synthesis?	NI
4.5 Were the findings robust, e.g. as demonstrated through funnel plot or sensitivity analyses?	PY
4.6 Were biases in primary studies minimal or addressed in the synthesis?	N
Concern regarding the synthesis and findings	High concern
Rationale for concern	No information on whether heterogeneity was accounted for in the synthesis. Interpretation of qualitative data is likely to differ with different authors. Risk of bias assessment results not incorporated in the synthesis.
PHASE 3: RISK OF BIAS IN THE REVIEW	
A. Did the interpretation of findings address all of the concerns identified in Domains 1 to 4?	PY
B. Was the relevance of identified studies to the review's research question appropriately considered?	Y
C. Did the reviewers avoid emphasizing results on the basis of their statistical significance?	N/A
Risk of bias in the review	Low risk of bias
Rationale for risk	Inclusion of published studies only stated as publication bias. Risk of bias scores not incorporated or justified but this may be due to the lack of literature.

Note: Y=Yes, PY=Probably Yes, PN=Probably No, N=No, NI=No Information

The systematic review authors identified seven broad themes, representing the views of children, parents and childcare providers, to be important with regards to physical activity and sedentary behaviour in 0-6-year-old children[75]. These were: the child; the home; out-of-home childcare; parent-childcare provider interactions; environmental factors; safety; and weather[75]. Each of these seven themes mapped onto between one and five levels of the socioecological model, where barriers and facilitators at the interpersonal level of the socioecological model were the most frequently mentioned[75]. Figure 3 shows the overarching theoretical framework the authors developed to map their seven themes and thus help explain physical activity and sedentary behaviour in early years' children[75].

Figure 3: Overarching theoretical framework of qualitative data on the barriers and facilitators to 0-6-year-old children's physical activity and sedentary behaviour from Hesketh et al[75] (CC BY 4.0)



a: includes the subthemes: predisposition and preferences, necessary respite, development, health and lifestyle; b: includes the subthemes: parents, siblings and peers, home environment; c: includes the subthemes: care-providers, childcare environment.

Across the 43 articles included in the Hesketh review, 77 different barriers and facilitators to preschool-aged children's activity behaviours were listed[75]. Within the child theme, parents and childcare providers perceived children to be naturally active and would therefore facilitate some daily downtime periods[75]. This would also allow the caregivers to carry out necessary tasks[75]. Not all sedentary behaviours were deemed to be negative, with developmental activities (e.g. reading and drawing) seen as beneficial compared to non-beneficial entertainment-based TV viewing[75]. However, many parents stated that media use was a main barrier to children's activity[75]. Under the home theme, parental barriers included a lack of time and resources to engage their children with physical activities[75]. Childcare providers perceived themselves to be important in influencing children's activity behaviours, but as with the quantitative research, it has been difficult to determine the precise role they play[75]. Childcare providers often referred to available space and resources in childcare settings as impacting on children's activity engagement[75].

The parent-childcare provider interactions theme was a novel finding to emerge from this systematic review, where parents believed that childcare providers played a key influence on children's activity behaviours, and vice versa[75]. Resources in the local environment (e.g. parks and community support) presented as either barriers or facilitators, with parents in rural areas believing that having more open space facilitated outdoor play but that a lack of resources may be a barrier to opportunties[75]. Risk aversion and ensuring a safe environment were barriers to physical activity mentioned by childcare providers, parents and children themselves[75]. Moderate weather conditions were perceived to facilitate activity whereas extreme conditions were thought to decrease physical activity and increase time spent sedentary[75]. The findings from this systematic review provide an overall summary of the barriers and facilitators to early years' activity behaviours identified from qualitative research[75]. Given that the systematic review analysed studies involving qualitative data collected from children, parents and childcare providers of 0-6-year-olds[75], in the following sections I will be discussing some of the included studies in depth, where they have collected data from parents of 2-4-year-olds, which is in line with the thesis aims. I will also be discussing studies that have been published since the systematic review was published[75].

Mothers

A qualitative study of a sample of mothers of 2-4-year-old children explored mothers' perceptions of the UK early years' physical activity and sedentary behaviour guidelines[80, 81]. Mothers were recruited through nurseries, preschools and toddler groups from four areas of varying socioeconomic statuses within Bristol, UK[81, 82]. The study used thematic framework approaches to analyse data from 24[81] one-to-one semi structured interviews. Overall, mothers were not aware of the recommended guidelines, and believed that their children were achieving appropriate levels of physical activity and sedentary time[81]. Mothers expressed confusion differentiating between physical activity and sedentary behaviours and believed that increasing their children's physical activity and decreasing their sedentary time would cause them additional stress[81].

Another qualitative study, which interviewed 26 participants from the same sample described in the study above[81], used the same methods to explore mothers' views of their children's screen viewing behaviours[82]. The study found that mobile phones were frequently used as portable television viewing and educational engagement devices, often on an ad hoc basis and as a distraction tool outside of the home environment[82]. Many of the mothers were concerned about and restricted mobile phone use but many acknowledged that they were an unavoidable and necessary part of life[82]. The findings from these two studies provide an insight into potential barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-olds in England[81, 82]. However, not unique to the two discussed studies[81, 82], there is a notable dearth of qualitative studies which have explored fathers' influences on preschool-aged children's physical activity and sedentary behaviours[75]. To better inform population level interventions and policies targeted at parents, it is essential to explore fathers' roles in their children's physical activity and sedentary behaviours.

Fathers

There is one qualitative study which aimed to explore the role of fathers in their young children's physical activity and sedentary behaviours[83]. Although this study had a focus on fathers, the interviews were conducted with mothers of 5-6-year-olds who discussed their perceptions of the fathers' influence on their children's physical activity behaviours[83]. The study used deductive content analysis to assess the data from 37 one-to-one telephone interviews conducted with mothers who were recruited through primary schools as part of the B-Proact1v Study run in Bristol, UK[83]. The authors found that mothers reported that fathers played an active role in encouraging and co-participating in their children's physical activity[83]. Fathers' availability was viewed as the main factor in the amount of activity involvement and there were indications of differences between the roles of fathers and mothers in their children's physical activity behaviours[83]. While the findings from this study provide valuable insights into fathers' influences on their young children's physical activity and sedentary time, there is a need for more fathers to provide qualitative data on their own perceptions of their influence on their children's activity behaviours, with a focus on younger children.

One Australian study explored mothers' (n=16) and fathers' (n=12) perceptions of the benefits and risks of active play and screen time in 3-5-year-old children through conducting semi-structured telephone interviews[84]. Parents believed that active play was beneficial to children's health and developmental skills such as socialisation, imagination and enjoyment. Conversely, they felt it could present risks such as exposure to strangers and safety concerns[84]. Parents felt that screen time promoted relaxation, education and learning but that it also contributed to negative health, cognitive and social outcomes, exposure to inappropriate content and the development of bad habits[84]. The authors observed few differences between mothers' and fathers' views, such as mothers being more likely to use screens for keeping their child in one place than fathers, and fathers referring to the health risks of screen time more often than mothers[84]. It is a credible finding that there may not be much of a difference in views between mothers and fathers regarding their preschool-aged children's activity behaviours. However, the authors stated that it was unclear what activities the parents undertook with their children, and variations in activities need to be considered with the development of interventions and polices[84]. It is essential to explore differences and similarities in the perceptions of mothers and fathers from different contextual backgrounds, to assess whether the findings from this study are replicated or contradicted in other populations.

Socioeconomic status

Efforts have been made by several studies to recruit participants across socioeconomic strata to provide a variety of parents' views on preschool-aged children's activity influences[75]. One United States of America (USA)-based study conducted surveys and focus groups to assess factors influencing obesogenic behaviours reported by parents of 2-5-year-old children[85]. Content analysis of the focus group data found that parents with lower educational attainment spent more time in active play with their children compared to parents with higher educational attainment[85]. The authors hypothesised that highly educated parents may spend less time with co-participating in physical activities with their children due to work commitments, even though they may have more disposable incomes to spend on play equipment and structured programmes[85]. Given that barriers and facilitators appear to vary according to parental education levels, it is important to assess factors across the socioeconomic strata to ensure that interventions and policies meet the needs of different groups[85].

Culture

As well as the possibility of barriers and facilitators varying across the socioeconomic strata, it is possible that different cultural beliefs may influence preschool-aged children's physical activity and sedentary time behaviours[86]. A couple of American qualitative studies investigated factors associated with activity behaviours in Hispanic[87] and Latino farmworker[88] families, as preschool-aged children from these migrant communities have been found to be less active[89] and more overweight and obese[90] than their non-Hispanic peers. The study by Grzywacz et al[88], involving 33 semi-structured interviews, found that mothers believed in limiting excessive physical activity to prevent their children from developing illnesses and other physical and emotional problems. Mothers believed in providing sedentary activities to promote their children's learning[88]. A lack of familiarity with neighbours and the physical and environmental hazards present in the rural community were also seen as barriers to activity[88]. Even though the mothers understood the health benefits of physical activity, the findings from this study illustrated the cultural beliefs and circumstantial barriers specific to the Latino farmworker community, therefore providing an example of cultural differences in parental influences on preschoolers' activity behaviours[88].

Another example of qualitative research conducted with immigrant communities in the USA, is a study which explored Brazilian immigrant mothers' practices towards facilitating or restricting physical activity in 2-5-year-old children[91]. Thematic analysis was conducted on data from 37 mothers who participated in focus groups[91]. The authors identified seven parental practice facilitators to children's physical activity: modelling physical activity; engaging and being physically active with their children; providing logistic support; offering motivational support; watching, supervising and teaching children how to engage in physical activity; monitoring and restricting children's screen time; and prompting children to be physically active[91]. The authors also recognised four parental practice barriers to activity: modelling of sedentary behaviours; having rules and restrictions due to safety- and weather-related concerns; limiting children's outdoor time due to a lack of parental time; and restricting children's outdoor and play time as a punishment[91].

A study which was conducted on the same sample of participants as above[91] aimed to look at practices, attitudes and beliefs towards preschool-aged children’s sedentary behaviours among Brazilian immigrant mothers in the USA[92]. Although mothers voiced concerns about their children’s screen time, they viewed the use of screens to have more advantages than disadvantages, and perceived screen time to be an acceptable part of daily life[92]. Mothers believed that screens provided positive educational and entertainment opportunities and were functionally acceptable to use for facilitating communication with family members who lived outside of the USA[92]. The mothers did discuss monitoring and setting rules and restrictions with regards to their children’s screen time and the content they viewed, and prompting their children to engage with other activities[92]. The findings from these two studies[91, 92] provide examples of parental beliefs, attitudes and practices towards 2-5-year-olds’ activity behaviours, which are potentially unique to Brazilian immigrants who live in the USA. Conducting qualitative research in different cultural contexts is key in identifying varying modifiable parental beliefs and practices which can be used to inform culturally specific interventions and policies[92].

Country

Most qualitative studies which have explored parental influences on 2-4-year-old children's activity have been conducted in western and middle-to-high-income countries which contrasts with the lack of qualitative studies conducted in non-western cultures and developing countries[75]. Using a combination of focus groups and one-to-one interviews, a study in Hong Kong used inductive thematic analysis and found that parents of preschool-aged children (median age: 4 years) discussed focusing on academic achievement, safety concerns, promotion of sedentary activities and a lack of time and resources as barriers to children's physical activity[93]. One study conducted in Malawi provides an example of parents' perceptions of influences on children's physical activity and sedentary time in a developing country[94]. Parents who participated in individual interviews and focus groups demonstrated a thorough understanding of physical activity examples and the associated physical and mental health benefits[94]. The availability of food and good health were considered by the parents as being the most important facilitators of children's physical activity[94]. These two studies further highlight differing parental influences in different countries which need to be considered when developing country-specific and culturally sensitive interventions and policies[93, 94]. It is important to explore factors associated with the promotion of beneficial activity behaviours in migrant communities and in developing countries, who may have different cultural influences and contexts.

2.3.2. Addressing the gaps in the qualitative literature in the thesis

The gaps in the literature discussed in section 2.3.1 highlight that there is a need for future qualitative research to be conducted: with fathers and male caregivers; across the socioeconomic strata; in ethnically and culturally diverse populations; and in low-to-middle-income countries. Much of the existing qualitative work has focused on mothers' perceptions of factors associated with preschool-aged children's physical activity and sedentary time[75]. This thesis will be adding to the field by conducting a qualitative study on fathers' perceptions of the barriers and facilitators of young children's activity behaviours, reported in Chapter 4, that can ultimately be used to better inform policy and practice. There is also a sparsity qualitative work that has recruited participants across the socioeconomic strata. I designed a study to recruit participants across the socioeconomic strata, as barriers and facilitators to children's activity are likely to be different for different groups, which must be addressed when developing population level polices and interventions. Although there is a need for more qualitative studies to be conducted in developing countries and within different cultures[75], it is beyond the aim and scope of the thesis to carry out the necessary qualitative studies to address these research gaps. The aim of the thesis is to inform intervention and policy development in England, UK (where I am based), therefore I will be exclusively interviewing parents from the England. This is because the four nations within the UK have different public health systems, so I will be focusing recruitment on participants from England to ensure that findings are contextually appropriate and could generate useful knowledge for the public health context in England.

To address Research Question 3 of the thesis: *'What are the barriers and facilitators of increasing physical activity and decreasing sedentary time in preschool-aged children?'*, I conducted a qualitative study which is described in Chapter 4. The qualitative study addresses the lack of literature conducted with fathers and explores a comparison between mothers' and fathers' barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-old children. The study aimed to recruit parents across the socioeconomic strata to ensure that a variety of factors are represented. The mixed methods approach of this thesis means that the qualitative findings from this study can be used to provide some contextual information to the quantitative study findings in Chapter 3 and the findings discussed in section 2.2.3 of this chapter.

2.4. Interventions to change physical activity and sedentary time in preschool-aged children

2.4.1. Effectiveness of physical activity interventions with preschool-aged children

In this section (2.4.1), I describe interventions which have effectively increased physical activity and decreased sedentary time in preschool-aged children, and what intervention components have been shown to be effective or ineffective in leading to behaviour changes. In section 2.4.2, I then go on to discuss the strengths and limitations of behaviour change theories which effective interventions have been based on. To inform the study conducted in Chapter 5 of the thesis, I introduce a preschool setting-based physical activity intervention in section 2.4.3.

Given the importance of being physically active in improving young children's health and developmental outcomes (see Chapter 1), it is crucial to determine what aspects of existing interventions have been effective in increasing physical activity levels in preschool-aged children, to better inform the development of future interventions and policies. Between 2010 and 2019, seven reviews assessed evidence from interventions which aimed to increase physical activity and decrease sedentary time in early childhood. Four of these reviews focused on childcare setting-based interventions only[95-98], whereas the other three reviewed interventions which were conducted in any settings (childcare, home and the community)[99-101]. In Table 3, I summarise 18 study interventions that have been identified across the two most recently published systematic reviews[100, 101], which have demonstrated a statistically significant positive effect on at least one measure of 2-4-year-old children's objectively measured physical activity and sedentary time, compared to the control groups in the randomised controlled trials (RCT). There are some common features across the identified interventions:

provision of training and/or educational materials for childcare providers and/or parents (15 out of 18); multifaceted interventions which include a structured physical activity component (13 out of 18); component which focuses on environmental or policy changes (14 out of 18); and interventions based on theories (11 out of 18).

Table 3: Summary of intervention components which have shown a positive effect on preschool-aged children's physical activity and sedentary time levels

Study	Intervention and Control Components	Theory
Alhassan et al[102] (2012) USA	Locomotor Skills-Based Structured PA Programme: 30 mins structured PA/day, 5 days/week; teachers received 8 hours of training on structured PA Control - Unstructured Free Playtime: 30 mins free play PA/day, 5 days/week; teachers received 2 hours of training on free play	N/A
Alhassan et al[103] (2013) USA	Intervention: Teacher training (8 hours) led by the study principal investigator on learning the structured outdoor playtime activities (based on SPARK programme involving age-appropriate, moderate-to-vigorous activities) Control: Teacher training (2 hours) led by the study's principal investigator focused on the importance of allowing students to play freely during allocated intervention time	N/A
Annesi et al[104-107] (2013) USA	Start For Life Intervention: 30 mins structured PA per day; teachers received 4 hours of training and a binder of daily lesson plans; teachers used 'achievement charts' to monitor children's progress with stickers Control: 30 mins structured PA per day	Self-efficacy theory and social cognitive theory
Bonis et al[108] (2014) USA	NAP SACC Intervention: Dietitians with PA training implemented four workshops that demonstrated the importance of PA the nutrition; dieticians maintained regular contact with staff and provided support in addressing barriers; also distributed education information to parents that focused on PA and nutrition recommendations at home	Social cognitive theory and

	Control: Received programme after completion of the project	socioecological framework
Chow et al[109] (2016) Canada	Intervention: Provision of the following PA resources: The Healthy Start Implementation Manual, a step-by-step guide for implementing, tailoring and adapting intervention activities and resources to fit the needs of various childcare centre environments; HOP, a PA guide and activity bag with child-tested activities and materials; and ongoing support and monthly communication throughout the intervention Control: Intervention waiting list	McLeroy's ecological model and population health approach
Cottrell et al[110] (2005) USA	Intervention: Received two pedometers (one for child and one for parent) plus a daily step log and specific information about age-appropriate diet and exercise guidelines and ways to increase steps taken; children with >85th percentile BMI also received information on ways to reduce caloric intake Control: Received one pedometer for child use, log book and information about age-appropriate diet and exercise guidelines	Paper inaccessible
De Bock et al[111] (2013) Germany	Intervention: State-sponsored PA Programme PLUS; three parent-teacher meetings; parents and preschools received: an intervention-specific website, an introductory video and a book with 15 project ideas Control - State-Sponsored PA Programme: Two 1-hour gym classes per week; one parent-gym trainer meeting	General system theory
De Craemer et al[112] (2014)	ToyBox Intervention: Teachers received 3 training sessions; 20-weeks structured PA; parents received: 2 newsletters, 2 tip-cards and one poster through children; environmental change in classrooms	PRECEDE-PROCEED model

Belgium	Control: Usual care	
Eliakim et al[113] (2007) Israel	Intervention: Parents received 2 orientation lectures on childhood obesity and the benefits of exercise in the first 2 months; nutrition curriculum in class; dietary information on working sheets/flyers; PA: 45 mins/day exercise training, 6 days/week; encouraged to reduce sedentary activities and increase PA after school Control: Parents received 2 orientation lectures on childhood obesity and the benefits of exercise in the first 2 months	N/A
Fitzgibbon et al[114] (2011) USA	Teacher-Delivered Weight Control Intervention: Two 20 mins lessons on nutrition and PA per week; two 20 mins PA sessions per week; parents received weekly newsletters with a homework assignment Control: One 20 mins lesson on general health concepts per week; parents received weekly newsletters without a homework assignment	Social cognitive theory and self-determination theory
Goldfield et al[115] (2016) Canada	Intervention: The experienced master trainer provided two 3-hour training workshops to childcare providers and a resource training manual - the manual included information on how providers could facilitate structured and unstructured PA that targeted fundamental movement skills; the goals of the programme were to increase PA to meet guidelines of 120 mins per day (60 structured, 60 unstructured); twelve bi-weekly ‘booster’ sessions provided by master trainer Control: Standard childcare curriculum	N/A

Palmer et al[116] (2016) USA	Intervention: Replaced outdoor free play with movement programme 2 days/week for 12-weeks - 30-min programme consisted of dancing, motor skills stations and PA games Control: Continued normal outdoor free play (e.g. 30 mins every morning on the playground)	Achievement motivation theory
Pate et al[117] (2016) USA	Intervention: No scripted curriculum was provided, teachers were encouraged to use SHAPES elements to modify instructional practices and the class Control: Regular instruction and organisational practices	Socioecological framework
Roth et al[118] (2015) Germany	Intervention: Programme (designed by professionals, led by preschool teachers); children received daily PA (30 mins; focused on coordinative skills and perception) and PA homework 1-2 times/week; parents invited to 3 interactive lectures on the promotion of motor skills in childhood Control: Usual curriculum	Psychomotor concept
Salazar et al[119] (2014) Chile	Intervention: The programme consisted of education material, weekly counselling by nutritionists and physical education teachers, a training programme for educators and educational and motivation strategies delivered to parents and families Control: Usual programme	Social cognitive theory and socioecological framework
Specker et al[120, 121] (2003-2004)	Fine motor + Calcium (Group 1): 30 mins/day sitting quietly; two 500mg calcium tablets/day, 5 days/week	N/A

USA	Fine motor + Placebo (Group 2): 30 mins/day sitting quietly Cross motor + Calcium (Group 3): 30 mins PA/day, 5 days/week (5 mins warm-up, 20 mins jumping, hopping, and skipping activities, 5 mins cool-down); two 500mg calcium tablets/day, 5 days/week. Cross motor + Placebo (Group 4): 30 mins PA/day, 5 days/week (5 mins warm-up, 20 mins jumping, hopping, and skipping activities, 5 mins cool-down)	
Trost et al[122] (2008) USA	Intervention: PA opportunities integrated into the preschool curriculum (e.g. maths, science); lead teachers required to include 2 move and learn curriculum activities >10 mins in each 2.5-hour session several times per week; teachers received one 3-hour training session Control: Usual curriculum	N/A
Yin et al[123] (2012) USA	Centre-Based Intervention: 30–45 mins structured outdoor play/day; 15–20 mins PA during recess; classroom activities: Sesame Street Workshop Healthy Habits for Life resource kit, including 9 modules, one module/2 weeks; teachers received 6-hours initial and 4-hour follow-up training Centre- and Home-based Intervention: Centre-based intervention PLUS: seven peer educators; parents viewed posters; take-home bag including a storybook, family activities, and games Control: Parents received monthly newsletters emphasizing prereading skills	Early childhood development theory and general system theory

The most recent systematic review[101] conducted both a meta-analysis and a realist synthesis to help determine the contexts and mechanisms which appeared to be the most effective or ineffective in improving preschool-aged children's physical activity and sedentary time across all 34 included interventions. A realist synthesis aims to identify contexts which trigger mechanisms and subsequent outcome changes, to understand how, why and in what circumstances certain interventions work[124]. Based on the realist review findings, the authors concluded that successful interventions were tailored to their target groups (parents and/or childcare providers) in terms of providing ongoing support to overcome emerging challenges, applying cultural considerations and acknowledging community expertise and needs[101]. Childcare settings which incorporated structured physical activity sessions into their usual routines (e.g. outdoor activities, dancing, gross motor skills sessions) appeared to be the most effective in increasing children's moderate-to-vigorous physical activity[101]. Furthermore, interventions delivered through 'hands-on' methods such as workshops seemed key in increasing childcare staff's knowledge and their ability to implement structured activities through changing the social culture of the childcare setting[101].

Although there have been few interventions trialled in the home, evidence from interventions which consist of both a home and childcare component suggests that changing parent and childcare staff practices (e.g. incorporating physical activity into preschool curriculums) can be effective in changing children's physical activity behaviours[101]. However, this was only observed when parent or childcare provider practices were reported to have been changed, through measuring these targeted constructs or mediating factors[101]. Even though educational strategies were the most common target across the interventions, there was no evidence that this mechanism was effective in increasing children's physical activity, either alone or when paired with other intervention targets[101]. Some of the included studies reported that the intervention dose was too low to influence children's physical activity, which may be in part be explained by the relatively active control practices[101]. Differences in intervention effects were observed for child gender and socioeconomic status[101].

Childcare settings present a major opportunity for physical activity promotion at a population level. In England, eligible disadvantaged 2-year-olds and all 3-4-year-olds are eligible for 15 hours of funded early education for 38 weeks of the year, with working parents of 3-4-years-olds being eligible for a further 15 hours[125]. In 2021, 62% of eligible 2-year-olds and 90% of all 3-4-year-olds were registered to receive funded early education, which corresponded to a decrease in uptake compared to 2020 (69% and 93%), likely related to the context of the COVID-19 pandemic[125]. The number of childcare-based physical activity interventions has exponentially increased over the past two decades and as discussed above, interventions have varied in their effectiveness in increasing physical activity levels in preschool-aged children[95, 99, 126]. In terms of future directions, it has been recommended that childcare-based interventions should consider national and international trends in the childcare sector and find imaginative ways to deliver interventions[126].

2.4.2. Theories of behaviour change used in physical activity interventions with preschool-aged children

As outlined in section 2.4.1, many of the interventions that have attempted to increase physical activity and decrease sedentary time in preschool-aged children (Table 3), have been based on one or two behaviour change theories[100]. In Table 4, I provide descriptions of the behaviour change models which have been used to inform these effective interventions.

Table 4: Summary of behaviour change theories and models used in interventions which have positively affected physical activity and sedentary time in preschool-aged children

Behaviour change theory or model	**Description**
Achievement motivation theory	Interventions which incorporate this theory aim to provide a motivational learning environment for children which encourages effort and reinforces the learning process[116, 127].
Early childhood development theory	Such theory-driven interventions focus on providing interactive and supportive learning environments for early years children, as this is a critical time in children's behaviour development[123].
General system theory	According to this theory, children's health behaviours exist within a larger network of relationships (e.g. siblings, parents, childcare providers)[111, 128, 129]. The theory suggests that efforts to change health behaviours need to involve as many agents in as many contexts as possible, to develop behavioural norms via interactions throughout the whole network[111, 123, 128, 129].
PRECEDE-PROCEED model	A comprehensive educational and ecological approach which provides a structure for planning a targeted public health intervention (PRECEDE) and a structure for implementing and evaluating the programme (PROCEDE)[112, 130].
Psychomotor concept	This approach focuses on the motor, social, cognitive, emotional and sensory development of a child and allows for engagement in enjoyable age-appropriate activities while training their motor skills[118, 131]. Children are encouraged to problem

	solve activity tasks in their own way, which will, in turn, promote their self-competence and self-esteem, on top of developing their motor abilities[118, 131].
Self-determination theory	This theory suggests that children are motivated to adopt behaviours when their needs for competence, autonomy and connection are met[114, 132]. Interventions informed by this theory allow for the differentiation between activities which children want to engage in and those that they are coerced into performing[114, 132].
Self-efficacy theory	Self-efficacy is defined as an individual's belief in their ability to execute control over one's behaviour and motivation to perform specific attainments[133]. Interventions which aim to improve self-efficacy can promote an individual's confidence in initiating and maintaining positive activity behaviours[134].
Social cognitive theory	This theory posits that modelling behaviours helps children to develop positive activity behaviours and relies on internal and external social reinforcement[108, 114, 119, 133].
Socioecological model/framework and McLeroy's ecological model	This model theorises that children's activity behaviours are influenced by factors operating at multiple levels (individual; interpersonal; organisational; community; policy and environmental), therefore intervention targets are formed across multiple levels[108, 109, 117, 119, 135, 136].

Some of the theories in Table 4 can be described as influencing behaviour change at the individual level in terms of guiding preschool-aged children's developmental skills through providing age-appropriate activity environments (i.e. early childhood development theory; psychomotor concept). Interventions which are based on other individual-level behaviour change theories have aimed to improve either children's, parents' or childcare providers' self-belief in their abilities to provide or engage with physical activity opportunities (i.e. achievement motivation theory; self-determination theory; self-efficacy theory). One limitation of interventions which target individuals' behaviours is that they require a high degree of agency, which is less effective than low agency population interventions, and could potentially increase inequalities[137]. Individual interventions may be unreliable when preschool-aged children are the primary intervention target, due to children's lack of control over the opportunities that they engage with and the sporadic nature of their physical activity engagement[28].

The remaining theories described in Table 4 affect behaviour change at wider levels and rely upon interactions between different agents to address behaviour change of individuals (i.e. general system theory; PRECEDE-PROCEED model; social cognitive theory; socioecological model; and McLeroy's ecological model). An advantage of interventions targeting higher levels such as preschool policies is that they can formalise an organisation's commitment to goals for physical activity and the implementation of healthy physical activity and sedentary time practices. These policies may be less likely to “wash out” (lose effectiveness over time) as they prompt continued training and assessment compared to individual-level approaches. Interventions which focus on systems, as opposed to individuals, assume that changes made at these levels will affect children’s behaviours, and they still require high levels of agency at individual levels. For example, changes to physical activity policy changes will lead to increased physical activity engagement by preschool-aged children and childcare provider training resulting in child and parental behaviour changes. Also, as these theories are broad reaching, such interventions can be difficult to operationalise, and it is unclear which factors are more influential on behaviour change than others.

As mentioned in the previous section (2.4.1), few studies have measured whether changes in individual or wider level mediators of behaviour change can explain intervention effects[101]. In the next section (2.4.3), I describe a UK-based intervention which is driven by the socioecological model (SEM) and social cognitive theory (SCT) and aims to influence behaviour at both the individual and wider levels. In Chapter 5 of the thesis, I analyse the reliability of mediator questionnaires which were developed for the intervention study described below.

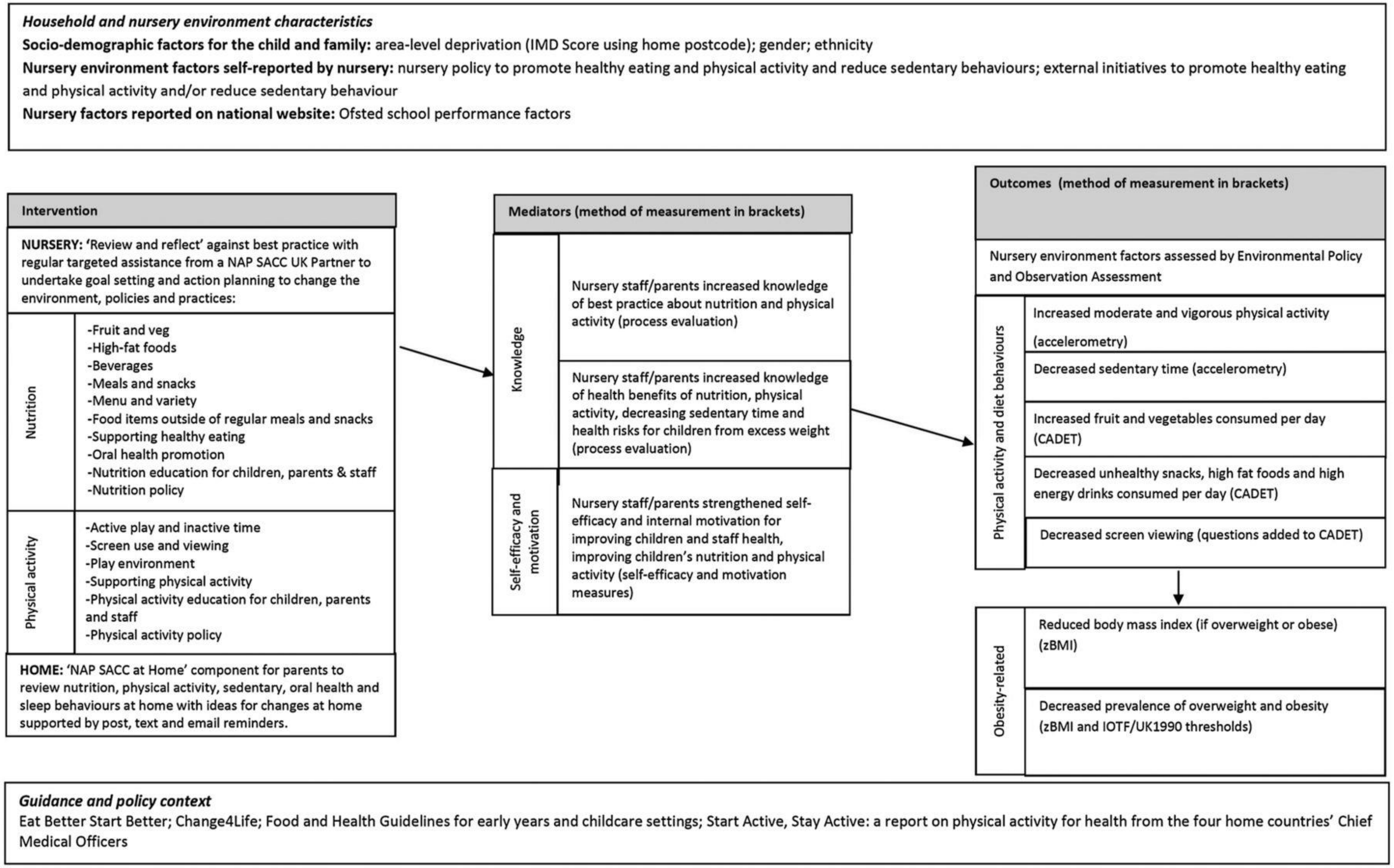
2.4.3. The NAP SACC UK intervention

The Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) is an intervention that aims to improve the physical activity and nutrition environment, policies and practices in childcare settings[138]. The original NAP SACC intervention was developed in the USA[138] and an updated version was developed in 2014 called Go NAP SACC[139]. Randomised controlled trials of NAP SACC conducted in the USA found that the intervention was effective in increasing accelerometry measured total physical activity by 17.5% and vigorous physical activity by 46.2%[108], and in decreasing children's BMI z-score[140]. The intervention was found to increase children's Environment and Policy Assessment and Observation (EPAO) nutrition scores by 11% from a baseline score of 8.6[138] and to increase parent's knowledge of raising healthy kids and nursery staff's knowledge of childhood obesity, healthy eating, personal health and working with families[140].

In England, a feasibility study was conducted to determine whether a version of the NAP SACC intervention, which had been adapted in line with UK guidelines, would be acceptable and feasible to implement within UK-based childcare settings[141]. The first steps of the intervention involved nursery managers and staff using the NAP SACC UK 'review and reflect' tool to identify 10 key areas in physical activity, nutrition and oral health which could be improved with the guidance and support of health visitors (NAP SACC UK Partners)[141]. Physical activity and nutrition experts delivered two workshops to raise nursery staff's self-efficacy, motivation and knowledge to make changes[141]. The nursery staff would use what they learned from the workshops to develop an action plan for improving the 10 identified areas, with the NAP SACC UK Partners providing regular support and guidance to make these improvements over the next six months[141]. The NAP SACC UK 'review and reflect' tool was then completed for a second time and the action plans were revised to set new goals and objectives to make progress on areas where improvements had not been made, with the continued assistance of NAP SACC UK Partners[141].

The NAP SACC intervention is based on components of social cognitive theory within the socioecological framework, which are described in Table 4[142]. As per the SCT and SEM, the logic model for the NAP SACC UK study (Figure 4) outlines parental and nursery staff's self-efficacy, motivation and knowledge as mediating factors in changing preschool-aged children's physical activity and nutrition behaviours[141]. As there were no existing measurement tools to measure these mediating factors, there was a need to develop questionnaires in the feasibility study to measure parental and nursery staff's self-efficacy, motivation and knowledge. Part of developing these measures involved assessing whether the questionnaires were reliable for measuring these mediating factors[141]. Few physical activity interventions which have been trialled in early years' populations have reported on mediating factors and how they have changed from pre- to post-intervention[101]. Aside from the qualitative investigations conducted in process evaluations in trials, the lack of reliable measures on mediators makes it difficult to ascertain why interventions have, or have not, effectively changed parent or childcare provider practices and therefore explain intervention outcomes[101].

Figure 4: NAP SACC UK logic model from Kipping et al[141] (CC BY 4.0)



In Chapter 5, I conducted a study to assess the acceptability, internal consistency and test-retest reliability of the parent and nursery staff questionnaires which were developed for the NAP SACC UK feasibility study[141]. This study examined whether these questionnaires were reliable in measuring the mediating factors of parents' and childcare provider's self-efficacy, motivation and knowledge towards 2-4-year-old children's physical activity behaviours. This study is described in Chapter 5 and addresses Research Question 4 of the thesis *'What self-report measures could be used to assess mediating factors relating to parents' and nursery staff's self-efficacy, motivation and knowledge towards preschoolers' activity behaviours?'*.

2.5. Summary

This chapter has provided a critical evaluation of both quantitative and qualitative literature relating to physical activity and sedentary time in 2-4-year-old children. I have discussed the inconsistent and often limited quantitative findings relating to the factors associated with physical activity measures in preschool-aged children. Findings from systematic reviews have highlighted issues regarding differences in data measurement protocols (associated factors and activity outcome variables) which have had implications for the synthesis of data across different studies. Through an exploration of the qualitative literature, it was evident that there is a lack of research conducted with fathers in relation to their involvement and views towards their children's activity behaviours. The literature also emphasised the need to apply socioeconomic, cultural and country-specific contextual information acquired from qualitative research in designing physical activity interventions and policies. I summarised components of interventions which have been effective in increasing physical activity and decreasing sedentary time in 2-4-year-old children and discussed some of the pros and cons of the behaviour change theories those interventions were based on. It was evident from intervention studies that potential mediating factors have not been adequately measured and that it has therefore been difficult to determine behaviour change mechanism pathways and intervention effects. Throughout the chapter I refer to the importance of using reliable and valid outcome measurement tools which are appropriate for the preschool-age population to measure and analyse data. Together with Chapter 1, this chapter has provided a thorough evaluation of the literature on physical activity and sedentary in preschool-aged children, and has identified research gaps and limitations which this thesis aims to address.

CHAPTER 3. LEVELS AND POTENTIAL CORRELATES OF SEDENTARY TIME AND PHYSICAL ACTIVITY IN PRESCHOOL-AGED CHILDREN

3.1. Overview

The work presented in this chapter was published in the International Journal of Environmental Research and Public Health[1]. My contribution to the published manuscript included drafting the proposal to apply for data access, the methodology, data preparation, data analysis, writing the original draft, and reviewing and editing later drafts of the manuscript for publication. Except for this overview (section 3.1), section 3.3, concluding implications for thesis (section 3.8) and minor edits, the chapter is presented as per the published article. **"International comparison of the levels and potential correlates of objectively measured sedentary time and physical activity among three-to-four-year-old children"** answers Research Question 1 of the thesis: *'What are the levels and potential correlates of sedentary time and physical activity in preschool-aged children?'* The findings of this study will provide an insight into the average daily levels of sedentary time and physical activity that preschool-aged children are achieving and also see what measured variables are associated with these activity levels.

In section 3.2 I outline the rationale for the study. I provide a critical assessment of the literature to inform the most appropriate accelerometry cut points and wear time practices to apply to the ICAD analyses in section 3.3. In section 3.4, I present the methods used, including descriptions of the study variables and statistical analyses. I present the study results in section 3.5, and a discussion of the findings in relation to the wider literature, followed by the strengths and limitations of the study in section 3.6. To conclude this chapter, I provide the study conclusions in section 3.7 and the implications of the findings for the thesis in section 3.8.

3.2. Rationale

Physical activity patterns track from childhood through to adulthood[143], making preschool-aged children an important population to target for physical activity interventions. Being physically active during the early years is associated with improved adiposity, cardiometabolic health indicators, motor skill development, bone and skeletal health, cognitive development, and psychosocial health[8]. Current Canadian[40] and Australian[39] guidelines advise that children aged 2-5-years-old should not be sedentary for periods of over 60 minutes at a time. The Canadian, Australian, USA[144] and UK[80] guidelines also specify that children under the age of five, who can walk unaided, should be physically active for at least 180 minutes per day and should spend at least 60 minutes of this time in MVPA[39, 40]. Only a few studies have looked at the proportion of preschool-aged children meeting these activity guidelines using objective measures of physical activity. Two studies from the UK[32, 33] found that 100% of children aged three-to-four-years met the recommended ≥180 minutes a day of TPA whereas a Belgian[70], Australian[34] and Canadian[35] study found that 11.0%, 5.1% and 83.8% of preschool-aged children met these guidelines, respectively. Furthermore, the Canadian study found that 13.7% of five-year-olds spent ≥60 minutes in MVPA per day[35]. It is, however, not possible to establish whether children in the UK are more physically active than children in Canada and Australia due to differences in definitions of accelerometer wear time applied across these studies[27, 29]. This emphasises the importance of applying standardised data processing methods to ensure comparisons across countries are valid.

A key stage in the development of behaviour change interventions is identifying variables which could either be potential targets to change behaviour (mediators) or variables that could affect the outcome of the behaviour change programme (moderators). Therefore, identifying the key correlates of preschoolers' sedentary time and physical activity is important for designing effective behaviour change programmes[73]. Narrative reviews have assessed the correlates of sedentary time[64, 67] and physical activity[64, 66] in preschool-aged children. Across the reviews, there was inconsistent support for associations between sedentary time and physical activity with correlates. For example, one review concluded boys were more active than girls[66], whereas the other did not[64]. Conflicting findings were also observed for day of the week, where one review found no association[66] and the other found a positive association[64] with physical activity. Both found no association between age, ethnicity, season, or parent education with physical activity[64, 66]. All three reviews were limited in that they included studies which used self-report measures of sedentary time and physical activity, which may not accurately detect associations. Since these reviews were published, there have been a few additional studies which have assessed the correlates of sedentary time and/or physical activity in preschool-aged children using objectively measured accelerometry data[145-152]. The findings across these studies are similarly inconsistent, and there is the issue of comparability as they have processed accelerometry data using different methods of processing and analysing data[145-152]. In addition, none of the studies have made cross-national comparisons of the proportion of children meeting guideline levels of sedentary time, total physical activity, and moderate-to-vigorous physical activity and using a standardised method of processing accelerometry data. Accordingly, I aim to determine the levels and correlates of sedentary time, total physical activity and moderate-to-vigorous physical activity in children aged 3-4-years-old using data from four countries, applying a consistent approach to data processing.

3.3. A critical assessment of appropriate accelerometry wear time practices to apply to preschool-aged children

To appropriately analyse the ICAD data, it is essential to apply accelerometry wear time practices which are specific to preschool-aged children, to consider their growth, development and habitual activity patterns[153, 154]. I acknowledge that some research groups have extended beyond this approach to look at 24-hour movement behaviours (physical activity, sedentary behaviours and sleep) but that is not the bulk of the research, so I have limited the discussion to cut point methods[155]. In this section, which is not included in the published article[1], I summarise the existing literature to inform suitable accelerometry wear time practices to be applied to the ICAD analyses.

3.3.1. Accelerometry cut points for preschool-aged children

Accelerometers are devices which measure the accelerations of the body part which they are attached to and can therefore detect bodily movements[156]. For preschool-aged children, accelerometers are often attached to an elasticated belt and worn around the child's waist, with the device positioned over the child's hip[157]. The raw accelerometry data output is provided in the form of counts per unit of time or counts per epoch[156]. The most standard method for converting raw accelerometry output into estimates of physical activity intensities (e.g. time spent in MVPA) is with the use of intensity-related accelerometry cut points[153, 154]. Accelerometry cut points are calculated using receiver operator characteristic curves or single regression equations which describe non-/linear relationships between counts and energy expenditure[153]. It is important for accelerometers to be calibrated against specific age categories as age has been shown to influence the relationship between accelerometry counts and energy expenditure[158]. Several studies have derived their own cut points using different methods, meaning that researchers must decide which cut points are appropriate to apply to their specific data[153]. Alternative accelerometry measurements such as the minimum acceleration value above which the most active 30 minutes were accumulated in the day could be used as an alternative to cut points to measure children's activity levels[159]. However, although such metrics have demonstrated agreement with equivalent cut point approach results, they have not yet been calibrated for the preschool-aged population[159].

Table 5 summarises five studies which have derived accelerometry cut points to measure young children's activity levels. Participants in the studies by Pate et al[160], van Cauwenberghe et al[161] and Sirard et al[162] provided the most appropriate age ranges to represent the preschool-age population. The studies by Pate et al[160], Evenson et al[163] and Puyau et al[164] only measured the relationship between energy expenditure and physical activity, which is limited in terms of the time delay between measured oxygen consumption (VO_2) and change in physical activity[161]. The study by Puyau et al[164] is the only instance of accelerometry data being measured in 1-minute intervals as opposed to 15 second epochs, making the derived thresholds less reliable predictors of the true physical activity levels. This is because collecting data in intervals less than 1-minute in length, is more accurate at capturing the sporadic nature of preschool-aged children's activity[165-167]. All of the studies had participants perform a variety of activities but only the study by Sirard et al[162] had children perform the activities in preschool settings, making the accelerometer calibration more representative of typical behaviour. The populations in all of the studies are limited in terms of generalisability as they were conducted in American[160, 162-164] and Belgian[161] populations.

Table 5: A comparison of five accelerometry thresholds derived to measure children's sedentary time and physical activity levels

Reference and N° citations	**Sample characteristics***	**Accelerometer and cut points (counts/15s)**	**Research methods**	**Statistical Analyses**	**Results**	**Strengths**	**Limitations**
Pate RR et al[160, 168] 2006 Google Scholar: 372 Web of Science: 239 Scopus: 249	30 preschool children (29 in analysis) 4.4 ± 0.8 (3.30 to 5.95) years Male (44.8%) African American (55.2%) and White (44.8%) BMI: 16.5 ± 2.2 (13.7 to 24.5) kgm^{-2} Height and weight data available in reference.	ActiGraph (ActiGraph, Fort Walton Beach, FL) Sedentary: 0-37/0-199 LPA: 38-419/200-419 MPA: 420-841 VPA: ≥842	Children wore an accelerometer and a Cosmed portable metabolic system during 10 minutes of rest and while performing three 5-minute structured physical activities (at 2mph, 3mph and 4mph respectively) in a laboratory setting. For cross-validation, the same children wore the same instruments while participating in unstructured indoor (blocks, reading, computer time, sociodramatic play, music or movement	Intercepts and slopes were fitted for each subject, and then an overall regression line was calculated for the relationship between VO_2 and accelerometer counts. Accelerometer counts for prediction of VO_2, other variables were considered both one at a time and in a multivariate model. Models were compared and assessed using goodness-of-fit statistics. Count cut points for MPA and VPA were identified through visual	The correlation between VO_2 and counts was r = 0.82 across all activities. Goodness-of-fit indices from the model with only ActiGraph counts were (R^2 = 0.904, standard error of the estimate = 4.70). Cut points for MPA and VPA were identified at 420 counts/15 s (VO_2 = 20 mL/kg per min) and 842 counts/15 s (VO_2 = 30 mL/kg per min), respectively. The ICC coefficient between measured and predicted VO_2	The age category of the sample is representative of preschool-aged children [4.4 ± 0.8 (3.30 to 5.95) years]. The cut points are derived from a narrow age range. The cut points are derived from a variety of activities. Accelerometry data was measured in 15 second intervals	The cut points are derived from activities performed in a laboratory setting only (however this was cross-validated with the same children performing a variety of activities in preschool settings in a separate study). The cut points are based on direct measures of energy

	Columbia, South Carolina, USA		play) and outdoor (climbing, swinging, digging, playing with balls or other objects, running or chasing) activities for 20 minutes each (spending 4-6 minutes on an activity) at their preschool. Expired respiratory gases were collected and oxygen consumption (VO_2) was measured on a breath-by-breath basis. Accelerometer data were collected at 15-second epochs.	inspection of the distribution of the VO_2 values for slow walking, brisk walking, and jogging. Intraclass, Spearman and Pearson correlations for the associations between measured and predicted VO_2 were calculated. Agreement between MPA/VPA based on measured VO_2 and estimated intensity was assessed using percentage agreement, kappa and modified kappa statistics. The equation VO_2 = 10.0714 + 0.02366 (counts/15 s) was used to determine cut points for MVPA and VPA.	was R = 0.57 and the Spearman correlation coefficient was R = 0.66 ($p < 0.001$). When these cut points were applied to the cross-validation data, percentage agreement, kappa and modified kappa for MPA were 0.69, 0.36 and 0.38 respectively. For VPA, the same measures were 0.81, 0.13 and 0.62. Sensitivity and specificity for the MPA cut points were 96.6% and 86.2% respectively and for VPA, 65.5% and 95.4% respectively.		expenditure only.

Evenson KR et al[163] 2008 Google Scholar: 1086 Web of Science: 674 Scopus: 732	33 children 7.3 ± 1.1 (5.1 to 9.0) years Female: 63.6%, Male 36.4% Black (15.2%), White (66.6%) and Other (18.2%) BMI: 16.6 ± 2.2 (13.2 - 21.7) kgm^{-2} Height and weight data available in reference. Piedmont, North Carolina	ActiGraph (#AM7164-2.2; Manufacturing Technologies Inc. Health Systems, Fort Walton Beach, Florida) Sedentary: 0-25 LPA: 26-573 MPA: 574-1002 VPA: ≥1003	Children wore both accelerometers and a COSMED portable metabolic system during 15 min of rest and then performed up to nine different activities for 7 min each on two separate days in the laboratory: Sedentary: Rest, watch a DVD and colour books. Light: Slow walk. Moderate: Stair climbing, dribble basketball and brisk walk. Vigorous: Cycling, jumping jacks and running. VO_2 and heart rate were measured, and accelerometer data were collected at 15-second epochs.	The relationship between accelerometer counts and VO_2max percentage of represented by each activity was calculated. Using receiver operating characteristic curve (ROC) analysis, cut points that maximised both sensitivity and specificity were determined for sedentary, moderate and vigorous activities. Differences by age group (5–6 vs 7–8 years) for each intensity level and for both accelerometers was determined by comparing the area under the ROC curve. Ratings suggested by Landis and Koch were followed.	Resting VO_2 averaged 4.7 ml/kg/min. The Pearson correlation between average heart rate and average VO_2 from the treadmill was 0.69. The maximal VO_2 was predicted at 39.8 ml/kg/min. For sedentary, MPA and VPA respectively; the sensitivity was 95%, 77% and 68%; the specificity was 93%, 81% and 89% and the area under the ROC curve was 0.98, 0.85 and 0.83.	The cut points are derived from a variety of activities. Accelerometry data was measured in 15 second intervals.	The ages of the children measured are not representative of preschool-aged children, even though the youngest age in the range is 5.1 [7.3 ± 1.1 (5.1 to 9.0) years] The cut points are derived from a large age range. The cut points are derived from activities performed in a laboratory setting. Activities not representative of preschool-aged children (dribble

							basketball and jumping jacks). The cut points are based on direct measures of energy expenditure only.
Puyau MR et al[164] 2002 Google Scholar: 1002 Web of Science: 618 Scopus: 636	26 children – Boys (n=14) and girls (n=12). Boys: 10.7 ± 2.9 (6 to 16) years. Girls: 11.1 ± 2.9 (7 to 16) years. White (n=16), African American (n=2), Hispanic (n=4) and Asian (n=4). CDC BMI Z scores: Boys: 0.42 ± 0.83 (-1.7	Computer Science and Applications Actigraph (model 7164; Computer Science and Applications, Shalimar, FL) Sedentary§: 0-199 LPA§: 200-799 MPA§: 800-2049 VPA§: ≥2050	Accelerometers were validated and calibrated against 6-hour energy expenditure (EE) measurements by room respiration calorimetry, activity by a Doppler microwave sensor, and heart rate by telemetry in a room calorimeter. During the 6 hours, the children performed structured activities, including:	Threshold levels were defined in terms of activity energy expenditure (AEE) computed as EE - RMR was regressed against counts to derive threshold counts. Descriptive statistics, Pearson correlations and multiple regression analyses were performed between counts and EE, and counts provided by the CSA and MM monitors.	The mean correlations between EE or AEE and counts were for the CSA-hip (r = 0.66 ± 0.08) and CSA-leg (r = 0.73 ± 0.07). EE or AEE was correlated highly with heart rate (r = 0.80 ± 0.10) and microwave activity counts in the calorimeter (r = 0.82 ± 0.04). Correlation between the CSA-hip and CSA-leg placement was r = 0.77. EE was significantly related	The cut points are derived from a variety of activities.	The ages of the children measured are not derived from preschool aged children [Boys: 10.7 ± 2.9 (6 to 16) years. Girls: 11.1 ± 2.9 (7 to 16) years]. The cut points are derived from a large age range. The cut points are derived from activities performed in a

	to 1.3). Girls: 0.32 ± 0.73 (-1.5 to 0.8). Height, weight and body mass index (BMI) information available in reference.		Sedentary: Nintendo, arts and crafts and playtime 1. Light: Aerobic warm-up and Walk 1. Moderate: Tae Bo, playtime 2 and walk 2. Vigorous: Jogging, jump rope, walk 3, skip, jogging and soccer. The children were monitored throughout a series of outdoor measurements under field conditions. Counts, VO_2, VCO_2, EE and heart rate were averaged at 1-minute intervals.		to counts and age but not to sex. Age increased the r^2 for the prediction of EE from counts by 2% to 3%. Age did not significantly alter the prediction of AEE from counts. Predicting AEE from the combination of the counts from the hip and leg increased the r^2 to 86%. The sedentary, light, moderate and vigorous categories were set at <0.015, ≥0.015 but <0.05, ≥0.05 but <0.10 and ≥0.10 kcal/kg/minute respectively.		laboratory setting (unclear whether how this was calibrated with the activities that were performed in field settings). The cut points are based on direct measures of energy expenditure only. Accelerometry data was measured in 1-minute intervals.
Van Cauwenberghe E et al[161]	18 children - 10 girls for phase 1 (calibration the accelerometer)	GT1M ActiGraph Sedentary: 0-372	The children spent 20 minutes in a free play session followed by 10 3-minute and 1 10-	Receiver Operating Characteristic (ROC) curve analyses were used to determine the	For sedentary, MPA and VPA respectively; the sensitivity was	This is the most recent publication out of the five	The cut points are derived from activities performed in a

2011 Google Scholar: 110 Web of Science: 49 Scopus: 63	and 154 children for phase 2 (predicted PA using cut points) Phase 1: 5.8 ± 0.4 years. Phase 2: 5.5 ± 0.3. IOTF definition: Normal weight (16) and Overweight (2) Ghent, Belgium	LPA: 373-584 MPA: 585-880 VPA: ≥881	minute structured activities in a laboratory which were based on the Children's Activity Rating Scale (CARS): sitting, standing, drawing, walking/jogging at 7 increasing speed levels and the 10-minute easy paced walk. Accelerometry data was measured in 15 second intervals. A second-by-second direct observation (modified CARS) was carried out by two researchers on the videotaped free play session and used as a criterion measure of PA. For phase 2, children wore the accelerometer for 5 consecutive days.	sedentary, moderate and vigorous accelerometer cut points where sensitivity and specificity were both maximised: counts per 15s of each calibration activities by the activity. For phase 2, ANOVA was used to determine the differences between estimations of time spent (in)active according to the various accelerometer cut points (Sirard et al, Pate et al and Evenson et al.	85.9%, 87.2% and 87.5%; the specificity was 91.2%, 82.2% and 91.3%; the area under the ROC curve was 0.95, 0.91 and 0.94.	summarised. The ages of the children from which the thresholds were derived from are on the upper end of what would be defined as preschool aged [Phase 1: 5.8 ± 0.4 years. Phase 2: 5.5 ± 0.3]. The cut points are derived from a narrow age range. The cut points are derived from a variety of activities. The cut points are based on a combination of direct measures of	laboratory setting. No ethnicity data is presented.

						energy expenditure and direct observation. Accelerometry data was measured in 15 second intervals.	
Sirard J R et al[162] 2005 Google Scholar: 261 Web of Science: N/A Scopus: N/A	16 children for phase 1 - 23 recruited but 7 removed (calibrating the accelerometer) and 269 children for phase 2 (validating the cut offs in preschool settings) See Table 2 in reference for by age category and phase data for gender,	ActiGraph accelerometers (Manufacturing Technology, Inc., Fort Walton Beach, FL) 3-year-olds Sedentary: 0-301 LPA: 302-614 MPA: 615-1230 VPA: ≥1231 4-year-olds Sedentary: 0-363 LPA: 364-811 MPA: 812-1234 VPA: ≥1235	Children performed five 3-minute structured activities. A modified Children's Activity Rating Scale (CARS) was used as the criterion physical activity measure: sitting and talking, fast walking (4.3 ± 0.6 km/hr), sitting and playing, slow walking (3.2 ± 0.6 km/hr), and jogging (6.9 ± 3.9 km/hr). Each child was measured for 15 seconds at a time. To	Receiver Operating Characteristic (ROC) curve analyses identified count cut offs for four physical activity intensities where sensitivity and specificity were both maximised. ROC curve analyses were calculated separately for the 3, 4 and 5-year-olds.	For sedentary, MPA and VPA respectively; the sensitivity ranged from 9.4% - 100%; specificity ranged from 66.7% - 100%; the area under the ROC curve ranged from 0.92-1.00 for the 3, 4 and 5-year-old thresholds. Pearson correlation coefficients between direct observation physical activity variables and ActiGraph variables collected during the	The paper does not provide the exact ages of the children, but the age range is derived from preschool aged children [3 to 5 years]. The cut points are derived for specific age groups (3yr, 4yr and 5yr). The cut points are derived from a variety of activities.	The cut points are derived from direct observation only.

	ethnicity, height, weight and BMI data. 3 to 5 years Columbia, South Carolina	5-year-olds Sedentary: 0-398 LPA: 399-890 MPA: 891-1254 VPA: ≥1255	evaluate the ability of the count cut offs to categorize activity intensity, children wore the accelerometer during the entire time they were at their preschool for up to 10 consecutive weekdays.		field trial are moderate in magnitude (0.46 to 0.70) and all are statistically significant (P < 0.001).	The cut points are derived from activities performed in preschool settings. Accelerometry data was measured in 15 second intervals.	

Note: LPA: Light Physical Activity, MPA: Moderate Physical Activity, VPA; Vigorous Physical Activity, ICC: Intraclass Correlation Coefficient
*Mean ±SD (range) for continuous data unless otherwise stated
§Thresholds described by Puyau et al were stated in counts/min in the references: Sedentary: 0-799, LPA: 800-3199, MPA: 3200-8199 and VPA: ≥8200

The accelerometry cut points available in the ICAD dataset are those described by Evenson et al[163] and a combination of those described by Pate et al[160, 168] and Puyau et al[164] (mainly consisting of those identified Pate et al[160, 168]). A variety of activities were performed and the accelerometry data were collected in 15 second epochs in two of the calibration studies[160, 163]. However, both of these studies were limited in that the activities were performed in laboratory settings and the cut points were derived based on energy expenditure only. The study by Evenson et al[163] is further limited on the basis that the participant age range and the activities performed, are not representative of those undertaken by children aged under five-years-old. The age range of the children in the study by Pate et al[160] is more representative of a preschool-age population and for this reason it would be more appropriate to use these cut points for the primary analyses of the ICAD (section 3.4.3). If more thresholds were available in the ICAD, it would be more appropriate to use the cut points specified by van Cauwenberghe et al[161] or Sirard et al[162] in the primary analyses. Both studies had participants which represented preschool-aged children; derived thresholds from a variety of activities; and collected accelerometry data in 15 second epochs. The study by van Cauwenberghe et al[161] is the only study to combine a measure of energy expenditure and direct observation to derive the cut points whereas Sirard et al[162] used direct observation only. Activities were performed in a laboratory setting in the study by van Cauwenberghe et al[161] as opposed to preschool settings in the study by Sirard et al[162], which is more appropriate.

It is evident that there is a large degree of variability with how different cut points are developed, presenting researchers with an obstacle in quantifying accelerometry data known as the cut point conundrum[169], which results in the magnitude of activity estimates being altered based on the cut points used. Without a standardised approach to reducing accelerometry data, it is only possible to choose the most appropriate cut points based on the population being analysed and those which are available.

3.3.2. Accounting for non-wear time with accelerometry data

Accelerometry non-wear time refers to intervals where participants are not wearing their accelerometers, such as when they are sleeping, showering or swimming[170]. Non-wear time needs to be excluded from the raw data to accurately assess the time spent in different physical activity intensities during participants' wear time[170]. In the ICAD[72], non-wear time is defined as 60 minutes of consecutive zeros allowing for two minutes of non-zero interruptions[171], which was removed from the raw dataset. Looking at this reference in more detail, non-wear time is defined as an interval of at least 60 consecutive minutes of zero activity intensity counts, with allowance for one to two minutes of counts between 0 and 100[171]. A study by Goodman et al[172] was conducted using the ICAD, where the authors removed hours with less than 30 minutes of data when conducting by hour analyses. There are no validation studies specifically advising on the number of minutes of wear time needed per hour for by hour analyses, therefore for the by hour analyses I present in section 3.5.3 when looking at the activity patterns across the day, I remove hours with less than two minutes of wear time in line with the reference by Troiano et al[171].

It is necessary to restrict the hours of analysis within a day to exclude the times that the participants are sleeping at night however the hours that the participants are asleep is not available in the ICAD. As the participants are from different countries, which may have variations in typical daily routines, it would not be appropriate to apply the same 'routine' to the whole analysis sample. To help guide the time period to restrict the analyses by, I assessed previous literature which have stated time period inclusion when analysing preschool-aged children's accelerometry data (Table 6). The studies are conducted in high-income countries which is representative of the data available to analyse in the ICAD. Looking at Table 6 together with the preliminary ICAD data analyses (data not shown), I decided to restrict the analyses from 6am-10pm (6:00-21:59)[32, 173] to best reflect when this population would be awake.

Table 6: A summary of a sample of studies which have stated the time periods and minimum valid day inclusions criteria for the analysis of accelerometry data in preschool-aged children

Reference	Time period	Minimum number of hours/minutes per day	Minimum number of days	Participant ages	Country
Hesketh et al[32]	6am – 11pm	10 hours	Not stated	4 years	UK
Hesketh et al[33]	7am – 6pm	10 hours	Not stated	3-4 years	UK
O'Dwyer et al[174]	7am – 8pm	10 hours 19 minutes (weekday) and 10 hours 24 minutes (weekend)	3 days including 1 weekend day	3-5 years	UK
Berglind et al[175]	7am – 9pm	10 hours	4 days including 1 weekend day	4 years	Sweden
Van Sluijs et al[173]	6am – 10pm	10 hours	3 days	4 years	UK
Hnatiuk et al[147]	6am - 9/11pm	10 hours	1 day	3-4 years	UK
Dawson-Hahn et al[176]	6am – 12am	3 hours	5 days	3-5 years	USA
Schmutz et al[148] and Leeger-Aschmann et al[177]	7am - 9pm	10 hours	3 days including 1 weekend day	2-6 years	Switzerland
Olesen et al[178]	N/A – preschool time period	3 hours in preschool	3 preschool days	5-6 years	Denmark
Sijtsma et al[179]	Sleep times recorded	6 hours 40 minutes	2 weekdays and 1 weekend day	3-4 years	Netherlands
Dolinsky et al[145]	Non-wear time removed only	6 hours	2 weekdays and 1 weekend day	2-5 years	USA
Bringolf-Isler et al[180]	Non-wear time removed only	10 hours	2 weekdays and 1 weekend day	4-7 years	Switzerland
Abbott et al[78]	Non-wear time	6 (baseline) – 8 (follow-up) hours	3 days including 1	3-5 years	Australia

	removed only		weekend day		
Hinkley et al[74]	Non-wear time removed only	7 hours	3 weekdays and 1 weekend day	3-5 years	Australia
Eichinger et al[181]	7am – 9pm	4 hours	3 weekdays and both weekend days	3-6 years	Germany

3.3.3. Number of valid days of accelerometry data

The accelerometry cut points described by Puyau et al[164] and Pate et al[160, 168] will be used in the primary analyses of the ICAD, as described earlier: Sedentary (0-199 counts/15 seconds), light physical activity (LPA) (200-419 counts/15 seconds), moderate physical activity (MPA) (420-841 counts/15 seconds) and vigorous physical activity (VPA) (≥842 counts/15 seconds). Studies by Byun et al[182] and Addy et al[183] have determined the number of days of accelerometry data needed to reliably estimate daily sedentary time and physical activity levels in children aged 3-5-years-old using these cut points. Both studies used data from the Children's Activity and Movement in Preschool Study (CHAMPS) which is described elsewhere[168]. In brief, ActiGraph (ActiGraph model 7164, Shalimar, FL, USA) accelerometry data was collected over 8-10 consecutive days from children from 22 preschools in greater Columbia, South Carolina, USA. In

Table 7, I have collated the results from the two studies[182, 183] which I will describe below.

Table 7: Number of days of accelerometry data needed to achieve acceptable reliability

Physical activity intensities (cut points)	**ICCs achieved with number of days of accelerometry data**			**Number of days of accelerometry data to achieve ICCs**			
	1	4	7	≥0.7	≥0.75	≥0.8	≥0.9
Sedentary (<37.5 counts/15 seconds)	0.32	0.65	0.76	5	6	9	19
Sedentary (<200 counts/15 seconds)	0.36	0.69	0.8	4	5	7	16
Total PA (≥200 counts/15 seconds)	0.36	0.79	N/A	4.24	5.45	7.26	N/A
MVPA (≥420 counts/15 seconds)	0.39	0.72	N/A	3.62	4.65	6.21	N/A

Note: ICC: Intraclass Correlation Coefficient

In the study by Byun et al[182], the count data was categorised using three different cut points for sedentary time: <37.5 counts/15 seconds[160], 200 counts/15 seconds[160] and <373 counts/15 seconds[161]. Two samples of children were analysed: Total-Days (n= 150) who had at least six days of valid data and In-School (n=191) who had at least four valid weekdays. The number of days of accelerometry data needed to reliably estimate sedentary time was calculated using the Spearman-Brown prophecy formula where an intraclass correlation coefficient (ICC) of 0.8 was considered a reliable cut off. The Standard Error of Measurement (SEM) was calculated to measure the precision of the sedentary time using the estimated ICCs. Looking at the results of the sedentary time cut point described by Pate et al[160, 168] (<200 counts/15 seconds) from the Total-Days sample, seven days of accelerometry data are needed to produce an ICC of ≥0.8 (see Table 7). One, four and seven days of data were calculated to produce ICCs of 0.36, 0.69 and 0.8. The SEMs for one, four, six, seven and nine days of data was 2.2, 1.6, 1.3, 1.3 and 1.2[182].

The study by Addy et al[183] reduced accelerometry data using cut points specified for 3-5-year-olds[160, 168]: total physical activity (≥200 counts/15 seconds) and MVPA (≥420 counts/15 seconds). Three different samples of participants were analysed: Total-Days (n=150) who had at least six days of valid data, In-School (n=199) who had at least four in-school days and Weekdays (n=204) who had at least four weekdays. Like the study by Byun et al[182], the Spearman-Brown prophecy formula was used to determine the number of days of accelerometry data required to obtain a specific ICC. For total physical activity, one day of accelerometry data achieved an ICC of 0.36 and four days achieved an ICC of 0.69 in the Total-Days sample (Table 7). Additionally, one day of accelerometry data achieved an ICC of 0.39 whereas four days of data achieved an ICC of 0.72 for MVPA.

Table 7 summarises the number of days of accelerometry data needed to achieve ICCs of values between ≥0.7 and ≥0.9 for the different physical activity intensities, based on the two studies[182, 183]. Although the study by Byun et al[182] stated that an ICC of ≥0.8 was considered acceptable based on previous literature, the study by Addy et al[183] discusses an ICC of ≥0.75 as achieving acceptable reliability. Based on psychometric theory, it has been stated that an ICC of ≥0.7 can be considered as an acceptable threshold[184]. This highlights the inconsistencies in determining an acceptable reliability threshold between different studies. The Spearman-Brown prophecy formula predicts a large number of days needed to reliably estimate physical activity levels, which does not coincide with data available in the ICAD and would therefore limit my ability to analyse the data. Thus, I have had to consider what is appropriate but also feasible, with choosing accelerometry wear time practices to apply to the ICAD, which I will describe in section 3.3.5.

3.3.4. What is considered a valid day of accelerometry data

A study by Hinkley et al[185] assessed the volume of accelerometry data required to reliably estimate preschool-aged children's activity measures and whether it was appropriate to include weekday and weekend data as a minimum requirement. Overall, ActiGraph Model GT1M accelerometry data were analysed from a sample of 1004 children participating in the Healthy Active Preschool Years study in Melbourne, Australia. The Spearman-Brown prophecy formula was used to estimate the number of days needed to estimate ICCs of 0.7, 0.8 and 0.9 and how many hours of accelerometry data is needed for each of those days. The cut points used to categorise total physical activity are those described by Sirard et al[162] which are different to those that are available to analyse the

ICAD. The authors found that four days, each consisting of five/six hours (300/360 minutes) of data, were needed to achieve an ICC of 0.7. Alternatively, 3.2 days of accelerometry data, with eight hours (480 minutes) per day also achieved an ICC of 0.7. The authors found that including a weekend day of data improved the reliability.

Table 6 summarises a sample of studies which have looked at correlates of sedentary time and physical activity in preschool-aged children and stated their inclusion criteria for the minutes of accelerometry wear time needed to consider a day valid and the number of valid days needed. Most of the studies do not specify a reference for their inclusion criteria and it is evident that there is a large variation in valid day criteria. As discussed in section 3.3.3, it is important to weigh up what is both reliable and feasible inclusion criteria, with the accelerometry data that is available to analyse.

3.3.5. Valid day inclusion criteria for the ICAD analyses

Based on the studies used by Byun et al[182] and Addy et al[183] (section 3.3.3), which have used the accelerometer cut points that are available in the ICAD, I would need participants with at least four valid days of accelerometry data to achieve an ICC ≥0.7 for all of the physical activity intensities. Combining this with the study by Hinkley et al[185] (section 3.3.4), a day could be considered valid if there are at least five to six hours of accelerometry data. Out of the 1246 participants in the ICAD aged 3-4-years-old with at least one valid day (six hours) of accelerometry data, 875 (70.2%) of the sample have four valid days of data (data not shown). By removing almost 30% of the potential sample using these criteria, the power would be reduced which would skew analysis results, if those who are excluded are different to those retained in the sample. To maximise the sample size whilst maximising the reliability, participants with three days of valid accelerometry data (1016) with at least eight hours of data (1227) will be analysed in the primary analyses (82.8%), which is in line with the validation study findings by Hinkley et al[185] to achieve an ICC of 0.7. So as not to reduce the power of the analyses further, the inclusion criteria of having at least one weekend day to increase reliability will not be applied to the data. It is appropriate to conduct sensitivity analyses looking at participants with four days of data with at least six hours of wear time; to see how the results compare to the suggested number of valid days to include as calculated for the cut points used in the study[182, 183].

3.4. Methods

3.4.1. Study design

Cross-sectional analyses were carried out on data obtained from the ICAD, which has been described in detail elsewhere[72]. In brief, the ICAD is a pooled database of raw Actigraph accelerometer (Actigraph LLC, Pensacola, FL, USA) data files and accompanying demographic, anthropometric, and health data collected from children (2–18-years) between 1997 and 2009. Data were pooled from 20 studies conducted in 11 countries and included cross-sectional, longitudinal, intervention and closed cohort studies. Data were reduced using standardised techniques to allow for comparison of physical activity outcome variables across studies (see below). Formal data sharing agreements were established between all study authors and the ICAD. All studies consulted their individual research boards to confirm that appropriate ethical approval had been attained for contributing data.

3.4.2. Participants

For this study, the analytical sample consists of children aged 3-4-years-old who had at least three days (week and/or weekend days) of valid accelerometry data[185]. To maintain the independence of the observations, follow-up waves of data were excluded from the analyses (n = 17). Participants aged two-years-old (n = 17) and participants from Australia (n = 7) were excluded due to the very small sample sizes for these groups. Data for the analysis sample were extracted from six studies: Ballabeina Study[186]—Switzerland; Belgium Pre-School Study[161, 187, 188]—Belgium; CHAMPS UK[189, 190]—UK; CHAMPS U.S.[168]—USA.; Iowa Bone Development Study (IBDS)[191, 192]—USA.; and Movement and Activity Glasgow Intervention in Children (MAGIC)[193]—UK.

3.4.3. Physical activity measurement

Physical activity was measured using waist-worn, uniaxial Actigraph accelerometers (models 7164, 71256, and GT1M). Raw data files were processed using KineSoft version 3.3.20 (KineSoft, Sakatchewan, SK, Canada). Non-wear time was defined as periods of 60 minutes of consecutive zeros allowing for two minutes of non-zero interruptions[171]. A day was considered valid if there was at least 480 minutes of accelerometry data[185]. The analysis of physical activity data was restricted to 06:00 and 21:59 to exclude the times when the children would be asleep[173]. When looking at physical activity patterns across the day, hours with less than two minutes of wear time were removed from the analyses[171]. Physical activity thresholds available in the ICAD were those specified by Puyau et al.[164] and Pate et al.[160]: sedentary (<800 cpm)[164], TPA (≥800 cpm)[164] and MVPA (≥1680 cpm)[160]. Mean hourly, daily, weekday and weekend minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity across the whole week were the outcome variables.

3.4.4. Variables

The following 10 potential correlates were examined: age, gender, country, season, ethnicity, parental education, day of the week (weekday vs weekend), time of sunrise, time of sunset and hours of daylight. These variables were explored based on a combination of what was available and what had been identified as potential correlates by previous studies[64, 66, 67]. Ethnicity data were available from three studies in the analysis sample and categorised as white or other (non-white). Parental education was available from four studies and was dichotomised into 'up to and including completion of compulsory education including vocational training' and 'any post-compulsory education including vocational training', as a measure of socioeconomic status. The season, time of sunrise, time of sunset and hours of daylight variables were derived from the date that the accelerometer started collecting data and the city, or nearest city, where the study took place using the website www.timeanddate.com. The countries in the sample were all in the Northern Hemisphere and therefore, had the same seasons (spring: March–May; summer: June–August; autumn: September–November; winter: December–February). The time of sunrise variable, time of sunset and hours of daylight variables were categorised into before and after 07:00; before and after 19:00; and less than or more than 12 hours, respectively.

3.4.5. Statistical analyses

Participant characteristics were summarised using frequencies and percentages for categorical data. The percentage of children meeting the recommended daily guidelines of ≥180 minutes of total physical activity[39, 40, 80, 144] and ≥60 minutes of moderate-to-vigorous physical activity[39, 40] were compared across categories of each correlate using chi-squared tests. Mean minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity were plotted for every hour between 06:00 and 21:59. Adjusted multilevel linear regression models were used to determine the association between sedentary time, total physical activity and moderate-to-vigorous physical activity for each potential correlate. Models were adjusted for age, gender, season, minutes of wear time and study clustering effects. Linear regression analyses were undertaken assuming a linear relationship, multivariate normality, homoscedasticity and little multicollinearity which were tested via inspection of scatter plots of the outcomes vs. the independent variable; histograms of the outcome variables; scatter plots of the residual errors vs. the linear predictor; and variance inflation factors of the variables included in the models, respectively. Results from the assumption tests clarified that these assumptions had been met (data not shown). ICCs and R-squared values (R^2), as proposed by Snijders and Bosker[194], were calculated for each of the models. Some studies[182, 183] suggest that four valid days of accelerometry data are needed to reliably measure activity levels to achieve an ICC of ≥0.7 when using the accelerometry thresholds specified in the analyses[160, 164]. Sensitivity analyses were, therefore, carried out on a sample where participants had at least four days of valid accelerometry data (data not shown). All analyses were carried out in Stata v15 (StataCorp, College Station, TX, USA).

3.5. Results

3.5.1. Participant characteristics

The 1052 participants in the analysis sample (Table 8) contributed an average of 4.82 days of data comprising 3.79 weekdays and 1.03 weekend days. The average daily wear time between 6:00 to 21:59 was 697.27 minutes (see Appendix 3). Data were collected between September 1998 and June 2009. Out of the six studies which contributed data, most participants were from the UK-based MAGIC study (36.8%).

Table 8: Sociodemographic characteristics of children

Characteristic	N (%)
Overall	1052 (100.00)
Age	
3	343 (32.60)
4	709 (67.40)
Gender	
Male	528 (50.19)
Female	524 (49.81)
Country	
UK	426 (40.49)
Switzerland	142 (13.50)
Belgium	104 (9.89)
USA	380 (36.12)
Season	
Winter	136 (12.93)
Spring	110 (10.46)
Summer	117 (11.12)
Autumn	689 (65.49)
Ethnicity	
White	200 (19.01)
Other	219 (20.82)
Missing/Not available	633 (60.17)
Parental Education	
Up to and including completion of compulsory vocational training	86 (8.17)
Any post-compulsory education including vocational training	300 (28.52)
Missing/Not available	666 (63.31)
Day of the Week	
Weekday	1052 (100.00)
Weekend	626 (59.51)
Time of Sunrise	
Before 07:00	433 (41.16)
After 07:00	619 (58.84)
Time of Sunset	
Before 19:00	548 (52.09)
After 19:00	504 (47.91)
Hours of Daylight	
Less than 12 hours	589 (55.99)
More than 12 hours	463 (44.01)
Study	
Ballabeina	142 (13.50)
Belgium Pre-School	104 (9.89)
Children's Health and Activity Monitoring Programme USA	361 (34.32)
Movement and Activity Glasgow Intervention in Children	387 (36.79)
Children's Health and Activity Monitoring Programme UK	39 (3.71)
Iowa Bone Density Study	19 (1.81)

3.5.2. Percentage of children meeting Canadian, Australian, USA and UK guidelines for sedentary time, total physical activity, and moderate-to-vigorous physical activity

Participants spent an average of 490.18 minutes per day in sedentary time (see Appendix 3). Table 9 shows that 70.0% of participants met recommended daily guidelines of ≥180 minutes of total physical activity and 78.8% of participants met daily guidelines of ≥60 minutes of moderate-to-vigorous physical activity, based on total physical activity (≥800 cpm)[164] and moderate-to-vigorous physical activity (≥1680 cpm)[160] thresholds specified by Puyau et al. and Pate et al. A greater percentage of four-year-olds than three-year-olds and boys than girls met the recommended guidelines for total physical activity and moderate-to-vigorous physical activity. The findings suggest that the percentage of children reaching total physical activity and moderate-to-vigorous physical activity guidelines varied between the different countries. The lowest percentage of children achieving guideline moderate-to-vigorous physical activity levels was observed in Belgium (50.0%), and the highest percentage was observed in the USA (88.7%). The percentage of children reaching the recommended total physical activity and moderate-to-vigorous physical activity levels increased from winter through to summer before it decreased in autumn and was greater on weekdays compared to weekends. A greater percentage of non-white children met the moderate-to-vigorous physical activity guidelines compared to white children (92.7% vs. 78.0%, $X^2 = 18.40$, $p < 0.001$). When the hours of daylight were more than 12 hours, a greater percentage of children met total physical activity (76.2% vs. 65.0%, $X^2 = 15.52$, $p < 0.001$) and moderate-to-vigorous physical activity (85.1% vs. 73.9%, $X^2 = 19.62$, $p < 0.001$) guidelines compared to when days were less than 12 hours long. A greater percentage of children met total physical activity and moderate-to-vigorous physical activity guidelines when the time of sunrise was before 07:00 and the time of sunset was after 19:00 compared to being after 07:00 and before 19:00. No differences were observed for parental education.

Table 9: Frequency and percentage of children meeting internationally recognised guidelines of ≥180 minutes of total physical activity per day and ≥60 minutes of moderate-to-vigorous physical activity per day by the different correlates

Correlate	N	≥180 min of TPA	X^2	p	≥60 min of MVPA	X^2	p
Overall	1052	736 (69.96)	N/A	N/A	829 (78.80)	N/A	N/A
Age							
3	343	223 (65.01)			257 (74.93)		
4	709	513 (72.36)	5.93	0.015	572 (80.68)	4.58	0.032
Gender							
Male	528	406 (76.89)			451 (85.42)		
Female	524	330 (62.98)	24.24	<0.001	378 (72.14)	27.76	<0.001
Country							
UK	426	297 (69.72)			332 (77.93)		
Switzerland	142	99 (69.72)			108 (76.06)		
Belgium	104	46 (44.23)			52 (50.00)		
USA	380	294 (77.37)	42.70	<0.001	337 (88.68)	74.70	<0.001
Season							
Winter	136	82 (60.29)			93 (68.38)		
Spring	110	79 (71.82)			85 (77.27)		
Summer	117	90 (76.92)			106 (90.60)		
Autumn	689	485 (70.39)	8.99	0.029	545 (79.10)	18.78	<0.001
Ethnicity							
White	200	143 (71.50)			156 (78.00)		
Other	219	171 (78.08)	2.41	0.120	203 (92.69)	18.40	<0.001
Parental Education							
Up to and including completion of compulsory vocational training	86	73 (84.88)			81 (94.19)		
Any post-compulsory education including vocational training	300	226 (75.33)	3.49	0.062	260 (86.67)	3.67	0.055
Weekday vs. Weekend							
Weekday	1052	720 (68.44)			813 (77.28)		
Weekend	626	386 (61.66)	8.03	0.005	423 (67.57)	19.07	<0.001

Time of Sunrise							
Before 07:00	433	344 (79.45)			382 (88.22)		
After 07:00	619	392 (63.33)	31.49	<0.001	447 (72.21)	39.09	<0.001
Time of Sunset							
Before 19:00	548	350 (63.87)			399 (72.81)		
After 19:00	504	386 (76.59)	20.21	<0.001	430 (85.32)	24.59	<0.001
Hours of daylight							
Less than 12 hours	589	383 (65.03)			435 (73.85)		
More than 12 hours	463	353 (76.24)	15.52	<0.001	394 (85.10)	19.62	<0.001

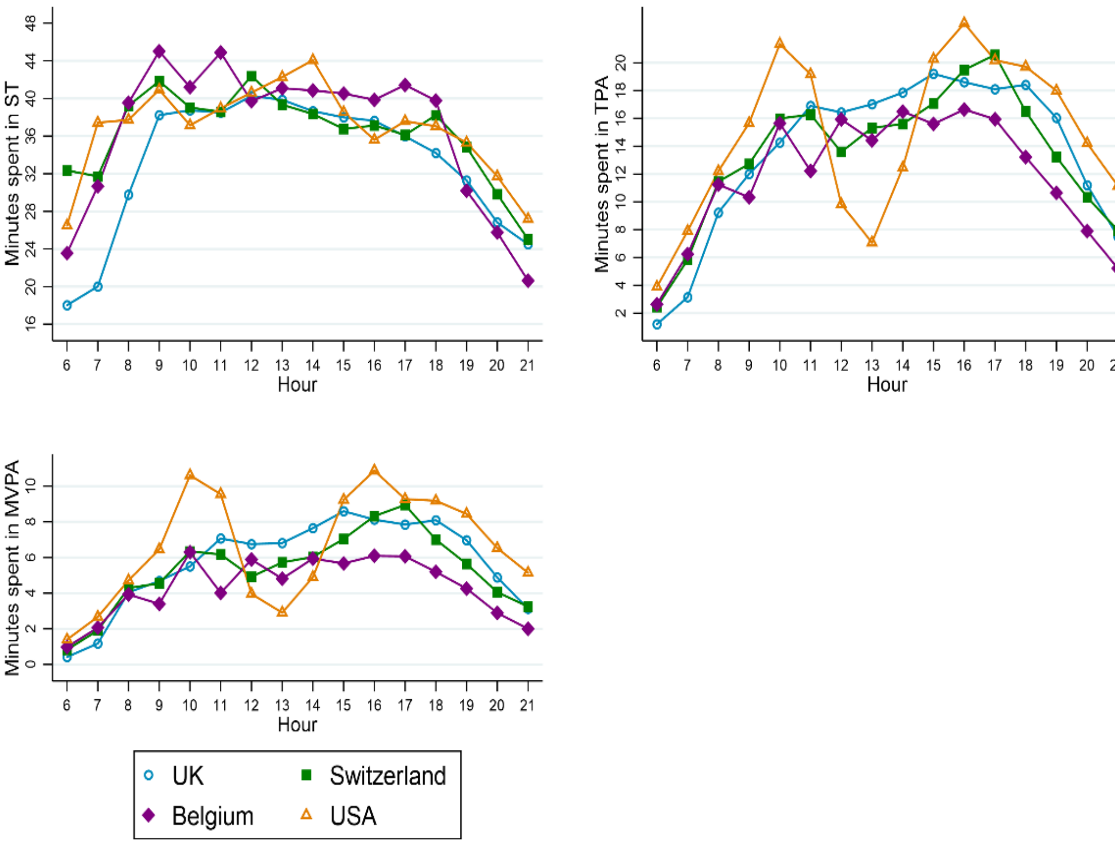
Note: Total Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity

3.5.3. Patterns of sedentary time and physical activity across the day

Figure 5, Figure 6 and Figure 7 show that sedentary time levels increase until around 09:00 and then decrease throughout the day, whereas total physical activity and moderate-to-vigorous physical activity levels increase throughout the day with variations in physical activity by country, day of the week and hours of daylight between 11:00 and 15:00. Figure 5 suggests that children from the USA showed a greater dip in total physical activity and moderate-to-vigorous physical activity levels between 11:00 and 15:00 than that observed around 12:00 in the UK and in Switzerland. Minutes spent in sedentary time appear to have been higher on weekdays compared to weekends (Figure 6) until 14:00 and 15:00 when minutes spent in sedentary time became similar. On weekdays, the minutes spent in total physical activity and moderate-to-vigorous physical activity rose until 10:00 to 11:00 before dipping, whereas, on weekends, the minutes spent in total physical activity and moderate-to-vigorous physical activity increased gradually throughout the day before reaching a peak at the same time as weekdays at around 16:00. Between the hours 09:00 and 18:00, the minutes spent in sedentary time were higher when the hours of daylight were less than 12 hours compared to being more than 12 hours (Figure 7). The minutes spent in total physical activity and moderate-to-vigorous physical activity were noticeably higher when the hours of daylight were more than 12 hours long, apart from the period before

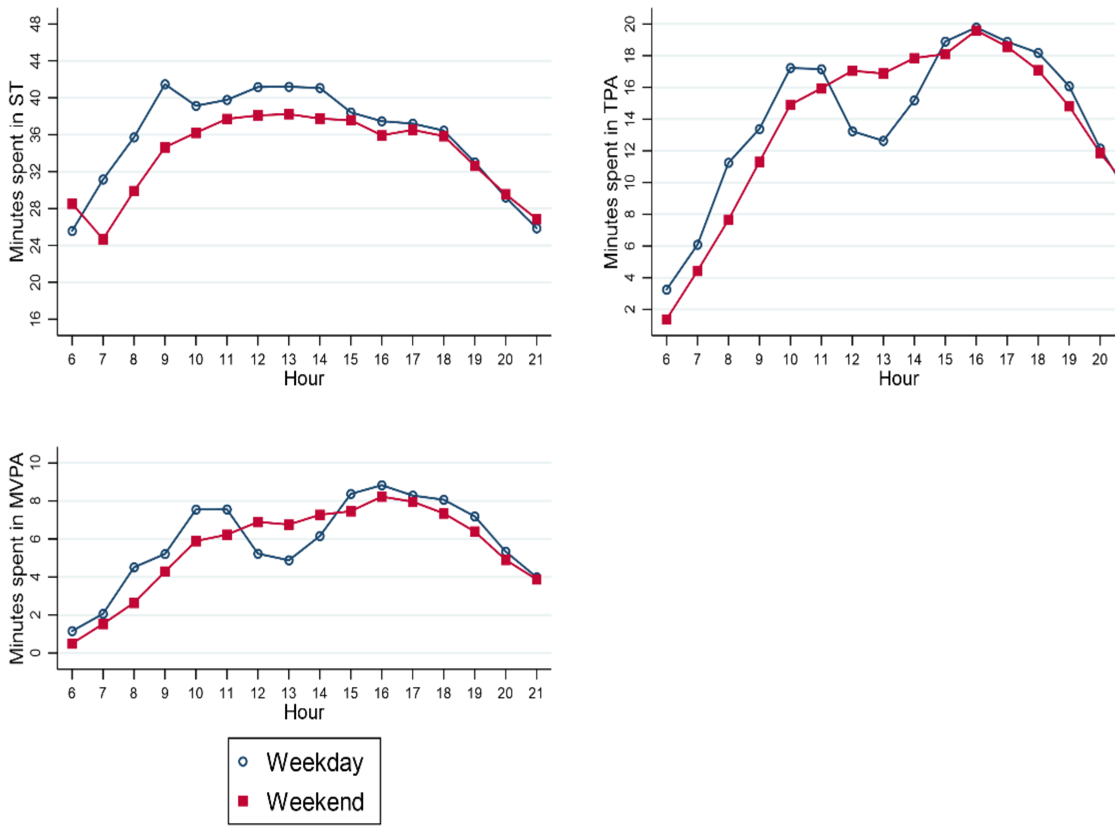
09:00 and at the dipped levels observed between 12:00 and 15:00 where levels were similar to those observed on days which are less than 12 hours long.

Figure 5: By country differences in minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity by hour



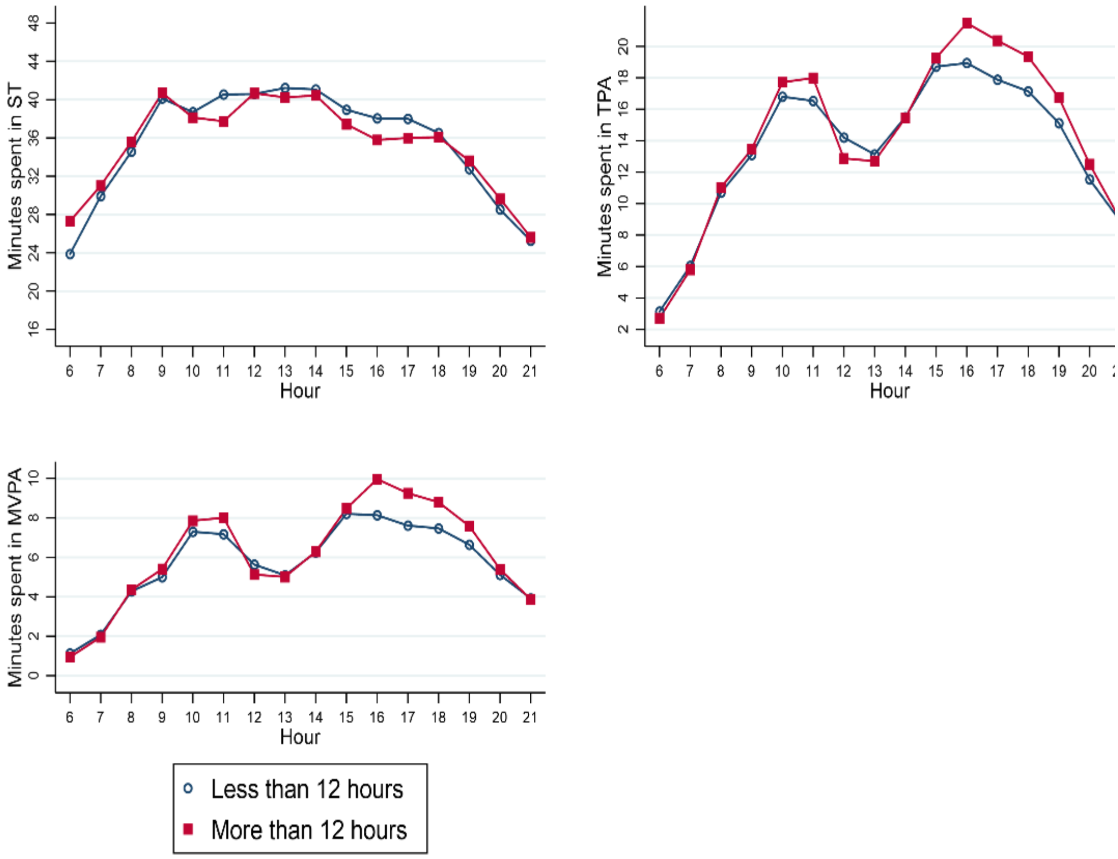
Note: ST: Sedentary Time, TPA: Total Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity

Figure 6: Differences in minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity by hour on weekdays compared to weekends



Note: ST: Sedentary Time, TPA: Total Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity

Figure 7: Differences in minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity by hour when the hours of daylight are less than 12 hours long compared to being more than 12 hours long



Note: ST: Sedentary Time, TPA: Total Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity

3.5.4. Correlates of sedentary time and physical activity in preschool-aged children

Table 10 shows the adjusted associations between the potential correlates and average daily minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity after adjusting for age, gender, season, minutes of wear time and study level clustering. Minutes spent in sedentary time were higher, while minutes spent in total physical activity were lower, in girls, winter and children whose parental education levels were higher compared to boys, spring and lower parental education levels, respectively. Children spent more minutes in sedentary time on weekdays compared to weekends and in moderate-to-vigorous physical activity summer compared to winter. There was evidence that four-year-olds, boys and non-white children spent more time in moderate-to-vigorous physical activity compared to three-year-olds, girls and white children, respectively. Minutes spent in sedentary time were lower and the time spent in total/moderate-to-vigorous physical activity was higher when the hours of daylight were greater, i.e. when the time of sunrise was before 07:00, time of sunset was after 19:00 and when the hours of daylight were longer than 12 hours long. UK-based children spent more time in total physical activity and fewer minutes in sedentary time compared to children from Switzerland, Belgium and the USA but only spent more time in moderate-to-vigorous physical activity compared to Switzerland and Belgium. The unadjusted analysis findings are available in Appendix 4.

Table 10: Multi-level adjusted associations between potential correlates and average daily minutes spent in sedentary time, total physical activity, and moderate-to-vigorous physical activity in children aged 3-to-4-years-old

Sedentary Time						
Correlate (Reference Category)	**N**	**β**	**(95% CI)**	**p**	**ICC**	**R^2**
Age (ref = 3−years)	1052	−3.54	(−9.85, 2.77)	0.272	0.085	0.635
Gender (ref = Male)	1052	17.81	(12.14, 23.49)	<0.001	0.085	0.635
Country (ref = UK)	1052				0.000	0.944
Switzerland		22.06	(12.09, 32.03)	<0.001		
Belgium		36.68	(25.34, 48.02)	<0.001		
USA		10.73	(2.54, 18.91)	0.010		
Season (ref = Winter)	1052				0.085	0.635
Spring		−14.01	(−26.28, −1.74)	0.025		
Summer		−12.16	(−24.90, 0.57)	0.061		
Autumn		0.93	(−9.42, 11.28)	0.861		
Ethnicity (ref = White)	419	−3.07	(−12.71, 6.56)	0.532	0.000	0.903
Parental Education (ref = Up to/including compulsory education)	386	14.91	(3.65, 26.17)	0.009	0.000	0.609
Weekday vs. Weekend (ref = Weekday)	1678	−33.60	(−40.03, −27.18)	<0.001	0.084	0.511
Time of Sunrise (ref = Before 07:00)	1052	10.80	(3.88, 17.72)	0.002	0.070	0.696
Time of Sunset (ref = Before 19:00)	1052	−15.20	(−22.20, −8.19)	<0.001	0.089	0.626
Hours of daylight (ref = Less than 12 hours)	1052	−10.33	(−17.53, −3.13)	0.005	0.085	0.636
Total Physical Activity						
Correlate (Reference Category)	**N**	**β**	**(95% CI)**	**p**	**ICC**	**R^2**
Age (ref = 3−years)	1052	3.54	(−2.77, 9.85)	0.272	0.085	0.273
Gender (ref = Male)	1052	−17.81	(−23.48, −12.14)	<0.001	0.085	0.273
Country (ref = UK)	1052				0.000	0.888
Switzerland		−22.05	(−32.02, −12.08)	<0.001		
Belgium		−36.68	(−48.02, −25.35)	<0.001		

USA		−10.72	(−18.90, −2.53)	0.010		
Season (ref = Winter)	1052				0.085	0.273
Spring		14.00	(1.73, 26.28)	0.025		
Summer		12.16	(−0.58, 24.89)	0.061		
Autumn		−0.93	(−11.28, 9.42)	0.860		
Ethnicity (ref = White)	419	3.07	(−6.56, 12.71)	0.532	0.000	0.884
Parental Education (ref = Up to/including compulsory education)	386	−14.91	(−26.17, −3.65)	0.009	0.000	0.203
Weekday vs Weekend (ref = Weekday)	1678	−3.65	(−9.30, 2.00)	0.205	0.096	0.224
Time of Sunrise (ref = Before 07:00)	1052	−10.80	(−17.72, −3.87)	0.002	0.070	0.395
Time of Sunset (ref = Before 19:00)	1052	15.20	(8.19, 22.20)	<0.001	0.089	0.256
Hours of daylight (ref = Less than 12 hours)	1052	10.33	(3.12, 17.53)	0.005	0.085	0.276
Moderate−to−Vigorous Physical Activity						
Correlate (Reference Category)	**N**	**β**	**(95% CI)**	**p**	**ICC**	**R^2**
Age (ref = 3−years)	1052	4.91	(0.77, 9.05)	0.020	0.095	0.299
Gender (ref = Male)	1052	−14.94	(−18.66, −11.21)	<0.001	0.095	0.299
Country (ref = UK)	1052				0.000	0.904
Switzerland		−15.93	(−22.46, −9.41)	<0.001		
Belgium		−22.48	(−29.90, −15.05)	<0.001		
USA		4.06	(−1.30, 9.42)	0.137		
Season (ref = Winter)	1052				0.095	0.299
Spring		7.96	(−0.10, 16.03)	0.053		
Summer		11.94	(3.57, 20.32)	0.005		
Autumn		3.58	(−3.24, 10.39)	0.304		
Ethnicity (ref = White)	419	9.53	(2.89, 16.18)	0.005	0.000	0.865
Parental Education (ref = Up to/including compulsory education)	386	−7.75	(−15.59, 0.09)	0.053	0.000	0.149
Weekday vs Weekend (ref = Weekday)	1678	−1.39	(−4.96, 2.18)	0.446	0.095	0.289
Time of Sunrise (ref = Before 07:00)	1052	−4.96	(−9.52, −0.40)	0.033	0.086	0.364
Time of Sunset (ref = Before 19:00)	1052	9.47	(4.86, 14.08)	<0.001	0.099	0.281

Hours of daylight (ref = Less than 12 hours)	1052	7.04	(2.30, 11.77)	0.004	0.098	0.284

Note: CI: Confidence Interval, ICC: Intraclass Correlation Coefficient. All models are adjusted for age, gender, season, minutes of wear time and study clustering effects.

3.6. Discussion

This study aimed to determine the levels and correlates of objectively measured sedentary time, total physical activity and moderate-to-vigorous physical activity in preschool-aged children using pooled data from the ICAD, which has been processed and analysed using standardised methods. Across four high-income countries, three-to-four-year-olds were sedentary for an average of over 8 hours per day. Thirty percent of the preschool-aged children were not engaging in the recommended ≥180 minutes of total physical activity and 21.2% were not getting ≥60 minutes of moderate-to-vigorous physical activity per day. Data by each hour suggest that the minutes spent in sedentary time decreased throughout the day, and the dips in total physical activity and moderate-to-vigorous physical activity levels generally observed between 11:00 and 15:00 were more prominent on weekdays compared to weekends, and in the USA compared to the other three countries. There was evidence for an association between all 10 potential correlates analysed and at least one of the outcome variables; average daily minutes spent in sedentary time, total physical activity and/or moderate-to-vigorous physical activity.

Overall, 70.0% of the sample achieved ≥180 minutes of total physical activity, which differs to findings from the UK[32, 33], Belgian[70], Australian[34] and Canadian[35] studies which found that 100%, 11.0%, 5.1% and 83.8% of preschool-aged children achieved recommended guidelines, respectively. Compared to the total physical activity threshold used in this study (≥800 cpm)[164], the two UK studies and Canadian study used thresholds of ≥152cpm[33, 160], ≥20cpm[32] and ≥100cpm[35, 195], respectively. These thresholds are lower than the ones used in this study, and therefore, a greater percentage of their participants could have achieved the physical activity guidelines. Similarly, the Belgian[70] and Australian[34] studies used thresholds described by Reilly et al. (≥1100 cpm)[196] and Sirard et al. (3-years: ≥1208 cpm; 4-years: ≥1456 cpm; 5-years: ≥1596 cpm)[162] which are higher than this study and may explain why such a small percentage of their samples achieved daily total physical activity guidelines compared to my sample. The Canadian study[35] found that 13.7% of five-year-olds spent ≥60 minutes in moderate-to-vigorous physical activity per day, whereas 78.8% of the ICAD sample achieved these recommendations. In comparing the different thresholds used in the studies, one might expect the percentage of my participant sample who achieved the recommended moderate-to-vigorous physical activity guidelines to be lower than the Canadian study, as they used a lower moderate-to-vigorous physical activity threshold, but this is not the case (78.8% vs. 13.7%). This highlights the difficulties with making comparisons between studies due to study differences in not only the accelerometry thresholds for different intensities but also the exclusion of participants based on insufficient accelerometry wear time[27, 29]. As I used a pooled dataset in which data has been processed in the same way across studies[72], the differences found between countries cannot be attributed to differences in data processing. I found that the greatest proportion of children reaching recommended total physical activity and moderate-to-vigorous physical activity guidelines were in the USA, followed by the UK, Switzerland and Belgium. An exploratory subgroup analysis (data not shown) found the percentage of four-year-olds was highest in Switzerland followed by the UK, Belgium and the USA, and the ratio of girls to boys was similar across the four countries. Most of the data were collected in autumn for UK, USA and Switzerland-based children and in spring for Belgium-based children. Minutes of wear time were highest in the USA followed by Switzerland, Belgium and the UK (see Appendix 3). It is therefore, unlikely that the between-country differences are a result of age, gender, season or minutes of wear time differences; which had been adjusted for in the regression analyses.

Visual inspection of the plots of sedentary time by hour suggested that children spent fewer minutes in sedentary time as the day progressed after an initial increase in sedentary time levels until 09:00. In general, the figures showed that total physical activity and moderate-to-vigorous physical activity levels peaked either side of 11:00 and 15:00, with the peak observed after 15:00 being the highest level of physical activity reached in the day. The findings are comparable to results from an Australian-based study[197] which found that sedentary time was at its lowest and moderate-to-vigorous physical activity levels were at their highest from the mid-afternoon through to the evening on both weekdays and weekends. The dip in total physical activity and moderate-to-vigorous physical activity levels observed in the USA between 11:00 and 15:00 was greater in width and magnitude than the dips observed in Switzerland and the UK at around 12:00, which may represent differences in the childcare routines practiced by the different countries. The patterns of sedentary time and physical activity in Belgium throughout the day were harder to distinguish, which is likely due to the lower sample size which contributed data. The dips in total physical activity and moderate-to-vigorous physical activity levels were more prominent on weekdays compared to weekends from 11:00 to 15:00 which may be representative of preschool lunchtime and napping procedures; however, we do not have preschool attendance data available to draw such conclusions. Reports from international early years settings suggest that compulsory sleep times are commonplace in childcare settings[198-200] which highlights the importance of having this information on policies and practices on sleep times available for analysis. The two peaks of moderate-to-vigorous physical activity levels in the morning and evening are elevated when the days are longer than 12 hours long compared to being less than 12 hours long. It could be suggested that more opportunities for outdoor play are available for children when the days are lighter, which is contributing to these higher activity levels[64].

The findings from the regression analyses replicate those from other studies which found no association between age and sedentary time[145-148, 177, 180, 201] and found that girls were more sedentary than boys[145, 146, 149, 201]. Children in Switzerland, Belgium and the USA spent more minutes in sedentary time than children in the UK. My findings replicate results from another study which found that children were more sedentary in winter[149] compared to spring, whereas other studies only found that they were less sedentary in autumn[177] compared to spring or did not find an association between seasonality and sedentary time[148, 180]. No association was found between sedentary time and ethnicity which is consistent with another study[146], and I found a positive association between sedentary time and parental education which is not consistent with other studies[145, 146, 149-151, 180] that found no association with sedentary time. It is possible that this is a chance finding due to the smaller sample sizes of participants who had ethnicity (n = 419) and parental education (n = 386) data. I found that children were more sedentary on weekdays compared to weekends, which is consistent with a previous study which found that hour-by-hour sedentary time levels tended to be lower on weekends compared to weekdays[197].

It is well established that older preschoolers are more active than younger preschoolers[145, 148, 149, 152, 177] and that boys are more active than girls[145, 148, 149, 152, 173, 177, 178, 180, 181, 202] although we did not observe a difference in minutes spent in total physical activity between three- and four-year-olds. I found that children in the UK were more physically active than children in Switzerland, Belgium and the USA, but there was less evidence to show that moderate-to-vigorous physical activity levels were higher in the USA. Similar to my findings, it has been observed elsewhere that children spend more time in moderate-to-vigorous physical activity in summer compared to winter[180] and another study observed that children were only more active in spring and not in summer compared to winter[173], although this was for moderate-to-vigorous physical activity not total physical activity as in this study. Another study found that children spent more time in total physical activity in summer compared to other seasons[148], whereas others found that children spent more time in moderate-to-vigorous physical activity in summer and less time in winter compared to spring[149]. Previous studies found no associations with ethnicity[66] or parent education[74, 149, 150, 152, 178, 180] and physical activity measures, whereas I found that non-white children spent more time in moderate-to-vigorous physical activity than white children, and children whose parents had lower education levels spent greater time in total physical activity than those with higher parental education levels. I did not observe a difference between weekday and weekend data physical activity levels which is consistent with one study[203], whereas another study found that children spent more time in moderate-to-vigorous physical activity on weekends compared to weekday[197]. When the hours of daylight were longer (including an earlier sunrise and later sunset) the children spent a greater time in physical activity and fewer minutes in sedentary time which is comparable to a study looking at older children (5–16-years) which found that longer evening sunlight was associated with increased daily physical activity[172].

3.6.1. Strengths and limitations

The strength of this study is that it adds to the limited literature on levels and correlates of objectively measured sedentary time and physical activity in preschool-aged children. There have been a particularly limited number of studies which have previously examined sedentary time and physical activity by ethnicity and parental education variables. Estimates for the ethnicity and parental education variables had large amounts of missingness therefore, we have assumed that these estimates would apply if the data were not missing. To my knowledge, there have been no previous literatures looking at differences in objectively measured sedentary time/physical activity by country, time of sunrise, time of sunset and hours of daylight in this age group. Consequently, there were no previous references to base the daylight variable categorisations on which may be a limitation in the analyses. As the data from the different studies within the ICAD have been processed in the same way, the results I present are a 'fair' comparison of levels of sedentary time/physical activity across different countries which have not previously been possible. It is important to acknowledge that there are a relatively small number of children in each of the countries that were included in the sample. Therefore, my findings are not representative of each country's population. The studies included in the analysis sample are all based in high-income countries; therefore, the results may not be generalisable to low-to-middle-income countries. Data used in this study were collected between 1998 and 2009 therefore, the results may not be generalisable to the current cohorts of preschool-aged children, especially given children's changing access to screens[204]. I was not provided with the raw data, so it was not possible to accurately identify the number of times children exceeded being sedentary for periods ≥60 minutes at a time; therefore, I was not able to measure the proportion of children meeting recommended sedentary time guidelines. Based on the information provided in the ICAD[72] codebook, there is no information on napping, and as such, it appears that nap/sleep time may have been considered as non-wear time which may have led to the overestimation of sedentary time levels and the underestimation of physical activity levels. The data is compositional in nature, therefore using compositional data techniques as opposed to standard techniques may have produced different results[205]. I did not have data available about childcare differences within and between samples, which could have been used to interpret the findings and to potentially explain between-country differences. Data from longitudinal studies can estimate modifiable factors associated with changes in sedentary time and physical activity[63], whereas this cross-sectional study is limited in only providing evidence of associations.

3.7. Conclusions

Using data from four high-income countries, I found that children spent over eight hours per day in sedentary time and 30.0% and 21.2% of children were not engaging in recommended daily amount of total physical activity (≥180 minutes) and moderate-to-vigorous physical activity (≥60 minutes), respectively. The minutes spent in sedentary time decreased throughout the day and the dips in total physical activity and moderate-to-vigorous physical activity levels observed between 11:00 and 15:00 were greater in the USA compared to Switzerland, Belgium and the UK and on weekdays compared to weekends. Age, gender, country, season, ethnicity, parental education, day of the week, time of sunrise, time of sunset and hours of daylight were all identified as potential correlates of minutes spent in sedentary time and/or total physical activity and/or moderate-to-vigorous physical activity. The associations between ethnicity and parental education with sedentary time and physical activity were derived from smaller sample sizes and should be investigated further in a larger population. Internationally, there is a need for public health interventions, to decrease sedentary time and increase physical activity levels in 3-4-year-olds. The potential correlates identified in this study can be considered in designing these public health interventions. However, further research is needed to determine modifiable factors associated with sedentary time and physical activity in preschool-aged children to inform effective behaviour change programmes.

3.8. Implications for thesis

The results from this study have highlighted a need for interventions in high-income countries to increase physical activity and decrease sedentary time levels in 3-4-year-olds, to help a greater percentage of children meet internationally recommended guidelines. These findings emphasise the rationale for the thesis, which aims to inform the design of physical activity interventions and policies. Although this study provides an insight into how sedentary time and physical activity levels can vary depending on the categories of 10 potential correlates, it is not possible to hypothesise how these measured variables could inform the design of effective behaviour change programmes using quantitative data alone. Chapter 4 will use qualitative methods to explore parents' perspectives on what the barriers and facilitators are to increasing physical activity and decreasing sedentary time in preschool-aged children. The topic guide for the qualitative study presented in Chapter 4 has been partially informed by the findings from this study, to explore potential explanations for the observed differences in sedentary time and physical activity levels further.

CHAPTER 4. A QUALITATIVE STUDY OF THE BARRIERS AND FACILITATORS OF PHYSICAL ACTIVITY AND SEDENTARY TIME IN 2-4-YEAR-OLDS

4.1. Overview

This chapter outlines the methods and findings associated with the qualitative study I conducted which addresses Research Question 3 of the thesis: *'What are the barriers and facilitators of increasing physical activity and decreasing sedentary time in preschool-aged children?'* I start by presenting the study rationale (section 4.2). I describe the participant recruitment methods and qualitative analysis methods used in the study in section 4.3. I then present the results of the study thematically, using evidence in the form of quotations from the interview transcripts in section 4.4. I discuss the study findings in relation to the empirical research and literature in section 4.5, where I also provide a discussion of implications of this study for practice and future research and the study strengths and limitations. To conclude, I summarise the study conclusions in section 4.6 and the implications for the overall thesis in section 4.7.

4.2. Rationale

Identifying the barriers and facilitators that impact on preschool-aged children's physical activity and sedentary time is important for designing effective behaviour change programmes[73]. Recognising barriers and facilitators to behaviour change can help promote the implementation of effective interventions and could help understand why an intervention or policy has or has not worked as intended[206]. Parents play a key role in influencing preschool-aged children's physical activity and sedentary time behaviours[63, 207, 208]. To develop successful public health interventions and policies, we need to understand these parental influences, and identify the barriers and facilitators to changing their children's activity behaviours across social, policy and physical environments[97].

A systematic review by Hesketh et al[63] looked at the longitudinal factors associated with changes in physical activity in 0-6-year-old children by conducting a narrative data synthesis of quantitative data gathered from four prospective cohort studies and 38 interventional studies. The review found that parental monitoring and childcare provider training were positively associated with overall physical activity and moderate-to-vigorous physical activity respectively (≥4 studies). There was some evidence (<4 studies) to suggest that maternal role modelling, sibling co-participation, opportunities for play, additional childcare providers, structured physical activity and playground density were also positively associated with physical activity. The review[63] also highlighted that there was a lack of information on the variables associated with change in physical activity in the environmental and policy domains of the socioecological model.

Hesketh et al also conducted a systematic review synthesising qualitative literature[75], regarding the barriers and facilitators of physical activity and sedentary time behaviours in 0-6-year-olds. The authors found that a combination of parents, childcare providers and children had identified seven broad themes to be important with sedentary time and physical activity: the child; the home; out-of-home childcare; parent-childcare provider interactions; environmental factors; safety; and weather[75]. The two systematic reviews have been critically appraised and discussed in more detail in sections 2.2 and 2.3 in Chapter 2 of the thesis. The qualitative review[75] highlighted the lack of qualitative studies conducted with fathers and male carers. The review mainly included studies with participants from lower socioeconomic backgrounds or racial minority groups and the authors advised on assessing the barriers and facilitators towards physical activity behaviours across the socioeconomic status strata, as such groups are less likely to engage with quantitative studies[75].

This study aims to explore parents' perspectives on why the positive associations were identified in the quantitative systematic review[63] and subsequently what the barriers and facilitators are to changing these factors to increase physical activity and decrease sedentary time levels in 2-4-year-old children. The study aims to address the identified gaps in the evidence base such as the paucity of qualitative data from fathers.

4.3. Methods

4.3.1. Recruitment

Parents of 2-4-year-olds across England were recruited through study adverts (Appendix 5) via Facebook parenting groups, Twitter, word of mouth, nurseries, children's centres and workplaces from July to November 2019, prior to the COVID-19 pandemic. Respondents contacted me via email or telephone to ask further questions and to express their interest in participating in the study. Inclusion criteria: parents of 2-4-year-old children who lived in England. Exclusion criteria: parents of children who were not 2-4-years-old, lived outside of England and were part of the same parent dyad. I sent eligible individuals the participant information sheet (Appendix 6) and consent form (Appendix 7) via email and arranged a convenient date and time to conduct telephone interviews. Recruitment of participants continued until saturation of codes/themes was achieved which also allowed the comparison of females' and males' perspectives (50/50 sample). Once 20 mums had been interviewed, the study materials were amended to solely invite fathers. The amended study adverts were shared on Facebook parenting groups and Facebook groups for fathers, which had proved to be the most successful recruitment method, to maximise the number of male respondents. Participants were posted a £10 high-street shopping voucher to thank them for their time and contribution.

4.3.2. Data collection

Semi-structured telephone interviews were recorded using an encrypted audio-recorder (Olympus Digital Voice Recorder DS-3400) and a telephone device (Olympus TP8). I read out each consent form statement and completed the consent form on the participants' behalf before recording the interview. Verbal consent was also audio recorded at the start of the interview.

A few of the interview topic guide questions (Appendix 8) asked the parents to describe their children's and their own typical physical activity and sedentary time behaviours; the activities they would like their children to engage with; and what they believed were the main barriers to physical activity were in 2-4-year-olds. The remaining questions explored the influences on children's physical activity and sedentary time behaviours, which were developed from the quantitative systematic review[63] findings highlighted in section 4.2, and the findings from the ICAD analyses Chapter 3. I piloted the interview with a male and female colleague who both had 2-4-year-old children; the language used and the structure of the questions were consequently amended to make the topic guide more user friendly.

I checked whether there were any factors that may impact on the children's abilities to engage in physical activity before deciding whether the interview was appropriate to conduct. Participants were asked background questions such as: age and gender; ethnicity; employment status; education level; city or town of residence; ages and genders of their children; relationship to the children; who else lived in the home with the participant; and where they saw the study advert. The topic guide was applied flexibly to explore mothers' and fathers' perspectives of the barriers and facilitators in increasing physical activity and decreasing sedentary time in preschool-aged children and how these can be overcome and facilitated. The topic guide was periodically adapted to improve the clarity and reflect emerging themes from subsequent interviews.

4.3.3. Ethical approval and considerations

This project has been reviewed and approved by the University of Bristol Faculty of Health Sciences Research Ethics Committee; ID: 84822 (Appendix 9). Both written and verbal informed consent were provided by all participants. There were no specific risks to this study. There is always a chance participants may feel uncomfortable with the interview process or content. Discussing physical activity and sedentary time of parents' children may have been sensitive if their children were overweight or the parents were struggling to engage their children in physical activity. I was mindful to remind participants that if they were uncomfortable with any of the content, we could move on or pause or stop the recording. The other potential burden was loss of participants' time, which was mitigated by ensuring it was a convenient time for the participants and they were reimbursed for their contribution.

I ensured confidentiality was upheld through measures such as: holding telephones interviews in private meeting rooms where nobody could overhear our conversation; using an encrypted audio recorder; storing transcription audio files on the University of Bristol server with only the study team having access to the folder; and removing any names or personally identifiable information from the transcripts and data analysis. All interview audio files were transcribed by university-approved transcribers (Bristol Transcription Services) verbatim. All data were stored in line with the General Data Protection Regulations (2018).

4.3.4. Analysis

The data was analysed using both deductive and inductive thematic analysis approaches, that included the development of a codebook, which is a technique used by Fereday and Muir-Cochrane[209, 210]. A codebook is a tool which can be used to assist the analysis of large qualitative datasets[210]. Codebooks define themes and codes by outlining detailed descriptions and inclusion/exclusion criteria on what can be included within each code, and also providing examples of each code[210]. Although using the codebook analysis technique is seen as time consuming, it ensures a detailed description of the analyses which has the potential to improve inter-rater reliability and replicability[210]. I began by repeatedly reading the transcripts to gain familiarity with the data. The deductive component of the codebook analysis technique involved creating an initial codebook[210] which was based on the study research questions, findings from the previous literature[63, 75], quantitative study findings[1] (Chapter 3) and a discussion with RJ, JW and RK who had each independently coded a single transcript. I conducted double coding of four transcripts with another colleague (KH) to test the codes and further refine the codebook. We assessed the refined codebook together, with an initial summary of findings, to inform the production of a more finalised codebook. Following the development of this more finalised codebook, I deductively applied it to all the data, using NVivo 11 to code the transcripts. The inductive approach throughout the coding process allowed for unexpected themes and codes to be developed from the data[210]. Once no more new codes emerged, the final codebook was assumed to represent the data. The final codebook consists of the code labels, definitions, descriptions, qualifications or exclusions and examples of quotations (see Appendix 10 for an excerpt of the codebook). I produced a summary of the study findings according to the themes and codes, presented with extracts of data (see Appendix 11 for an excerpt of the detailed summary of findings), with a final discussion in relation to previous literature (section 4.5).

The codebook analysis method is a form of thematic analysis. Alternative methods I could have used include reflexive thematic analysis[211] or framework analysis[212]. With reflexive thematic analysis, researchers can be more flexible and freer with their analysis, whereas I had distinct inclusion/exclusion criteria I developed for each code and then applied them to the data[211]. As I wanted to specifically find out the barriers and facilitators to children's activity engagement, I wanted to apply a more deductive approach and required a more structured analysis method. Framework analysis is another approach I could have used which would involve organising the data into tables, having a theme/code on the side column and putting associated quotes in the adjacent column[212]. There are similar elements between framework and codebook analyses, but with a codebook you develop a more detailed set of criteria and apply those codes to the data, therefore providing more detail than tabulating the data with a framework analysis approach[209, 212].

4.3.5. Reflexivity

I am a female in my late twenties who was born in rural mid-Wales, UK to Sri Lankan parents and I do not currently have any children. My highest academic qualification to date is a Master's in Public Health degree and I worked as a Research Associate in Public Health Research prior to starting my doctorate degree. I have previously had some experience of collecting qualitative data and have attended courses on qualitative data analysis methods, but this is my first experience of conducting a qualitative study and qualitative data analysis as the primary researcher. Not having children meant I did not have any preconceived views from personal parenting experiences when conducting the research.

4.4. Results

4.4.1. Participants

I conducted forty interviews with 20 mothers and 20 fathers between August and November 2019. Eighty individuals responded to the study advert in total: 13 respondents did not arrange an interview after receiving the participant information sheet and one week follow-up email; three respondents' children were not 2-4-years-old meaning they did not meet the eligibility criteria; one respondent was away during the interviewing period; 19 mothers responded after the first 20 recruited mothers had completed their interviews for the study;

and four respondents had arranged interviews but did not respond to their scheduled phone call or follow-up email.

Participant characteristics are presented in Table 11. Most participants were from the Southwest of England, white, recruited via Facebook, lived in the 1st index of multiple deprivation (IMD) quintile and were in full-time employment. The participants had a total of 26 girls and 22 boys between the ages of 2-4-years-old with a mean age of 2.71 years. The results below provide an overall summary of the findings according to the themes which emerged from the data: children's characteristics and circumstances; children's interactions with other children; parents' priorities and circumstances; parents' social networks and information sharing; home and childcare environments; organisation-run activities; local authority, council and community-run opportunities; and accessibility and the environment. Under each theme, barriers are described, followed by the facilitators. Quotes have been presented according to the parents' gender and participant reference number and the children's age, gender and IMD quintile have been provided as additional subject descriptors.

Table 11: Participant characteristics of mothers and fathers

Characteristic	N (%)
Relationship to child	
Mother	20 (50.0)
Father	20 (50.0)
Age; Mean (SD)	35.33 (4.93)
Ethnicity	
White	38 (95.0)
Indian	1 (2.50)
Chinese	1 (2.50)
IMD score; Mean (SD) *	15.38 (11.6)
IMD quintile	
1st (least deprived)	12 (30.0)
2nd	9 (22.5)
3rd	7 (17.5)
4th	6 (15.0)
5th (most deprived)	2 (5.00)
Not found	4 (10.0)
Employment status	
Student	1 (2.50)
Stay at home parent/caregiver	3 (7.50)
Full-time	22 (55.0)
Part-time	14 (35.0)
Education	
No qualifications	1 (2.50)
Up to GCSEs/GCEs/O-levels or similar	2 (5.00)
A-levels/NVQs/GNVQs	11 (27.5)
First degree/diploma/HNC/HND	14 (35.0)
Higher degree (e.g. MSc, PhD)	12 (30.0)
Recruitment pathway	
Facebook	30 (75.0)
Twitter	2 (5.00)
Nursery	4 (10.0)
Workplace	2 (5.00)
Word of mouth	2 (5.00)
Geographical location in England, UK	
South West	27 (67.5)
North West	8 (20.0)
East Midlands	2 (5.00)
West Midlands	1 (2.50)
East of England	1 (2.50)
South East	1 (2.50)

Note: SD: Standard Deviation, IMD: Index of Multiple Deprivation, GCSE: General Certificate of Secondary Education, GCE: General Certificate of Education, O-levels: Ordinary Levels, A-levels: Advanced Levels, NVQ: National Vocational Qualification, GNVQ: General National Vocational Qualification: HNC: Higher National Certificate, HND: Higher National Diploma
*N=36 as four participants' postcodes were not linked to IMD scores

4.4.2. Barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-olds

Children's characteristics and circumstances

Barriers relating to children's individual characteristics and circumstances included their: age, size and abilities; interests and fears; and mood, tiredness and illnesses. Parents talked about their children being unable to use certain equipment or follow instructions which prevented them from participating in unstructured and structured play (see section 1.3 of Chapter 1). A few parents discussed the children's young age and small size as the reason for these inabilities.

Mother 4 (2-year-old girl and 4-year-old boy, 5th IMD quintile): The smallest one hasn't figured it out yet [riding bikes and scooters] so we're working on that.

Father 36 (2-year-old girl, 2nd IMD quintile): We've got a balance bike for her, but bless her, she's such a little dot, she can't reach the floor yet.

A couple of mothers factored their children not yet being potty trained into deciding whether to go to settings where toilet facilities were not available.

Mother 6 (2-year-old boy, 2nd IMD quintile): Another thing is that when there are no toilets. That can be a problem. They can do a nature wee when they're little but when they start getting older.

Mother 7 (2- and 3-year-old boys, 4th IMD quintile): There are no toilets [in the park]. When your toddler is toilet training, I have to take a little, we have got a little elephant potty, good one for boys! That can get a bit difficult and when they were in nappies and you couldn't change them.

Parents were less likely to engage their children in activities which the children did not enjoy or had lost interest in.

Mother 20 (3-year-old boy, 1st IMD quintile): We tend to find as soon as it's a structured thing, so like with the dance one, as soon as [three-year-old son] has to do anything that somebody was telling him and it wasn't on his terms, he just shuts down and he's just like, I want to go home now, so we tend to find he just likes the free play stuff.

Tiredness and illness resulted in children moving less and sitting more. A few mothers spoke about facilitating sedentary activities when their children were tired or unwell whereas fathers more commonly suggested that their children initiated sedentary behaviours themselves when they were tired or poorly.

Mother 12 (3-year-old boy, IMD not found): He's not one to sit still too long, unless he's really tired when I want him to sit down and chill out for a bit, therefore I'll encourage the Kindle or TV if he is tired.

Father 32 (3-year-old girl, 1st IMD quintile): Yeah she only sits still really when she's tired and she wants to watch television which she only wants when she's tired, or when she's ill.

Mothers reported their children being nervous about participating in activities without parental supervision, while fathers identified specific elements of the activities themselves that their children were scared of.

Mother 4 (2-year-old girl and 4-year-old boy, 5th IMD quintile): No we tried, he wanted to do Kung-Fu. We tried him for about three weeks then decided he didn't want to do it anymore he was not happy for me not to be allowed to go in with him was the issue. He was too nervous to go on his own so we decided to leave that but no we don't really do anything structured.

Father 33 (2- and 3-year-old boys, IMD quintile not found): There was quite a few older kids there [at football class] so he was a bit intimidated even though I was there with him he wasn't quite sure about it. He'd watch. He just didn't wanna join in.

Facilitators under this theme related to the children's ages, abilities, interests and personalities. Parents felt that their children were now able to engage with activities more, and could play independently without parental supervision, compared to when their children were younger.

Father 30 (3-year-old girl, 4th IMD quintile): Over the last 12 months she's started to become a lot more independent with it [soft play *centres], so she's actually doing the things herself now, whereas before she was like, you'd have to go with her and hold her hand all the way around, so now she's a lot better with it.*

Children enjoying certain activities meant that they were more willing to participate in them. Parents described their children as always wanting to move around and not sitting still for long periods of time.

Father 39 (3-year-old boy, 1st IMD quintile): He loves playing hide and seek. He loves hiding behind blankets, he loves wrestling, playing, all sorts, what kids do really (…) He's quite boisterous, he'll joke around a lot with his activities, try to push me out the room and stuff. He's just quite active.

Children's interactions with other children

It was a common assumption from parents that siblings and other children sometimes had a negative impact on children's physical activity and sedentary time. Children sometimes copied the activities their siblings were engaged with, which would include sedentary activities. Parents found the logistics of managing more than one sibling by themselves difficult when taking their children to activities; and they also had to assess the age-appropriateness and additional costs of activities for all their children.

Father 27 (4-year-old boy, 3rd IMD quintile): Yeah, certainly since we've got two, it's increasingly difficult to coordinate. Even with one, it took us a while, once my wife went back to work it took us a while to *adjust. (…) it's finding time to do everything, and have everyone have the opportunity to do things that they enjoy.*

Although something mentioned by several parents, regardless of gender, mothers more frequently referred to having to factor the additional needs of the children's infant siblings.

> *Mother 3 (2-year-old girl, 3rd IMD quintile): It's predominately the weather. Especially now we have a smaller one as well if it is very wet and cold we might go for like a puddle walk in wellies and stuff but we certainly wouldn't go out for as long as we would now sort of now we're out sort of four to five hours a day and maybe we would go out for maybe an hour if it wasn't too wet and cold.*

> *Mother 13 (2-year-old girl, 1st IMD quintile): Again, it would be a lot better if these things were on weekends where I could just go with her on my own and not have to worry about trying to take a little baby with me as well.*

Parents were reluctant to take their children to play settings at certain times of the day, on weekends and during school holidays because the settings were busy with often older children, who they find to be bigger and more physically rough.

> *Father 11 (3-year-old, 1st IMD quintile): I don't know if you've got kids yourself, but if you tend to go to soft plays at the weekend, it's just a nightmare. It's too busy, there's too many, and the main thing*

> *is there's too many bigger children there which means that the little ones tend to get pushed about, so that's one thing.*

Mothers in particular also commented on avoiding parks due to teenagers displaying antisocial behaviours, which was not mentioned as a concern by fathers.

> *Mother 7 (2- and 3-year-old boys, 4th IMD quintile): Certain points of the day we won't go [to the park], so we have got a college across the road from the park. There is absolutely no way we will go there around 3:00. It is full of teenagers. It is not a nice place to be at that point of time.*

Most parents observed how their children were more active through entertaining, copying and playing together with their siblings. Children were considered to have developed play, physical and coordination skills quicker from having older siblings. A few children's interests in unstructured and structured activities were prompted by their older siblings' participation in such activities.

> *Mother 15 (4-year-old girl, 4th IMD quintile): Definitely, because she wants to keep up with what she's [older sibling] doing. The younger one has learnt to ride a bike a lot quicker and things because she's obviously the younger one.*

> *Mother 8 (2- and 4-year-old girls, 1st IMD quintile): If we don't have a club on that day, she tends to play with her big sisters. If it is dry, they will play in the garden. If it is not, they will play in the house.*

They tend to play schools, or mums and dads, all that imaginary play, then dinner and then play again for about an hour and then go to bed.

Fathers were more likely to mention how they have learnt from their older children's experiences to better engage their younger children with more physical activity opportunities.

Father 29 (2-year-old girl, 4th IMD quintile): Because we've got an older son, we've seen what he went through and what he did at nursery, and we sort of replicated that environment for her at home as well on the back of it.

Father 40 (2-year-old girl, 1st IMD quintile): …so her sister went into it all when she was three and she'll be following in her footsteps doing gymnastics and things like that.

Children engaged with different activities, more imaginative play and at higher intensities when they were with other children, compared to being by themselves or with adults. Having other children around in structured and unstructured activity settings made children more comfortable and engaged with the activities.

Mother 10 (4-year-old boy. 3rd IMD quintile): Whereas another kid, they'll superhero their way around the climbing frame or they'll chase each other or sing songs, it's just far more free. I think they interact with the park differently, so they're more likely to make a story of it as opposed to just move from item to item.

Father 34 (2-year-old boy, 2nd IMD quintile): I think he tends to explore a bit more with them or um…yeah he's very much influenced by older kids I think. When he sees them doing something he wants to try it and we find that his development really increases as well.

Parents' priorities and circumstances

This was the most dominant theme where most barriers and facilitators were identified, which included parents': priorities; motivation; interests; knowledge; co-participation in activities; safety measures, rules and restrictions; time; tiredness and mood; and parent-child ratio. There were a broad range of parents' priorities which conflicted with physical activity opportunities for their children. Parents would encourage screen time when they were busy trying to get other tasks done and would engage their children with sedentary activities as a downtime technique. Parents prioritised more relaxed evenings and weekends spent as a family, and maintaining their routine and lifestyle, over committing to regular activities.

Father 26 (3-year-old girl, 1st IMD quintile): Yeah, I think having quiet time or still time is pretty important, so sometimes we'll tell her to do that, you need to go and watch TV or play with her train set or whatever, yeah, or do some drawing or a bit of crafting just 'cause I think it's good that she's not running around all the time.

Mother 10 (4-year-old boy. 3rd IMD quintile): Then we've never really done stuff in the evenings because it's limited family time, so I think it's those things. It's getting the balance of time with him and *money. He does an awful lot at nursery as well, it's difficult to know what the right number of extra things is.*

Fathers were more likely to comment on how they would prioritise activities being worth the associated cost, travel or time.

Father 18 (3-year-old boy, 1st IMD quintile): I suppose it's a balance between how far away it is and how long it's going to take to get there and how much enjoyment he'll have when he does get there. There was something on in the south of [place] last week and we decided not to bother because it was going to take an hour to get there and it was going to cost £10.00 and then we weren't sure if he'd enjoy it or not. So we gave that one a miss.

Father 24 (4-year-old girl, 3rd IMD quintile): But yeah, we look at the costs and, yeah, you can look at it as is it worth them doing that?

Parents generally thought that their children were doing enough activities in their childcare settings, so there was no need to engage them with additional activities at home or by engaging them with organisation-run structured and unstructured classes. Parents did not always feel motivated to seek out and commit to structured classes and did not always facilitate unstructured play.

Father 30 (3-year-old girl, 4th IMD quintile): All different things. They try and do more structured stuff [at nursery] as well which is why we try to be less structured at home.

Mother 21 (2-year-old boy, 3rd IMD quintile): Yeah, I do want to try that [using a bike and scooter]. I think that's more me. I need to get him a helmet, but I keep saying to him 'as soon as I get you a helmet and knee pads', so I just need to go and get that for him.

Parents' dislike of activities or activity environments would prevent them from taking their children to those opportunities more often.

Father 38 (2-year-old boy, 2nd IMD quintile): [Referring to indoor play areas] Other people! I'd rather they were doing something outside rather than inside. It's difficult in the winter and joking aside there is probably limited places to take them – it would be very busy and that's probably my issue more than theirs. They always like the fact that it's busy. It gives me hives but yeah.

Some parents did not know what activities were appropriate or available for their children to engage with.

Father 23 (2- and 3-year-old girls, 4th IMD quintile): Maybe I suppose I think I don't know what's out there for kids as well. I don't know enough about… there's nothing that's… looking at it, now you've mentioned that, I think actually I'm thinking should I be putting my kids in classes? Maybe I should. I've not seen any advertised or anything like that. I don't know of any classes other than something that you get at nursery on a community notice board or something like that.

Logistics could also present a barrier to physical activity. For instance, one mother mentioned that she did not know the process of how to take her child swimming. Interestingly this was the only non-white participant who grew up in a non-European country, which highlights the impact of different cultural upbringings on parents' knowledge, motivation and self-efficacy with engaging and accessing activities for their children in countries that they did not grow up in.

Mother 14 (3-year-old girl, IMD quintile not found): It's just not knowing how it… I've never been to like the leisure centres. I think just knowing like the process. I know it's like really easy, but it's just knowing, get changed, like can I manage her on my own? (…) And then do I have to have lessons first before I take her swimming because I don't know how to swim, and I know they aren't big pools, just really shallow ones, but there's still a risk.

Engagement in activities which involved parental co-participation would depend on the parents' abilities and willingness to participate fully. Children wanting to be carried by their parents or wanting their parents to be present at activities were also barriers to activity.

Mother 10 (4-year-old boy. 3rd IMD quintile): In the [rugby class] that's for his age, a parent is involved as well, so it depends on the level of energy that the parents are willing to put in and also the level *of control for the kids that are unruly and if the parents don't keep on top of their own child, the class just kind of disintegrates.*

Father 24 (4-year-old girl, 3rd IMD quintile): Yeah, she tends to walk a lot. If I'm with her then she tends to want to be picked up by me or put on my shoulders.

Parents were hesitant about their children engaging with activities they deemed to have safety and traffic-related concerns.

Father 29 (2-year-old girl, 4th IMD quintile): I think it's probably, sometimes I'm just overly cautious, so the cotton wool dad, it's terrible because I try not to be, but with a two year-old you pretty much have to be, because she wants to go where the bigger kids are, or where, and they don't care, they just see her as another body and don't realise and recognise that she's two, they just push past, so I think that's the biggest one.

Father 25 (3-year-old girl, IMD quintile not found): The traffic and the gangs. To be honest, there's not an awful lot of that around, we're in a relatively rural part of [place], but you're just, I don't know, just conditioned to be scared to do it, perhaps. If I moved back to [place] where I grew up I wouldn't have an issue with it, at all.

Mothers were more likely to comment on these safety issues and would also assess the risks of their children picking up illnesses before participating in activities.

Mother 12 (3-year-old boy, IMD not found): They quite often pick up bugs and both of my children are really healthy and I think it's because I don't actually put them in --, I don't see friends if their kids are ill. They're really healthy and I don't want the stress of them being ill, so I'd rather avoid soft play and things like that for that reason.

Parents held back on signing up their children for structured classes until they were older or until they started school.

Father 38 (2-year-old boy, 2nd IMD quintile): [Referring to trampolining and gymnastics classes] Probably, yeah, just you know is he quite ready for that sort of formal instruction at that age and you know, we've probably decided that he's not quite ready but now he's probably getting to a point where it would be okay.

Furthermore, mothers would sometimes restrict indoor and outdoor play in their home settings.

Mother 2 (2-year-old girl, 2nd IMD quintile): She would like to do in the garden when it's winter and obviously she gets really frustrated when she can't go in it and just go outside and scoot around or play on the trampoline. I think that's more us controlling her because she'd probably go if we wrapped her up, she for one would be more than happy to do the same scooting and things like that out in the rain so I *think there is a difference but I think that probably comes from us more than her.*

Parents described timing clashes and having limited time outside of their other commitments, to dedicate to their children's physical activity.

> *Mother 15 (4-year-old girl, 4th IMD quintile): I would have gone for swimming lessons with her earlier I think, except they don't have the timings that we're available, or things don't fit in with our lifestyle.*

Particularly on weekends, children were more likely to engage with sedentary activities or not be taken to active opportunities because their parents were tired.

> *Father 39 (3-year-old boy, 1st IMD quintile): So, I think it is quite important that the parent engages and encourages different activities. Some days I'm really good at it, some days I'm not quite as good at it. Depends on your own energy levels.*

Parents prioritised going outside on most days for everyone to get fresh air, to improve their mental wellbeing and for their children to burn off "*excess*" energy to help manage their sleep and behaviour. Families prioritised spending more time together on weekends which sometimes involved longer outings in different places. It was more important to parents that their children enjoyed the activities that they engaged with, so that they will incorporate activity as part of their lifestyle, over forcing them to engage with activities. Some parents reflected on their own upbringings and other families' attitudes towards children's physical activity, to either replicate or learn from, which motivates them to ensure their children engage with activities to be healthy and well-rounded. There were several examples of parents proactively creating and maintaining opportunities for their children to play and move around.

> *Mother 19 (2- and 4-year-old boys, 2nd IMD quintile): We'll usually have things planned like that and if we're not doing something that's a paid for activity I try to get them to the park. I know that sounds really worthy and don't mean it to it's just that for me, if he doesn't do an activity he is so hard to parent because he has so much energy. He has to run it off...*

> *Mother 16 (2-year-old girl, 2nd IMD quintile): Just for their health, really. I grew up quite active, and I think it's probably helped me stay healthy, so yeah, I think it's an important part of their health and if they are used to being active, then hopefully as adults they will stay active.*

An identified contrast based on gender was that mothers were more likely to engage their children with activities which made their children happy and well-rounded, whereas fathers were more likely to engage with activities that aligned with their own interests.

> *Mother 22 (2-year-old boy and 4-year-old girl, 1st IMD quintile): He's more of a soft play dad. He likes soft play. He likes parks to a certain extent but he doesn't like farms or zoos or anything like that. I*

would be the one that would be encouraging them to do to that, not so much their dad.

Father 23 (2- and 3-year-old girls, 4th IMD quintile): We socialise with our friends that have got kids as well. (…) So, we get a little bit of cider in, put some music on for the kids sometimes. I used to be a DJ so I've got like laser lights. We put on a little kids disco and then obviously calm it down by about eight o'clock.

As well as gender, occupation appeared to impact on parent decisions and assumptions. For instance, a few parents highlighted their understanding of the importance of physical activity on their children's mental and physical health and development, which was sometimes informed by their professions.

Father 33 (2- and 3-year-old boys, IMD quintile not found): I agree with making them move around as much as possible, I do believe it helps their development and their skills with hand-eye co-ordination and just being generally more sociable [child's mother is a midwife].

Sometimes parents must be involved in organisation-run structured and unstructured activity sessions. A few parents get their children involved in helping with the housework and parents play games with them in their home environments.

Mother 22 (2-year-old boy and 4-year-old girl, 1st IMD quintile): She will play games with her dad if her dad's in the house so sometimes they'll play hide and seek and things like that.

Some parents specified restricting their children's daily screen time allowance and would sometimes make their children engage with structured activities even if they showed resistance.

> *Father 33 (2- and 3-year-old boys, IMD quintile not found): We try to go anyway 'cause they enjoy it [swimming lessons] when they get there. It's just the initial don't wanna get out of bed and that sort of thing. We try to enforce it anyway.*

Mothers were more likely to comment on how having safe environments encourages them to engage their children with different activities.

> *Mother 13 (2-year-old girl, 1st IMD quintile): Like I said, she's at that age now where I just let her do what she wants cause I know in the house that she's safe and she's got lots of things, as you can imagine, in her bedroom to play with.*

Parents described having more time to engage their children with activities on days when they were not working or when they were stay-at-home parents.

> *Father 25 (3-year-old girl, IMD quintile not found): Sometimes if it's really, really wet on the day then we shan't bother [going to the park] but, other than that, I'm lucky to be in quite a flexible job, so I've got lots of time when I have her to, yeah, just go off and do our own thing, really.*

Parents stated that they would get more involved in certain activities when both parents were present, from a logistic or reassurance perspective, often on weekends.

> *Mother 19 (2- and 4-year-old boys, 2nd IMD quintile): It's hard, it's really hard to manage two very active children, so I think can sometimes put mums or dads off. The known is safer isn't it, you kind of know your environment. Going into something new if I'm honest with you, I would only do if I had my husband around.*

Parents' social networks and information sharing

Children's grandparents were described as allowing more screen time than the children's parents would normally allow. Grandparents would also facilitate more sedentary indoor activities with the children due to their advanced ages and limited abilities.

> *Father 38 (2-year-old boy, 2nd IMD quintile): Currently he spends one day a week with his grandparents. Fair to say he's less active on those days. On that day because they're 75 and they are not quite as active as they used to be and so to keep up with him, definitely a few more sedentary things with them. I mean they take him to the park but they don't tend to do quite so much.*

Not knowing local people with similar aged children, and friends and family with similar aged children living far away, limited opportunities for play.

Mother 17 (3-year-old boy, 3rd IMD quintile): Most of his cousins, all of his cousins on my side of the family, live away from us. So, he wouldn't see them so much on a daily basis. Generally, when he does see them, he sees them for longer periods. We go on holiday with them and that kind of thing.

Only one mother commented on being unaware of community events whereas fathers attributed their lack of knowledge to their dislike of social media platforms or not knowing where to look for local opportunities.

Mother 13 (2-year-old girl, 1st IMD quintile): We've got a community centre who host events and things like that, or a town hall type thing, but I don't hear of anything ever going on, unless I'm left out of the circle, I don't ever hear of anything going on.

Father 28 (2-year-old boy and 4-year-old girl, 1st IMD quintile): Well, I don't know, when I try I can never find anything. There could be some kind of central information place where you can find stuff, because it's all over the show.

Grandparents and great-grandparents who lived nearby were able to take children to structured and unstructured activities on days when they were looking after the children or when the parents were unable to take their children.

Father 29 (2-year-old girl, 4th IMD quintile): We are lucky because her grandad and nana look after her on a Tuesday and Wednesday, so they make sure that through the week on one or both days they go and *do an activity with her, so they would take her to a dance class, for example, that I mentioned earlier, or they take her to the toddler time at the trampolining centre.*

Parents created more opportunities for their children to engage with activities and play with other children through organising meet ups with their social networks which included: friends; family members; colleagues; neighbours; and parents they have met through National Childbirth Trust (NCT) classes, nursery and school environments.

Mother 20 (3-year-old boy, 1st IMD quintile): I've also got a very good group of mum friends that I met when I was pregnant with [three-year-old son] and we've also all had seconds within a very close space of time as well, so we tend to try and meet up at least once a month as a big group.

Fathers commented on how it was mainly the children's mothers' who formed social networks to facilitate meetups. Parents would arrange gatherings and find out about local opportunities through social media, word-of-mouth, posters and leaflets. Fathers preferred using internet searches and mobile phone applications to seek out opportunities over using social media.

Father 18 (3-year-old boy, 1st IMD quintile): I think that [wife] has built up a network of people she knows with WhatsApp groups and Facebook groups. There's enough people now to call on and there's normally somebody around.

Father 32 (3-year-old girl, 1st IMD quintile): Either at school people tell us there, or if I'm looking for something, I just Google it specifically. And there is [Facebook group] and Hoop, it's what it's called – Hoop is quite nice.

Home and childcare environments

Children sometimes engaged with sedentary activities in their home and childcare environments which includes nurseries, childminders, preschools and schools. Gardens and outside space at home were sometimes described as inappropriate for outdoor play in terms of safety and available play equipment.

Mother 14 (3-year-old girl, IMD quintile not found): Yes, but she hardly plays out there. Our garden is not really, I haven't really sort of like done it up, no toys, just like…

One father believed that not having a garden limited opportunities for outdoor play.

Father 23 (2- and 3-year-old girls, 4th IMD quintile): I worked out percentage wise and I think we can save 20% of damage to the flat by having a garden! But yeah having a garden I think would be optimal for just running around, eating outside, messy play, that kind of stuff.

Some nurseries focused on child-led small world play or sedentary activities, over more active play, and did not let children outdoors when the weather was poor.

Father 39 (3-year-old boy, 1st IMD quintile): It is actually learning or if there's a day when he does not want to do much, then they allow that as well, that's their key policy is that they lead what they do for the day.

Parents described having children's toys and play equipment available in their homes and gardens for the children to play with throughout the day. Children sometimes helped with the housework and played games by themselves, with their siblings or with their parents in their home environment.

Mother 3 (2-year-old girl, 3rd IMD quintile): I think we have everything out as well I know that some people their toys aren't out on display they have things put away but all of ours are all sort of accessible so she has access to everything all day so she hasn't kind of got to ask me to get things for her to do or anything like that that would stop her from being able to just go and do an activity.

Parents were grateful for having gardens and outside space at home for their children to engage with outdoor play regularly.

Father 35 (3-year-old boy, 1st IMD quintile): In the garden we've got a couple of slides, swings, trampoline, sand and water table, sand pit, mud kitchen and some outdoor ride alongs as well. They're the sort of things he would play on with, either with his brother or with us and sort of make-believe games he likes to do as well. (...) We're really *fortunate with the garden we've got at the moment, it's like 90 foot so it's good. They're out there quite a lot.*

Childcare settings also provided indoor and outdoor toys and play equipment for the children to engage with. A few parents felt that nursery environments were set up and led in a way that promoted active play and some parents specified that the children played outdoors in all weathers.

Mother 12 (3-year-old boy, IMD not found): They have two hours outside between half 12 and half four. (…) They don't stop that at school though, so if it's raining, they'll still go out for a couple of hours. Rain doesn't stop play at school, it just stops play outside at home.

There were examples from all the different childcare settings of providing regular outings for the children and engaging them with externally run unstructured and structured activities.

Father 25 (3-year-old girl, IMD quintile not found): But I know that they get out to the local park quite a bit, they've got quite a large play area at the nursery and they do visits to the local old people's home, for singing and stuff like that, yeah.

Parents and grandparents who owned dogs provided opportunities for children to go on dog walks to a variety of environments and to subsequently go play in parks.

Father 35 (3-year-old boy, 1st IMD quintile): In the summer we tend to walk the dogs in the park. He'll go every day and we'll walk down and he'll have five-ten-minute play in that. So, once a week in the winter, but most days in the summer.

Organisation-run activities

Issues regarding organisation-run structured classes were discussed in terms of long waiting lists, age restrictions and clashing timings. Parents were also put off classes where they felt the instructors were unable to cater for different abilities within the class or when the instructors were bad at interacting with the children.

Father 38 (2-year-old boy, 2nd IMD quintile): We have a lack of swimming pools in [place] so he's on a waiting list, that's about a 12-month waiting list so um, yeah. Probably when he's coming up to four, he'll start his swimming lessons.

Mother 19 (2- and 4-year-old boys, 2nd IMD quintile): I actually took my little boy [four-year-old] to a dance class in [place] before I found [dance company] cause he loves music and I just thought it was going to be great to get out the house and do some dancing and it was so awful because the lady that ran it took it all so seriously and was reprimanding him for basically enjoying it too much.

Mothers also mentioned how some organisation-run structured classes did not run over the school holidays.

Mother 16 (2-year-old girl, 2nd IMD quintile): I have looked into the football classes I think actually we might start her on, but in summer holidays they tend to stop running the classes, so it's kind of waiting for the new term.

Parents did not want to spend limited finances on their children attending multiple different organisation-run structured and unstructured classes. Parents were reluctant to enrol their children in sessions which required block payments rather than paying per class attended, as they would lose money whenever they missed a session.

Mother 8 (2- and 4-year-old girls, 1st IMD quintile): To be honest with four kids, it comes down to cost a lot. They do have the [gymnastics class] and the backing music classes and stuff, but they just end up being so expensive, especially because a lot of them you have to pay per term. With four of them, the chances of one of them being poorly at any one point, or having something else on, it feels like a lot of money to pay if you are not sure that they are going to go to every class. I tend to stay away from the classes where you have to pay for a term upfront.

Parents felt that there were a lack of organisation-run unstructured activities in their local area or a lack of age-appropriate settings for free play.

Father 11 (3-year-old, 1st IMD quintile): I guess they need more of them [soft play centres]. I think the way they're set up, and the one *thing I've noticed is they're very good for really small children and they're really good for eight-year-olds and that kind of age, but the middle bracket in there it's quite difficult because although my daughter is capable of going on the bigger kid's stuff, but then there are kids charging around and so there's maybe not a great provision for that middle group.*

Many parents expressed their dislike of indoor play environments because they found them too loud, busy, unsafe, stressful and unhygienic; especially on weekends, in school holidays and at parties. On top of being considered too expensive, organisation-run unstructured activities had the additional problem of price increases over the school holidays.

Mother 10 (4-year-old boy. 3rd IMD quintile): In terms of soft play, we do that quite a lot but we don't tend to go as much during the school holidays because it's full of ginormous children that run around far too fast and obviously it's busier and it tends to be more expensive as well.

A few children attended organisation-run structured activities on a weekly basis throughout the year, which run between 30 to 60 minutes in duration.

Father 37 (3-year-old girl, 2nd IMD quintile): Yeah, all year around I think apart from maybe two - three weeks of the year during sort of Christmas and stuff like that. Yeah like her dance classes run every week of the year and her – well her skiing lessons do as well.

Some mothers commented on being happy to spend more money for higher quality lessons which have a higher instructor to child ratio.

Mother 12 (3-year-old boy, IMD not found): It's about 15 quid for half an hour but it's worth it because four is really the maximum in the class. (…) I'd rather pay for quality, because really it is about getting him to be able to swim as soon as possible.

Parents were grateful for having different options of inexpensive sessions and environments where their children could engage with unstructured play. Parents were more likely to take their children to toddler-specific sessions, quieter environments and sometimes pay for annual season passes to attractions.

Mother 13 (2-year-old girl, 1st IMD quintile): We've got a trampoline park about ten minutes away, which we go to quite often because the toddler sessions are really quiet, so there's no other kids bouncing on her head and stuff.

Father 30 (3-year-old girl, 4th IMD quintile): …we've got a season pass for the zoo. It's about 15-20 miles away, so we'll probably go 10-15 times a year, and she'll just walk around the zoo, go and see different animals, so that's another option.

Instructors who were more successful in engaging children with structured and unstructured activities were said to do so by being enthusiastic, encouraging and by getting to know the children individually. They focused on making the sessions age-appropriate and fun by creating games and competitions, so that the children were learning by play. Having instructors in unstructured sessions helped the children engage with available equipment and activities fully and having more than one instructor present in structured sessions helped the classes run more smoothly.

> *Father 26 (3-year-old girl, 1st IMD quintile): Yeah I think all the activities that I've seen them do [in gymnastics classes], they're all fun and they're all games and it's not just this is how you do a forward roll, do a forward roll and that's all they do, whatever, it's all learning by play, which is key at that age.*

Local authority, council and community-run opportunities

Parks, toddler groups and events are both run and maintained by either, or a combination of local authorities, councils and community organisations. Mostly mothers discussed issues with parks regarding the lack of facilities or interactive and appropriate playing equipment.

> *Mother 5 (3-year-old boy, 3rd IMD quintile): Like I said because we're in a small rural village it's not a fantastic park so actually they get bored fairly quickly so by the time you get there and you go half an hour they're like oh shall we go home you know whereas if you're in one of the town parks you can spend a couple of hours there take a picnic but you couldn't do that at our park.*

One father thought that his child could interact with some park equipment dangerously if left unsupervised.

Father 28 (2-year-old boy and 4-year-old girl, 1st IMD quintile): The climbing frame has a platform on it, and they like jumping off and grabbing on to a bar, and like "Watch this" but it's really dangerous, so I try not to encourage it too much.

Parents mentioned a lack of toddler, parent and play groups in their local area for their children to attend.

Mother 7 (2- and 3-year-old boys, 4th IMD quintile): A lady came two hours a week to help me get out of the house more and do more activities with them. That was massive. The only problem with that is the funding stopped for [charity playgroup]. They didn't do the same amount of sessions. The only session they do now is when I am at work! It was unfortunate.

Only fathers commented on family friendly events, which were described as expensive, stressful and loud, with sometimes limited places available.

Father 32 (3-year-old girl, 1st IMD quintile): We tried the toddler disco once, or [wife] tried it I have to say, but she really doesn't like loud noises so that wasn't a massive success.

Several children regularly played games in, and ran around park settings, as well as engaged with a variety of park equipment through physical and imaginative play. Active travel methods were more commonly used to get to local parks, but a few parents would drive to parks further afield because they had more to offer, were better maintained and to retain their children's interest in parks with a change of scenery.

> *Mother 19 (2- and 4-year-old boys, 2nd IMD quintile): Otherwise you're stuck with just your local park and however good your local park is kids are going to get so bored of that. The reason we'll travel sometimes to parks is because the boys love going somewhere new and that's probably thinking about it why we do so many different things is because it's to keep their interest up.*

Regular toddler, play and parent groups, provided opportunities for parents to take their children to interact with different activities and children, in mainly indoor environments during weekdays.

> *Father 40 (2-year-old girl, 1st IMD quintile): That's why her mum takes her to the toddler group instead. It's obviously not gymnastics but they can run about and play with toys and they can do certain things so she just gets her a bit more active during the week.*

Parents described taking their children to family friendly events which were sporadically run throughout the year in their local area.

> *Mother 8 (2- and 4-year-old girls, 1st IMD quintile): As we have the age range of two up to eight, we tend to do things that are a little bit less structured, just because you can play it by ear how well people are coping. Recently they did a thing in the community where they hid painted rocks and they had a Facebook page. My kids loved that.*

Accessibility and the environment

Barriers and facilitators were identified which related to the families' environments and their accessibility to their environments. Parents were less likely to take their children to opportunities if they were not easily accessible by active or passive travel methods. Parents with cars would sometimes choose to drive over choosing active travel options whereas parents without cars found it difficult to get to physical activity opportunities.

> *Mother 6 (2-year-old boy, 2nd IMD quintile): Well if I don't have the car, then that restricts whether we go to places. I do feel to get to a decent place, to get them outside, you have to drive. That obviously is a restriction.*

Parents described traffic safety concerns with regards to restricting their children from playing outside the house and near activity settings.

> *Father 23 (2- and 3-year-old girls, 4th IMD quintile): I suppose there is a percentage of the fact that in the daytime it's a busy road outside, yeah. We live upstairs in a flat. Straight out on the high street. To get to the park you've got to go through a busy high street and it's all… not one of them on its own but all together it was quite a substantial percentage of like 'oh, maybe I'll wait until later' or that type of thing so that's the issue of where we are.*

Mothers described the quality of pavements and a lack of car parking spaces as problematic when going to activities.

Mother 20 (3-year-old boy, 1st IMD quintile): Parking as well, that one makes me a bit nervous. If I don't know there's a good car park, especially with the two of them, trying to get them out on a main road or something.

A couple of mothers did not take their children to nature reserves: one did not own a car and relied on lifts; and the other did not like dog poo that was not disposed of properly.

Mother 6 (2-year-old boy, 2nd IMD quintile): Dog poo is really I hate. There is a nature reserve at the end of our road but I have never been there because every time someone comes back with dog poo on, every single time and I just hate that. There is always dog poo there.

Parents engaged their children with more sedentary indoor activities and fewer outdoor opportunities in the winter or when the weather was poor, commonly referring to when it was raining.

Mother 12 (3-year-old boy, IMD not found): If it's raining I'll think, okay, today we'll do some painting or we'll do playdoh, so I think of an indoor activity, like a rainy day activity.

Fathers commented on doing fewer outdoor activities with their children when the evenings were darker.

Father 35 (3-year-old boy, 1st IMD quintile): In the winter obviously we don't go in the garden in the evenings, once I get home from work. It's dark now.

Owning a car has allowed most parents to take their children to opportunities as well as a larger range of options. Parents also chose active travel methods where it was feasible.

Father 38 (2-year-old boy, 2nd IMD quintile): There's probably two [parks] within scooting/walking difference. We'll alternate between or we'll – if we're bored of those, we'll then drive to an alternative one 10 or 15 minutes away if needs be just for a change of scenery.

Some parents walked around the shops and in towns and cities with their children on days when they were not working.

Father 32 (3-year-old girl, 1st IMD quintile): Sometimes at the weekends so in the weekend in the morning we do ballet. So we go there – if it's nice weather I sometimes take her to city centre and we did a lot of playing in that water feature thing at [place].

Mothers also commented on the built environment being suitable for using scooters and bikes in terms of flat pavements and enclosed spaces.

Mother 15 (4-year-old girl, 4th IMD quintile): You know, a bike ride that we go on, or we go down the local tennis courts that not being used for tennis, so we cycle down there. Because we've got an enclosed *space that's safe with nobody there, for the bike, you know, it's like two tennis courts' size.*

Having natural environments local to families' homes provided opportunities for children to explore and walk or run around.

Mother 21 (2-year-old boy, 3rd IMD quintile): He'll tend to go straight to the sea. I try and bring us down a bucket and spade. But yeah, he does like the water, so he'll run straight for that. I just let him paddle. There's loads of rock pools with like crabs and things. We recently did a pirate hunt. I gave him a little map and he had to follow that then run and find treasure.

Parents facilitated more outdoor opportunities in the summer months, in "*nice*" weather and during lighter evenings.

Mother 21 (2-year-old boy, 3rd IMD quintile): He climbs up there and he's got the slide, he's got a swing, he's got the swimming pool that he had out in the summer and he's got… we built him a mud kitchen out of palettes and he loves that.

Fathers were more likely to comment on taking their children to opportunities during specific seasons or school holidays compared to mothers who referred to daily circumstances, primarily the weather.

Father 27(4-year-old boy, 3rd IMD quintile): [Referring to going to the park] During term time it's probably once a week, during holiday time it's probably three or four times a week.

Mother 13 (2-year-old girl, 1st IMD quintile): After lunch, if it's dry enough, we open the backdoor so she can play in the garden.

4.5. Discussion

The data presented in this chapter has highlighted the barriers and facilitators that parents of 2-4-year-old children in England expressed as relating to their children's physical activity and sedentary time behaviours. Barriers and facilitators were categorised under eight general themes: *children's characteristics and circumstances; children's interactions with other children; parents' priorities and circumstances; parents' social networks and information sharing; home and childcare environments; organisation-run activities; local authority, council and community-run opportunities; and accessibility and the environment.* Barriers and facilitators were often interconnected across the themes and were usually dependent on the parents' circumstances and their environments, which commonly changed as their children grew older.

Parents reported that children were sometimes not interested in taking part in physical activity, because their children were *"not in the mood"* or well enough to engage with activities. However, when children did enjoy an activity, they willingly engaged and rarely sat still. This common observation by parents suggests that exposing children to different activities to try and find some they enjoyed may help to increase their engagement in physical activities[213]. Without exploring what activities children enjoy and understanding that different children may enjoy different things, there may be a risk that parents attribute their children's lack of engagement down to unchangeable personality traits, which in turn could demotivate parents in engaging their children with physical activities. Thus, identifying activities that children enjoy is a critical component of promoting physical activity for preschool-aged children[213].

It was evident from the data that some equipment and activities were not suitable or available for the younger children, which may partially explain why four-year-olds are more active than two-year-olds and three-year-olds[1, 74] (see Chapter 3). Parents described their children's confidence and independence improving with age and experience, meaning that they eventually learnt how to interact with equipment. However, the availability of ergonomically adapted equipment[214] could increase younger children's engagement with such equipment e.g. ride-on toys and park equipment. Successful engagement in activities that were organised by external groups was achieved when sessions focused on play over technique. This focus on fun, which is consistent with identifying activities that the children enjoyed (discussed above), appears to be critical to making activities appropriate for this age group and appealing to children. It is important to flag that some structured activities were often unavailable for younger ages. As such, increasing the availability of equivalent unstructured activities (such as free play gymnastics sessions) could be an effective method of providing more age-appropriate methods of exposing children to a wider range of activities, which has been highlighted in previous research to be preferred by preschoolers themselves[213].

Siblings and other children are key influences on preschoolers' physical activity levels[75, 215, 216]. Overall, parents framed this influence as positive, stating that their children were more active at higher intensities, engaged with more imaginative play and developed skills faster when interacting with siblings or other children. This assumption resonates with quantitative data that shows how young children often observed and imitated behaviour of siblings and peers[215, 217-219]. For instance, a longitudinal study in Canada found that 3-5-year-old children influenced each other's accelerometry-measured moderate-to-vigorous physical activity over time in childcare settings[217]. However, a few mothers in the current study presented a conflicting perspective to this idea, in that it was often more difficult for them to encourage their older child to be active if they had the child's infant sibling to take care of. Therefore, this data signals the benefits of children having the opportunity to play with other children their own age or older, which again is consistent with the concept of promoting more unstructured play opportunities for children[21, 22, 220]. Engagement in active play and opportunities for structured and unstructured physical activity fits with the WHO physical activity guidelines for under-fives, to promote motor skill development and the exploration of the physical environment[21].

Parents perceived that they were the most important influences on their children's physical activity. Parents' knowledge, motivation and self-efficacy were key contributors to these participants' ability to engage their children with activities. For example, knowledge of age-appropriate activities was observed to stem from parents' own childhood experiences, educational and career background-based knowledge and their ability to seek out and share opportunities. Participants demonstrated their knowledge of the harms associated with excessive screen exposure on their child's activity levels through restricting their children's screen time. However, for parents who mentioned using screen time as downtime or safety measures in terms of keeping their child in one place, this may indicate a lack of knowledge, motivation or means towards providing alternative activities that are healthier[221-223].

Furthermore, a lack of motivation to seek out and engage children with activities outside of childcare settings may be reflective of parents not knowing exactly what their children do in those settings and how much activity preschool-aged children should engage with. Although parents mentioned wanting their children to keep active for obesity prevention reasons, their main motivations to engage their children with activities were for several other reasons: to spend time as a family; to go outdoors for fresh air; to improve their children's and their own mental wellbeing; to manage their children's sleep and behaviour; to develop children's physical and social skills to become well-rounded; and to engage children with activities that they enjoy. These findings highlight ways in which we could encourage parents to engage their preschool-aged children with structured and unstructured activities to help children to be more physically active, through framing the activities in line with these motivations.

It is crucial to note that parents' knowledge, motivation and self-efficacy cannot be separated from the wider social determinants of health and there is evidence that they are associated with ethnicity[224] and socioeconomic status[225]. This was evident through one interview with a non-white participant, whose lack of knowledge, motivation and self-efficacy towards taking their child swimming demonstrated how society and providers of services make a lot of assumptions about how to provide and access physical activity opportunities. This observation may be applicable to other families who are raising families in a different country and culture to which they were raised[226, 227]. Participants who could work part-time, had flexible working hours or be stay-at-home parents had more time to dedicate to their children's physical activity[228-230], signalling an example of activity levels being linked to their parents' higher socioeconomic status. This highlights the importance of considering disadvantaged communities' circumstances when aiming to reduce health inequalities, through ensuring that underprivileged children can partake in activities.

Another key finding which related to the social determinants of health is parental costs and resources. Several studies have highlighted potential barriers to children being physically active as limited parental financial support and a lack of transportation means[231, 232]. A lack of disposable income and material resources were key barriers among the study participants. For instance, the parents often referred to the cost of activities run by organisations as being too expensive, and not taking their children to unstructured activities during the school holidays because of price increases. Families with limited incomes have less to spend on equipment and activities in the home environment[233], and for external activities and settings which facilitate physical activity[231], which highlights the importance of having affordable environments which all families can access. Some parents felt there was a lack of free or low-cost playgroups which could limit low-income families from exposing their children to different activities and other children, while also establishing local social networks[234, 235]. Families who did not own cars were restricted in getting to different physical activity opportunities easily. For example, participants who owned cars spoke about driving to better parks, which would result in more activity, thus widening the differences in children's activity exposure and levels compared to families who did not own cars. Ensuring that opportunities are accessible to individuals who do not own cars, which will more likely affect ethnic minority and low-income families[236, 237], can be improved through appropriate public transport and urban planning[238, 239].

Access to gardens was also mentioned by parents as an important structural influence on their children's physical activity. Having access to a garden allows children to regularly play outside in an enclosed environment without needing such a high level of parental supervision and time. This environmental factor has the potential to be a barrier or facilitator and much like access to other physical activity settings, is a factor that partially explains socioeconomic inequalities in children's physical activity levels. One in eight households in the UK (12%) have no access to a private or shared garden[240], with White people four times as likely than Black people to have outdoor space at home. Those in unskilled and semiskilled manual occupations, casual workers or unemployed individuals are almost three times as likely as those in administrative, managerial and professional occupations to be without a garden[240]. Garden ownership is beneficial for several aspects of health[241] on top of promoting children's physical activity, and should therefore be a priority for new housing developments. Parents often described taking their children to parks and natural environments for outdoor activity. Reassuringly, people who live in the most deprived areas in England who may not have access to gardens, are twice more likely than people in the least deprived areas to be within a five-minute walking distance to a public park[240] which is a credit to appropriate urban planning.

Across the interviews it was clear that mothers and fathers shared common assumptions and recognised similar barriers and facilitators to their children's physical activity across social and structural domains. However, there were some themes that were discussed differently according to gender. For example, the establishment of social networks was much greater among mothers. Mothers were observed to be the main parent to seek children's physical activity opportunities through their social networks which included family, friends, colleagues, communities and childcare settings. This finding echoes qualitative research which has explored mothers' feelings of isolation, loneliness and disconnection with other adults in early motherhood[242] and the importance to them of establishing social networks to buffer these effects[243, 244]. This may also be reflective of gendered working norms, where fathers were reported to be more involved in the evenings and on weekends when they were not working, which has been observed in parents of older children[83, 245]. Even with the shift in gendered childcare roles[246], mothers are still more likely to work part-time or become stay-at-home parents[247] who can dedicate more time to their children's care, of which organising opportunities for physical activity is a part of.

Mothers in the study were also more likely to engage with social media[244] compared to fathers, who were more likely to seek opportunities through internet searches, workplaces and childcare settings on an ad hoc basis. One view on this which is consistent with decades of feminist theory and research is that rather than solely disliking social media, fathers could be off-loading the responsibility of seeking physical activity opportunities onto mothers, based on the gendered division of labour they have adopted in relation to childcare which is embedded in society[248-250].

Parents (usually mothers) were less likely to take their children to environments which they deemed to be unsafe and unhygienic. Many parents expressed being put off by other older children for safety and noise reasons, particularly in unstructured play settings such as soft play centres. Having time slots to restrict numbers and having age-specific sections were suggested by the parents to prevent these issues but strict enforcement would be required to make sure children stay within their designated areas. Some parents expressed safety concerns about the built environment surrounding and beyond their homes which could be addressed with appropriate urban planning, policies and funding[251]: traffic and speed restrictions; reduction in criminal activity; enclosed outdoor spaces; adequate car parking places; toilet facility availability; and improved pavement quality. It is vital for housing and urban planning to promote children's physical activity[252, 253] through making mothers in particular feel safe[254, 255]. Maintenance of the built and natural environment is lower, while road safety issues and criminal activity are higher in more deprived areas[251, 256-258], thus the safety concerns discussed are likely to be greater amongst parents from lower socioeconomic backgrounds. Mothers' concerns about teenagers in parks are unlikely to be resolved unless the lack of opportunities for older children and adolescents are also addressed, such as the decrease in youth services by 69% since 2010/11[259], highlighting the importance of using systems-based approaches with intervention and policy development[260, 261].

4.5.1. Strengths and limitations

The main strength of this study is the original parental insight into the barriers and facilitators of preschool-aged children's physical activity and sedentary time. The in-depth qualitative approach of this study has provided data that would be unachievable to obtain through conducting a quantitative study. A major strength was the sample of parents which was equally split between mothers and fathers, as qualitative studies with parents of preschoolers usually represent the mothers' voices[75]. The majority of the mothers in the study identified as the primary caregivers whereas the fathers considered themselves to be the secondary caregivers of the children. This limited the ability to draw as many confident comparisons related to the parents' gender compared to their caregiving status. However, the study demographics with regards to caregiver status are representative of the division of work and childcare between UK-based mothers and fathers[247], which makes the study findings transferable to the general population in the UK.

The study sample was limited in being overwhelmingly white and of higher educational status. Efforts were made to recruit parents from varying ethnic minority and socioeconomic groups, but there are limits to the transferability of these study findings beyond white middle-class parents. Given that there are inequalities in children's physical activity, which was interpreted in these findings, further qualitative and quantitative work should have a greater focus on the influence, barriers and facilitators of preschool-aged children's physical activity in ethnic minority and lower socioeconomic groups. Although it was possible to suggest recommendations of how to overcome the several structural barriers that were identified in this study, further research needs to be conducted with stakeholders to understand their systems and identify the barriers and facilitators at their levels.

4.6. Conclusions

The broad range of barriers and facilitators identified across the parents' social and structural environments emphasises the need for multisectoral interventions and policies to reduce health inequalities, through increasing physical activity and decreasing sedentary time in 2-4-year-olds in England. The increased availability and accessibility of affordable, age-appropriate unstructured activities would allow children from all socioeconomic backgrounds to explore different activities while having the opportunity to play with other children. Additionally, increased funding to public health in local authorities could offset cost-related barriers through subsidising access to activities for families with low incomes. Parental knowledge, motivation and self-efficacy were key factors in engaging children with physical activity opportunities. This signals an important role for health visitors, charities and children's centres in engaging and providing information to parents from lower socioeconomic backgrounds and migrant communities in particular.

It was evident that there was a lack of structural support for facilitators of activity in terms of the design and maintenance of the home, built and natural environments which are more likely to negatively affect ethnic minority and more deprived communities, thus highlighting structural drivers of physical activity inequalities. These structural drivers of inequality may be addressed through changes in public health policies, urban planning policies (including housing) and funding to appropriate stakeholders to provide suitable and safe settings for parents to promote their children's physical activity. Based on the study findings, it is unlikely that fathers can have more of an influence on engaging their children with physical activities without a societal shift in the division of work and childcare. Future research needs to explore the barriers and facilitators in policy makers and other stakeholders in making structural changes in policy to facilitate parents' ability to promote their children's physical activity.

4.7. Implications for thesis

The findings from this study have provided a wide range of barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-old children in England. Further, this chapter adds richness to the thesis overall as I present an in-depth exploration of how these barriers and facilitators play out in families' everyday lives. This thesis aims to inform the design of public health interventions and policies to improve preschool-aged children's activity behaviours. The qualitative evidence presented in this chapter is invaluable in developing acceptable and effective interventions as it highlights potential avenues for implementation, as well as ways interventions may not be acceptable for certain settings or populations. The next chapter in the thesis (Chapter 5) will further illuminate the qualitative findings in this chapter, as it aims to assess the reliability of an evaluation tool which measures parental and nursery staff's self-efficacy, motivation and knowledge towards 2-4-year-olds' activity behaviours.

CHAPTER 5. SELF-REPORT TOOLS USED TO MEASURE PARENTAL AND NURSERY STAFF'S MEDIATING FACTORS RELATING TO PRESCHOOLERS' PHYSICAL ACTIVITY BEHAVIOURS

5.1. Overview

The work presented in this chapter has been published in Public Health Nutrition[2]. My contribution to the published manuscript includes the conceptualisation, methodology, participant recruitment and data collection, data preparation, data analysis, writing the original draft, and reviewing and editing later drafts of the manuscript for publication. Besides this overview (section 5.1), minor edits and final implications for thesis (section 5.7), the chapter is as per the published article. **"Acceptability, internal consistency and test-retest reliability of scales to assess parental and nursery staff's self-efficacy, motivation and knowledge in relation to preschoolers' nutrition, oral health and physical activity"** answers Research Question 4 of the thesis: *'What self-report measures could be used to assess mediating factors relating to parents' and nursery staff's self-efficacy, motivation and knowledge towards preschoolers' activity behaviours?'* The findings of this study will determine whether newly developed questionnaires demonstrate adequate acceptability and reliability to measure these outcomes.

I start by presenting the rationale for the study in section 5.2. In section 5.3, I describe the methods used in the study in terms of participant recruitment, questionnaire development and the quantitative analyses used. In section 5.4, I provide the results of the study and discuss the study findings comparative to the wider literature in section 5.5. Finally, in section 5.6, I outline the study conclusions, followed by the implications of the findings in relation to the thesis in section 5.7.

5.2. Rationale

Globally, an estimated 38.3 million (5.6%) of children aged under-five were overweight in 2017[262]. Guidance and support for caregivers and childcare settings to provide healthy diets and physical activity opportunities have been identified as strategies to reduce the prevalence of obesity in preschool-aged children[263]. Parents of preschool-aged children can make certain foods available and accessible in the home environment to promote positive food behaviours[264-266] and parental encouragement and beliefs about physical activity are important predictors of children's physical activity levels[208, 267]. Various studies have reported that childcare policies have influenced children's dietary intake, and that preschools have a responsibility to assist parents in providing healthy food to children[268]. Childcare staff can also influence the level of physical activity children engage in by encouraging them to be active[269]. Early childhood caries (ECC) are a global pandemic and prevalence among children aged 3-5-years varies between different countries and continents[270]. Parents and preschool staff need to supervise and be trained in tooth brushing practices together with reducing children's consumption of sugary foods and drinks to prevent the onset of ECC[270]. Parental and family dental health habits influence their children's oral health[271]. In 2017, around 71% of eligible 2-year-olds and 95% of 3-4-year-olds received government funded early education in the UK[272] (see section 2.4.1 for more recent figures).

As parents' and nursery (preschool) staff's encouragement have been associated with the quality of children's diet, oral health and level of physical activity, interventions attempt to increase caregivers' self-efficacy, motivation and knowledge to improve these behaviours[271, 273]. Self-efficacy, a strong predictor of health behaviour change[274] is defined as one's confidence in their ability to perform the target behaviour and is a construct of Bandura's social cognitive theory[133, 273]. Motivation refers to one's readiness to change a specific behaviour, which is defined as the degree to which a person feels a change is important[275, 276]. Parental and nursery staff's knowledge of healthy diets and physical activity may also help encourage children to engage in healthy eating and physical activity[277]. I am not aware of parent and/or nursery staff questionnaires which measure a combination of attitudes and knowledge towards preschooler's nutrition and physical activity. The aims of the current study are to test the NAP SACC UK mediators for, 1) acceptability by examining response rates and missing data; 2) maximising the internal consistency of the scales using Cronbach's α coefficients; and 3) assessing the levels of test-retest reliability of individual items and scales using weighted kappa coefficients, intraclass correlation coefficients and paired *t*-tests.

5.3. Methods

5.3.1. Sample

Nurseries from Bristol, UK were identified using the www.1bigdatabase.org.uk, which is an online database of childcare and family information. Nursery managers were recruited through postal invitations, followed by an email invitation 10 days later (Appendix 12). Nursery managers were also sent a participant information form (Appendix 13) and their written informed consent was obtained (Appendix 14). Participating nursery managers (n = 21) recruited nursery staff and parents via email (Appendix 15). Parents were also recruited via an online advert on the survey forum of the UK-based parenting website www.netmums.com (Appendix 16). Data were collected between November 2016 and January 2017. Inclusion criteria were nursery staff and parents or guardians, who work with or have 2-4-year-old children. Online consent was gained from each participant prior to data collection commencing (Appendix 17). This project has been reviewed and approved by the University of Bristol Faculty of Health Sciences Research Ethics Committee; ID: 41585 (Appendix 18).

5.3.2. Study design

Nursery managers were instructed to send a link to the online nursery staff questionnaire via email to all nursery staff who worked with 2-4-year-olds. This was repeated for the parent questionnaire to parents who had 2-4-year-old children. Participants were asked to provide their email address at the end of the questionnaire; those who did were automatically sent the questionnaire again one week later. They were sent a reminder email a further three days later. Participants' questionnaires were included in the analyses if the second administration was completed between 7 and 11 days after the first administration. Each participant was reimbursed with a £10 voucher on completion of the first and second administrations of the questionnaire.

5.3.3. Development of the mediator questions

The NAP SACC intervention (see section 2.4.3) was designed in the USA to improve the nutrition and physical activity environment, policies and practices in nursery settings[138]. The aim of the NAP SACC UK feasibility cluster randomised controlled trial (cRCT) was to assess the acceptability of the intervention, randomisation and the study measures within the UK[141]. A set of potential mediator questions were created for the NAP SACC UK study to measure parents' and nursery staff's knowledge, motivation and self-efficacy towards children's physical activity, oral health, nutrition and sedentary behaviours[141]. The mediator questions (Appendix 19) were based on the questionnaire items used in the Active for Life Year 5[278] study and were adapted using the best practice of diet as recommended by the Children's Food Trust[279] and UK physical activity guidelines[80]. The self-efficacy, motivation and knowledge items were split into two sections; children's nutrition/oral health and children's physical activity. All the self-efficacy items started with the same stem, "I feel able to", and were followed by dietary, physical activity or oral health-related behaviours where the response options were: 1 - "Disagree a lot"; 2 - "Disagree a little"; 3 - "Not sure"; 4 - "Agree a little"; and 5 - "Agree a lot". The same health-related behaviours were included in the motivation items but used the stem, "I am motivated to". The motivation response options were: 1 - "Never"; 2 - "Sometimes"; 3 - "I don't know"; 4 - "Most of the time"; and 5 - "Always". Multiple choice questions were set for the knowledge items and varied in terms of having one or multiple correct response options.

5.3.4. Data analysis

Descriptive statistics were used to summarise the participant characteristics, response rates and missing data. Using the data from the first administration of the questionnaire, Cronbach's α coefficients were calculated to determine the internal consistency of the four scales: nutrition self-efficacy, physical activity self-efficacy, nutrition motivation and physical activity motivation. Values of at least 0.7 were considered acceptable[280]. To assess test-retest reliability of the individual items, weighted kappa coefficients for ordinal variables[281] were calculated. To interpret the kappa coefficient results, the cut-offs detailed by Landis and Koch[282] were used: 0.00 – 0.20 = "Slight", 0.21 - 0.40 = "Fair", 0.41 - 0.60 = "Moderate", 0.61 - 0.80 = "Substantial" and 0.81 - 1.00 = "Almost Perfect" agreement. A score was derived by calculating the total for each of the self-efficacy and motivation scales. For the knowledge items, the percentage of correct answers was derived for each participant. ICCs were used to assess the test-retest agreement at scale level for each of the five scales with an ICC > 0.7 considered acceptable[184]. The sample size required for estimating an ICC of 0.8 with a 95% confidence interval ±0.1 for two repeated measures was 50 participants[283]. Paired *t*-tests were calculated on the continuous test and retest total self-efficacy, motivation and knowledge scale scores to determine whether the scores were higher at the test or retest administration. All analyses were carried out in Stata v15 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

5.4. Results

5.4.1. Participants

Eighty-two parents and 69 nursery staff completed the first and second questionnaire administrations within seven to 11 days and were included in the analyses. Participants' demographic characteristics are shown in Table 12**.** Most parents were mothers (72.0%) and 43.9% were in the 31-35-year age group whereas nursery staff were mainly in the 25-30-year age category (31.9%). The majority of parents (41.5%) and nursery staff (37.7%) had a university degree. The Index of Multiple Deprivation scores of the 21 recruited nurseries ranged from 3.59 to 53.27 which were spread across the following IMD quintiles: 1st (3); 2nd (8); 3rd (3); 4th (2); and 5th (5).

Table 12: Baseline characteristics of parents and nursery staff who completed two administrations of their respective questionnaires within an interval of 7 to 11 days

Parent Characteristics	**N = 82**
Age (Years); Number (%):	
Under 25	3 (3.66)
25 – 30	12 (14.63)
31 – 35	36 (43.90)
36 – 40	25 (30.49)
41 and Over	6 (7.32)
Relationship to child; Number (%)	
Mother	72 (87.8)
Father	9 (11.0)
Other	1 (1.22)
Highest Level of Education; Number (%):	
Did not complete secondary school	1 (1.22)
GCSE or GNVQ Level or equivalent	7 (8.54)
A-Levels or Advanced GNVQ or equivalent	9 (10.98)
University degree	34 (41.46)
Postgraduate degree or higher	31 (37.80)
Employment Status; Number (%):	
Student	6 (7.32)
Housewife/Househusband	12 (14.63)
Full-time	21 (25.61)
Part-time	41 (50.00)
Unemployed	2 (2.44)
Number of children; Mean (SD)	1.68 (0.73)
Number of children; Number (%):	
1	36 (43.90)
2	39 (47.56)
3	4 (4.88)
4	3 (3.66)
Nursery Staff Characteristics	N = 69
Age (Years); Number (%):	
Under 25	17 (24.64)
25 – 30	22 (31.88)
31 – 35	11 (15.94)
36 – 40	5 (7.25)
41 and Over	14 (20.29)
Highest Level of Education; Number (%):	
GCSE or GNVQ Level or equivalent	16 (23.19)
A-Levels or Advanced GNVQ or equivalent	21 (30.43)
University degree	26 (37.68)
Postgraduate degree or higher	6 (8.70)

Note: GCSE: General Certificate of Secondary Education; GNVQ: General National Vocational Qualification; A-levels: Advanced Level

5.4.2. Acceptability and missing data

The number of times that individuals clicked the consent button on the questionnaire link was 130 and 103 for parents and nursery staff respectively; it was not possible to distinguish whether the same individuals clicked consent multiple times as they would not have provided any identifying information at this stage (email addresses). One hundred and two parents completed the first administration of the questionnaire and 88 (86.3%) completed it for the second administration. For the nursery staff questionnaire, 86 and 74 (86.0%) participants completed the first and second administrations, respectively.

Seventy-three (89.0%) and 69 (84.1%) of the parents completed all items in the first and second questionnaire administrations, respectively. The number of nursery staff completing all the items showed an increase from the first 57 (82.6%) to second 59 (85.5%) administration. Thirty-eight (71.7%) and 34 (64.2%) of the 53 parental items had no missing data at test and retest administrations respectively. Fifty-two (80.0%) of 65 nursery staff questionnaire items had no missing data at both test and retest administrations.

5.4.3. Cronbach's α coefficients

Table 13 and Table 14 show the Cronbach α coefficients of each item for the test scale if the item is removed as well as the α of the scale. The *Nutrition Self-Efficacy* scale showed an acceptable level of internal consistency (alpha = 0.80). The

Physical Activity Self-Efficacy scale had the weakest internal consistency in the parent questionnaire but still at an acceptable level (alpha = 0.73). The removal of the item 17 relating to the provision of opportunities to walk to/from nursery would noticeably improve the internal consistency of the scale (alpha = 0.81). The *Nutrition Motivation* scale showed a high level of internal consistency (alpha = 0.86) and the *Physical Activity Motivation* scale demonstrated the highest overall Cronbach's α (0.89). Unlike the equivalent item in the *Physical Activity Self-Efficacy* scale, the removal of item 37 had less of an increase on the internal consistency (alpha = 0.92). The *Nutrition Self-Efficacy* and the *Nutrition Motivation* scales in the nursery staff questionnaire had α coefficients of 0.89 which both showed high levels of internal consistency. Both the *Physical Activity Self-Efficacy* and *Physical Activity Motivation* scales also demonstrated high levels of internal consistency (alpha = 0.91).

Table 13: Cronbach's alpha coefficients for the four scales in the parent questionnaire

Nutrition Self-Efficacy Scale	Cronbach's α if item removed
1. I feel able to provide my children with fruit at all main meals	0.77
2. I feel able to provide my children with vegetables at all main meals	0.78
3. I feel able to reduce the amount of processed meat, fish or potato products served to my children at all main meals	0.78
4. I feel able to provide my children with home-cooked meals each week	0.78
5. I feel able to reduce the number of high-sugar or high-fat snacks served to my children each week	0.76
6. I feel able to reduce the amount of sugary breakfast cereals served to my children each week	0.78
7. I feel able to reduce the number of fizzy drinks and cordials served to my children each week	0.78
8. I feel able to increase the amount of water served to my children each week	0.80
9. I feel able to make changes to the portion sizes served to my children each week	0.79
10. I feel able to increase how often my children brush their teeth with fluoride toothpaste	0.78
Alpha for overall scale:	**0.80**
Physical Activity Self-Efficacy Scale	
11. I feel able to provide my children with time for indoor activities and games each week	0.70
12. I feel able to provide my children with space for indoor activities and games each week	0.68
13. I feel able to provide my children with toys/equipment for indoor activities and games each week	0.71
14. I feel able to provide my children with time for outdoor play and games each week	0.67
15. I feel able to provide my children with space for outdoor play and games each week	0.66
16. I feel able to provide my children with toys/equipment for outdoor play and games each week	0.69
17. I feel able to provide my children with opportunities for walking to/from nursery each week	0.81
18. I feel able to provide my children with opportunities for outdoor play regardless of the weather	0.71
19. I feel able to reduce the amount of time the adults in my household spend using screens across the week	0.73
20. I feel able to reduce the amount of time the children in my household spend using screens across the week	0.72
Alpha for overall scale:	**0.73**

Nutrition Motivation Scale	
21. I am motivated to provide my child with fruit at all main meals	0.85
22. I am motivated to provide my child with vegetables at all main meals	0.85
23. I am motivated to reduce the amount of processed meat, fish or potato products served to my child at all main meals	0.84
24. I am motivated to provide my child with home-cooked meals	0.86
25. I am motivated to reduce the number of high-sugar or high-fat snacks served to my child	0.84
26. I am motivated to reduce the amount of sugary breakfast cereals served to my child	0.84
27. I am motivated to reduce the number of fizzy drinks and cordials served to my child	0.85
28. I am motivated to increase the amount of water served to my child	0.85
29. I am motivated to make changes to the portion sizes served to my child	0.87
30. I am motivated to increase how often my child brushes their teeth with fluoride toothpaste	0.85
Alpha for overall scale:	**0.86**
Physical Activity Motivation Scale	
31. I am motivated to provide my child with time for indoor activities and games	0.88
32. I am motivated to provide my child with space for indoor activities and games	0.87
33. I am motivated to provide my child with toys/equipment for indoor activities and games	0.88
34. I am motivated to provide my child with time for outdoor play and games	0.87
35. I am motivated to provide my child with space for outdoor play and games	0.86
36. I am motivated to provide my child with toys/equipment for outdoor play and games	0.87
37. I am motivated to provide my child with opportunities for walking to/from nursery	0.92
38. I am motivated to provide my child with opportunities for outdoor play regardless of the weather	0.87
39. I am motivated to reduce the amount of time the adults in my household spend using screens	0.89
40. I am motivated to reduce the amount of time the children in my household spend using screens	0.88
Alpha for overall scale:	**0.89**

Table 14: The Cronbach's alpha coefficients for the four scales in the nursery staff questionnaire

Nutrition Self-Efficacy Scale	Cronbach's α if item removed
1. I feel able to serve fruit and vegetables to children at all main meals	0.89
2. I feel able to limit the amount of processed meat, fish or potato products served to children	0.87
3. I feel able to limit the amount of salt used in food for children	0.87
4. I feel able to limit the number of high-sugar or high-fat snacks served to children	0.88
5. I feel able to limit the use of cakes and/or other sweet or high fat foods to celebrate event	0.88
6. I feel able to make changes to the types of beverage provided to children	0.87
7. I feel able to make changes to how we promote oral health at nursery	0.88
8. I feel able to make changes to how staff role-model healthy eating foods served at meal and snack times	0.87
9. I feel able to make changes to how staff incorporate healthy eating learning into children's daily activities	0.87
10. I feel able to increase staff access to professional development in child nutrition	0.88
11. I feel able to increase communication with parents about child nutrition	0.88
12. I feel able to make changes to our written policy on child nutrition	0.87
Alpha for overall scale:	**0.89**
Physical Activity Self-Efficacy Scale	
13. I feel able to provide an appropriately-sized indoor space for children's physical activity and play	0.90
14. I feel able to provide appropriate indoor toys and equipment for children's physical activity and play	0.90
15. I feel able to increase the amount of time provided for indoor physical activity and play for children	0.90
16. I feel able to increase the amount of adult-led indoor physical activity and play for children	0.90
17. I feel able to provide an appropriately-sized outdoor space for children's physical activity and play	0.90
18. I feel able to provide appropriate outdoor toys and equipment for children's physical activity and play	0.90
19. I feel able to increase the amount of time provided for outdoor physical activity and play for children	0.90
20. I feel able to increase the amount of adult-led outdoor physical activity and play for children	0.91
21. I feel able to make changes to the amount of screen-time allowed in our nursery per child	0.91

22. I feel able to make changes to how staff role-model good physical activity habits	0.90
23. I feel able to make changes to how staff incorporate physical activity learning into children's daily activities	0.90
24. I feel able to increase staff access to professional development in children's physical activity	0.90
25. I feel able to increase communication with parents about children's physical activity	0.90
26. I feel able to make changes to our written policy on children's physical activity	0.90
Alpha for overall scale:	**0.91**
Nutrition Motivation Scale	
27. I am motivated to serve fruit and vegetables to children at all main meals	0.90
28. I am motivated to limit the amount of processed meat, fish or potato products served to children	0.89
29. I am motivated to limit the amount of salt used in food for children	0.89
30. I am motivated to limit the number of high-sugar or high-fat snacks served to children	0.88
31. I am motivated to limit the use of cakes and/or other sweet or high fat foods to celebrate events	0.88
32. I am motivated to make changes to the types of beverage provided to children	0.88
33. I am motivated to make changes to how we promote oral health at nursery	0.88
34. I am motivated to make changes to how staff role-model healthy eating foods served at meal and snack times	0.89
35. I am motivated to make changes to how staff incorporate healthy eating learning into children's daily activities	0.88
36. I am motivated to increase staff access to professional development in child nutrition	0.88
37. I am motivated to increase communication with parents about child nutrition	0.89
38. I am motivated to make changes to our written policy on child nutrition	0.89
Alpha for overall scale:	**0.89**
Physical Activity Motivation Scale	
39. I am motivated to provide an appropriately-sized indoor space for children's physical activity and play	0.90
40. I am motivated to provide appropriate indoor toys and equipment for children's physical activity and play	0.90
41. I am motivated to increase the amount of time provided for indoor physical activity and play for children	0.90
42. I am motivated to increase the amount of adult-led indoor physical activity and play for children	0.90
43. I am motivated to provide an appropriately-sized outdoor space for children's physical activity and play	0.90
44. I am motivated to provide appropriate outdoor toys and equipment for children's physical activity and play	0.90

45. I am motivated to increase the amount of time provided for outdoor physical activity and play for children	0.89
46. I am motivated to increase the amount of adult-led outdoor physical activity and play for children	0.90
47. I am motivated to make changes to the amount of screen-time allowed in our nursery per child	0.90
48. I am motivated to make changes to how staff role-model good physical activity habits	0.90
49. I am motivated to make changes to how staff incorporate physical activity learning into children's daily activities	0.89
50. I am motivated to increase staff access to professional development in children's physical activity	0.90
51. I am motivated to increase communication with parents about children's physical activity	0.90
52. I am motivated to make changes to our written policy on children's physical activity	0.91
Alpha for overall scale:	**0.91**

5.4.4. Test-retest analyses

Test-retest analyses found that most of the weighted kappa coefficients for individual items fell under the 'Moderate' category for the parent (75.0%) questionnaire and for the nursery staff (55.8%) questionnaire (Table 15). The parent questionnaire scales demonstrated substantial levels of agreement (ICC = 0.62 to 0.80). Overall, the nursery staff questionnaire scales demonstrated good levels of test-retest reliability, apart from the *Physical Activity Motivation* (ICC = 0.48) scale which can be in part explained by 50% of the individual items displaying 'Fair' test-retest reliability. Paired *t*-tests found that self-efficacy, motivation and knowledge scale scores for parents were higher in the questionnaire's second administration. Paired *t*-tests showed strong evidence that the *Nutrition Motivation* (t = -2.91, df = 81, p = 0.00) and *Knowledge* (t = -3.22, df = 81, p = 0.00) scales were substantially higher at the retest administration. Similarly, the nursery staff scale scores were all higher in the questionnaire's retest administration however there was no evidence that this increase was substantial.

Table 15: Weighted kappa coefficients of the items, intraclass correlation coefficients and paired t-tests of the test scales in the parent and nursery staff questionnaires

Parent Questionnaire Scales											
		Weighted Kappa Coefficients; Frequency (%)							**Paired *t*-test**		
	N° Items	**Slight (0 < 0.2)**	**Fair (0.2 < 0.4)**	**Moderate (0.4 < 0.6)**	**Substantial (0.6 < 0.8)**	**Almost Perfect (0.8 < 1.0)**	**ICC (95% CI)**	**Mean Difference (95% CI)**	**t**	**df**	**p**
Nutrition Self-Efficacy	10	0	1 (10.0)	7 (70.0)	2 (20.0)	0	0.80 (0.71, 0.87)	-0.59 (-1.33, 0.16)	-1.56	81	0.12
Physical Activity Self-Efficacy	10	0	0	8 (80.0)	1 (10.0)	1 (10.0)	0.76 (0.65, 0.84)	-0.10 (-0.97, 0.77)	-0.22	81	0.82
Nutrition Motivation	10	0	2 (20.0)	7 (70.0)	1 (10.0)	0	0.62 (0.47, 0.74)	-1.74 (-2.94, -0.55)	-2.91	81	0.00
Physical Activity Motivation	10	0	0	8 (80.0)	2 (20.0)	0	0.77 (0.66, 0.84)	-0.59 (-1.63, 0.46)	-1.11	81	0.27
Knowledge	13	N/A	N/A	N/A	N/A	N/A	0.74 (0.63, 0.82)	-2.55 (-4.12, -0.97)	-3.22	81	0.00
Nursery Staff Questionnaire Scales											
		Weighted Kappa Coefficients; Frequency (%)							**Paired *t*-test**		

	N° Items	Slight (0 < 0.2)	Fair (0.2 < 0.4)	Moderate (0.4 < 0.6)	Substantial (0.6 < 0.8)	Almost Perfect (0.8 < 1.0)	ICC (95% CI)	Mean Difference (95% CI)	t	df	p
Nutrition Self-Efficacy	12	0	3 (25.0)	7 (58.3)	2 (16.7)	0	0.82 (0.72, 0.88)	-1.30 (-2.63, 0.02)	-1.97	68	0.05
Physical Activity Self-Efficacy	14	0	2 (14.3)	10 (71.4)	2 (14.3)	0	0.78 (0.67, 0.86)	-0.59 (-2.13, 0.94)	-0.77	68	0.44
Nutrition Motivation	12	1 (8.33)	5 (41.7)	6 (50.0)	0	0	0.61 (0.43, 0.74)	-1.25 (-2.76, 0.27)	-1.64	68	0.10
Physical Activity Motivation	14	0	7 (50.0)	6 (42.8)	1 (7.14)	0	0.48 (0.28, 0.65)	-1.03 (-2.73, 0.68)	-1.20	68	0.23
Knowledge	13	N/A	N/A	N/A	N/A	N/A	0.76 (0.64, 0.84)	-0.61 (-2.44, 1.21)	-0.67	68	0.50

Note: ICC: Intraclass Correlation Coefficient, CI: Confidence Interval.

5.5. Discussion

In this study, I found that the parental and nursery staff questionnaires on their self-efficacy, motivation and knowledge towards preschool-aged children's physical activity, nutrition and oral health behaviours demonstrated high levels of acceptability, with most participants completing the second administration of the questionnaire. Eighty-four percent of the parents and 86% of the nursery staff participants completed all the items. When analysing the missing data further, no items were consistently unanswered by multiple participants or between the test and retest administrations of the questionnaires. This indicates that the items were acceptable.

The self-efficacy and motivation scales demonstrated acceptable and high levels of internal consistency. Removing the item on providing weekly opportunities to walk to/from nursery from the parent questionnaire would improve the internal consistency of the two physical activity scales. The findings suggest that this item does not fit as well within the *Physical Activity Self-Efficacy* and *Physical Activity Motivation* scales and could therefore affect the scores produced for these two scales. Based on these findings, I would advise removing this item from these scales or to include it as a separate item in the questionnaire; however, the internal consistency of the scales would still be acceptable if the item was to be left in the questionnaire.

The individual self-efficacy and motivation items demonstrated good levels of test-retest reliability; where over 50% of the kappa coefficients were categorised as 'Moderate' for the parent and nursery staff questionnaires. A handful of items were found to have 'Fair' and 'Slight' agreement, which might suggest that participants do not understand the questions or are guessing the answers[284]. Total scores for the self-efficacy, motivation and knowledge scales were derived for each participant and test-retest analyses were carried out using paired *t*-tests. Amongst the parent population, there was a substantial difference between the test and retest responses for two of the scales. In terms of the *Knowledge* scale, no substantial test-retest difference was observed when the exact same items were answered by the nursery staff. Differences in the results between the parents and nursery staff may be the result of differences in participant age and education levels but it is unclear due to the limited sample size.

The test-retest correlations of the self-efficacy, motivation and knowledge scales ranged from 0.48 to 0.82 across both the parental and nursery staff questionnaires. The findings are comparable with findings from literature looking at similar topic areas and/or populations. In a study by Wright et al[273], the one-week test-retest reliability of parental self-efficacy scales relating to children's physical activity and dietary behaviours ranged from 0.80 to 0.88. Cronbach's α coefficients for the four scales ranged from 0.80 to 0.88 in two different participant samples. In a study by Whittaker and Cowley[285], the ICCs of three parenting self-efficacy scales relating to children aged one to four, including a play scale, ranged from 0.77 to 0.95 and the internal consistency ranged from 0.66 to 0.84. The Cronbach's α coefficients and test-retest reliability of a seven-item effort motivation scale was 0.92 and 0.61 for teachers and 0.89 and 0.69 for parents of preschool-aged children[286]. Nutrition knowledge scales demonstrated test-retest reliability coefficients between 0.33 and 0.75 in a study by Vereecken et al[284]. The Cronbach's α coefficients for four oral health-related knowledge, fatalism and self-efficacy measures ranged from 0.76 to 0.91 when measured in mothers of children aged 1-5-years[287].

5.5.1. Strength and limitations

To my knowledge, there are not currently any existing questionnaires which measure parents' and nursery staff's self-efficacy, motivation and knowledge towards preschooler's nutrition, oral health and physical activity. The analyses have demonstrated that the items and scales in the questionnaires are acceptable, internally consistent and reliable. A limitation in this study and other similar studies is that the analyses were carried out in a single sample, therefore, we cannot assume that the results would be reproduced when repeated using different populations. It is important to acknowledge that the sample size and characteristics were limited, which are not representative of the general population, and therefore it is uncertain whether these items would be deemed as acceptable to more diverse populations. In the UK, Level 6 qualifications for early years staff are degree level and include Qualified Teacher Status (QTS), Early Years Professional Status (EYPS), Early Years Teacher Status (EYTS) and other early years related degree level qualifications[288]. In England in 2016, 29% of nursery staff had a minimum of a Level 6 qualification[288] compared to this nursery staff sample where 46.4% of individuals had a university degree or higher (minimum Level 6 qualification). Although the percentage of the nursery staff sample with a university degree was higher than the English average, this would only be a problem if internal consistency and test-retest reliability would be different in a group who had a lower level of educational achievement. However, I acknowledge that the nursery staff questionnaire results may not be generalisable to early years staff in other countries which have different requirements for early years staff qualifications. I recognise that our results may not be replicated if using paper-based or face-to-face versions of the questionnaires as opposed to the online versions used in this study. This is important to consider in low-to-middle income countries where device and internet access may not be available to administer tablet/web-based forms of the questionnaire. However, there is evidence to suggest that acceptability, internal consistency and test-reliability outcomes are comparable between paper-based and device/web-based forms of questionnaire administration[289-291]. Due to the limitations stated above, caution needs to be taken when interpreting the magnitude of the results and deciding whether to remove certain items for use in studies.

5.6. Conclusions

The scales provided here are an acceptable and reliable method of assessing parents' and nursery staff's self-efficacy, motivation and knowledge about preschoolers' diet, oral health and physical activity. The items in the questionnaire show low levels of missing data, and good levels of acceptability, internal consistency and test-retest reliability. Overall, the findings suggest that the questionnaires would be suitable measures in assessing parent and nursery staff levels of self-efficacy, motivation and knowledge.

5.7. Implications for thesis

In the assessment of a public health interventions and policies, which aim to promote favourable activity behaviours, it is important to have outcome measurement tools which are specific to the target population. This study provides evidence that the two questionnaires discussed show sufficient acceptability, internal consistency and test-retest reliability in measuring parents' and nursery staff's mediating factors towards 2-4-year-olds activity behaviours. The discussion in the next chapter (Chapter 6) triangulates the findings from Chapter 3, Chapter 4 and Chapter 5, together with the comprehensive literature review in Chapter 2, to inform the design of physical activity interventions and policies for UK-based children aged 2-4-years-old.

CHAPTER 6. DISCUSSION

6.1. Overview

In this final chapter, I will discuss the findings from my thesis, which aims to inform future research and the design of UK-based interventions and policies to decrease sedentary time and increase physical activity levels in 2-4-year-olds, by addressing the following four research questions:

1) What are the levels and potential correlates of sedentary time and physical activity in preschool-aged children? (Chapter 3);
2) What does the most methodologically robust evidence show in terms of factors associated with changes in physical activity and sedentary time in preschool-aged children? (Chapter 2);
3) What are the barriers and facilitators of increasing physical activity and decreasing sedentary time in preschool-aged children? (Chapter 4); and,
4) What self-report measures could be used to assess mediating factors relating to parents' and nursery staff's self-efficacy, motivation and knowledge towards preschool-aged children's activity behaviours? (Chapter 5).

In this chapter, I provide a summary of the main findings from each thesis chapter in section 6.2 and triangulate the findings together with the wider literature in section 6.3. I will discuss the implications of the thesis findings for future research in section 6.4 and for policy and practice in section 6.5. Finally, I will discuss the strengths and limitations of the thesis (section 6.6), my self-reflections of the doctorate experience (section 6.7), and thesis conclusions (section 6.8).

6.2. Summary of main findings

Table 16 provides a summary of the key contributions of this thesis by each chapter.

Table 16: Summary of the objectives, methods, main findings and chapters in order of the thesis research questions

Research objective	Research methods	Main findings	Chapter
1) To determine the levels and potential correlates of physical activity and sedentary time in 3-4-year-old children in high-income countries	Individual-participant meta-analysis of accelerometry data from the MRC Epidemiology Unit's International Children's Accelerometry Database (ICAD)[1]	Across the UK, Switzerland, Belgium and the USA, children in the analysis sample spent 490 minutes in sedentary time per day and 30.0% and 21.2% of children did not engage in World Health Organisation recommended daily total physical activity (≥180 minutes) and moderate-to-vigorous physical activity (≥60 minutes) guidelines. The minutes spent in sedentary time decreased throughout the day. The dips in total physical activity and moderate-to-vigorous physical activity levels observed between 11:00 and 15:00 were greater in the USA compared to Switzerland, Belgium, and the UK and on weekdays compared to weekends. There was evidence for an association between all 10 potential correlates analysed (age, gender, country, season, ethnicity, parental education, day of the week, time of sunrise, time of sunset, and hours of daylight) and at least one of the outcome variables: average daily minutes spent in sedentary time, total physical activity and/or moderate-to-vigorous physical activity.	3
2) To explore the known factors associated with changes in physical activity and sedentary time in preschool-aged children	Critical appraisal using the ROBIS tool and summary of existing systematic reviews assessing factors associated with changes	Two systematic reviews[62, 63] were perceived to have a relatively low risk of bias. Bingham et al[62] found that being male (2/3 studies) and time spent playing with parents (3/4 studies) were positively associated with total physical activity. Maternal depressive symptoms were also found to be negatively associated with	2

	in physical activity and sedentary time in preschool-aged children	subjectively measured total physical activity in one study. No determinants of light or moderate-to-vigorous physical activity were identified. Hesketh et al[63] found that parental monitoring and childcare provider training were positively associated with preschool-aged children's physical activity and moderate-to-vigorous physical activity respectively (≥4 studies). There was some evidence (<4 studies) to suggest that maternal role modelling, sibling co-participation, opportunities for play, additional childcare providers, structured physical activity and playground density were also positively associated with physical activity.	
3) To investigate parents' perspectives on the barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-olds in England	In-depth qualitative telephone interviews conducted with 40 parents of 2-4-year-olds	Identified barriers and facilitators were categorised under eight general themes: children's characteristics and circumstances; interactions with other children; parents' priorities and circumstances; parents' social networks and information sharing; home and childcare environments; organisation-run activities; local authority, council and community-run opportunities; and accessibility and the environment. Identified facilitators included the increased availability and accessibility of affordable, age-appropriate unstructured activities would allow children from all socioeconomic backgrounds to explore different activities while having the opportunity to play with other children. Parental knowledge, motivation and self-efficacy were key factors in engaging children with physical activity opportunities.	4

		Barriers included a lack of structural support for facilitators of activity in terms of the design and maintenance of the home, built and natural environments, which was found to affect participants from ethnic minority and deprived backgrounds. Thus, this work highlighted potential structural drivers of physical activity inequalities. Mothers in this sample had more of an influence on engaging their children with physical activities than fathers, largely due to an unequal division of work and childcare.	
4) To evaluate self-report measures which assess parents' and nursery staff's self-efficacy, motivation and knowledge towards 2-4-year-olds' activity behaviours in England	Acceptability, internal consistency and test-retest reliability analyses of questionnaires developed for the Nutrition and Physical Activity Self-Assessment for Childcare (NAP SACC) UK feasibility study[2]	Response rates were 86.3% and 86.0% and missing data 15.9% and 14.5% for the second administration of the parent and nursery staff questionnaires, respectively. All self-efficacy and motivation scales had acceptable levels of internal consistency (Cronbach's α coefficients >0.7). Weighted κ coefficients for individual items mostly fell under the 'moderate' agreement category between test and retest (7-11 days post-baseline) scores for the parental (75.0%) and nursery staff (55.8%) items. The intraclass correlation coefficients for the self-efficacy, motivation and knowledge scales ranged between 0.48 and 0.82. Paired t tests found an increase between test and retest knowledge scores for the Nutrition Motivation ($t = -2.91$, $df = 81$, $P = 0.00$) and Knowledge ($t = -3.22$, $df = 81$, $P = 0.00$) scales in the parent questionnaire.	5

6.3. Synthesis of findings

In this section, I triangulate the findings from the literature review and three research studies, to address the overall aim of the thesis (as discussed in section 1.9 of Chapter 1). The *triangulation protocol* approach to analysing mixed methods research involves taking the findings from different studies, where data have been collected and analysed separately, and corroborating the study findings with each other to gain an overall picture of the research question[56]. This analytical technique involves listing the study findings from each study at the interpretation stage of the thesis and describing where findings from each method agree (convergence), provide complementary information (complementarity) or contradict (discrepancy) each other[56]. Using this technique also helps to detect 'silences' where findings from one study are not found in the other studies[56]. This synthesis will encompass my own interpretation of how the findings relate to each other and contribute to the research objectives. I critically evaluate the findings in relation to the empirical evidence and literature in the field.

The findings from the ICAD analyses[1] in section 3.5.2 of Chapter 3 found that a greater percentage of four-year-olds met internationally-recommended daily physical activity guidelines of ≥180 minutes total physical activity (72.4% vs. 65.0%, $p=0.015$) and ≥60 minutes moderate-to-vigorous physical activity (80.7% vs. 74.9%, $p=0.032$) compared to three-year-olds[21]. Similarly, age was shown to be positively associated with time spent in moderate-to-vigorous physical activity (β=4.91, p=0.020) in the adjusted multi-level linear regression analyses (section 3.5.4). This is unsurprising given the social and physical developmental capabilities of older children compared to younger children[292-295]. The findings from the qualitative study presented in Chapter 4 uncovered other possible contributing factors, such as the availability of age-appropriate opportunities and equipment. Therefore, this thesis overall suggests there is a need to consider age in physical activity intervention and policy design, as a way of increasing the number of preschool-aged children meeting daily recommended amounts of physical activity.

This thesis shows that the gender of a child is a meaningful factor in physical activity and sedentary time engagement. Section 2.2.3 of Chapter 2 reports that being male was identified as having a positive association with total physical activity in the systematic review by Bingham et al[62]. The findings from the ICAD analyses in section 3.5.2 corroborate this, where a greater percentage of boys achieved recommended total physical activity (76.9% vs. 63.0%, $p<0.001$) and moderate-to-vigorous physical activity (85.4% vs. 72.1%, $p<0.001$) guidelines compared to girls. Being female was also shown to be positively associated with sedentary time (β=17.8, $p<0.001$) and negatively associated with moderate-to-vigorous physical activity ($\beta=-14.94$, $p<0.001$) in the adjusted analyses in section 3.5.4. The findings from my ICAD analyses in Chapter 3 indicate the need for gender informed intervention and policy design in younger children, as gender differences become apparent as soon as individuals can be active.

Further, it is consistently shown in the literature that males are more active and spend less time sedentary than females throughout the lifespan[296-299], where gender differences have been observed in previous research to begin in early childhood[145, 149]. These disparities in activity behaviours will be in part due to gender differences in social and physical development, together with societal norms and environmental interactions[300-302]. There have been interventions which aim to reduce gender inequalities in physical activity for older children which have demonstrated little to no effectiveness[303-305]. One study found that having fewer supervising childcare staff has been shown to increase physical activity in preschool-aged girls, potentially due to girls being more likely to engage in sedentary activities with the childcare providers[306]. The Hesketh et al[63] review found that having additional childcare providers was positively associated with changes in physical activity, which may be apparent in preschool-aged children overall, but highlights that gender differences may be missed. These findings demonstrate the need for further quantitative and qualitative exploration of important factors to address this gender gap in physical activity in 2-4-year-old children.

Parental influences were the most dominant theme identified in the qualitative work in Chapter 4 regarding barriers and facilitators to children's activity behaviours, which is consistent with findings from previous qualitative literature[75]. Time spent playing with parents, parental monitoring and maternal role modelling were three parental forms of influence that were found to be positively associated with preschool-aged children's physical activity in the two systematic reviews discussed in Chapter 2[62, 63]. Parental self-efficacy, motivation and knowledge were discussed in Chapter 4 as being key barriers and facilitators to increasing physical activity and decreasing sedentary time in 2-4-year-olds (e.g. being able to seek out activity opportunities, being motivated to encourage daily outdoor play time and knowledge of age-appropriate activities). Several studies have found quantitative associations between parental self-efficacy, motivation and knowledge and positive physical activity behaviours in their children[307-310]. The questionnaire assessed in Chapter 5 was shown to be reliable for measuring these parental influences, thus providing an appropriate tool to assess these key mediating factors in activity behaviour change for the 2-4-year-old population, which are currently lacking and under-reported in physical activity interventions[101].

In Chapter 3, there was evidence of 3-4-year-olds spending more time being sedentary on weekdays compared to weekends ($\beta=33.6$, $p<0.001$), but with 77.3% vs. 67.6% achieving moderate-to-vigorous physical activity guidelines on weekdays vs. weekend days ($p<0.001$). The qualitative findings presented in Chapter 4 provided some examples of what activities 2-4-year-olds engaged with on different days of the week. For instance, parents spoke about spending time as a family on the weekends, which could either consist of more sedentary activities when the parents were tired or being active for longer periods due to having both parents at home. The qualitative findings also broadly highlighted a gendered division of labour, where fathers in the sample had more of a role in their children's activity behaviours on weekends, whereas mothers tended to adopt a 'main role' in terms of physical activity on a daily basis. These findings also corroborate findings from the Hesketh et al systematic review[63] which found that maternal role-modelling was positively associated with children's physical activity.

The adjusted multilevel regression analyses conducted on the ICAD data (section 3.5.4) found that children with highly educated parents spent more time being sedentary compared to lower educated parents' children ($\beta=14.9$, $p=0.009$) and less time in total physical activity ($\beta=-14.9$, $p=0.009$). Non-white children spent more time in moderate-to-vigorous physical activity than white children ($\beta=9.53$, $p=0.005$) with 92.7% of non-white children achieving ≥60 minutes of moderate-to-vigorous physical activity per day compared to 78.0% of white children ($p<0.001$). Although the data does not show a racial or socioeconomic inequalities, a number of studies summarised in the Marmot Review[311] on addressing social determinants in health, suggested that starting in early childhood is the best approach to improving public health in an equitable way.

The findings from the ICAD analyses may be a result of ethnicity and parental education being categorised as binary variables or because the sample sizes were not powered to detect associations. It is also possible that the types of activities children in the ICAD study sample engaged with led to this finding, or potentially that such inequalities do not become apparent until later in childhood.

If observed in isolation, these findings could be interpreted as presenting an absence of socioeconomic and racial inequalities within children's activity behaviours. However, the qualitative data presented in Chapter 4 signalled that socioeconomically deprived and ethnic minority parents faced different financial and structural barriers which could negatively impact their children's exposure and access to different activities associated with being physically active (e.g. garden access, car ownership, built environment maintenance). This finding is well placed within the wider literature, which describes consistent inequalities in physical activity levels[312] and childhood obesity[313]. Given that the qualitative study sample was predominately white middle-class parents, the observed examples are illustrative and could be examined in more detail in future studies to develop a more exhaustive list of barriers for marginalised groups. Nevertheless, the qualitative evidence in this thesis provides a strong indication for the need towards designing interventions and polices that consider the wider social determinants of health, to limit widening socioeconomic and racial inequalities.

The ICAD analyses (Chapter 3) found that sedentary time levels were lower in spring compared to winter ($\beta = -14.01$, $p = 0.025$) and that moderate-to-vigorous physical activity was higher in summer compared to winter ($\beta = 11.94$, $p = 0.005$). Comparatively, the minutes spent in sedentary time were lower ($\beta = -10.33$, $p = 0.005$) and minutes in moderate-to-vigorous physical activity were higher ($\beta = 7.04$, $p = 0.004$) when there were more than 12 hours of daylight, compared to days where there were less than 12 hours of daylight. This was also reflected in the percentage of children who achieved recommended total physical activity (76.2% vs. 65.0%, $p < 0.001$) and moderate-to-vigorous physical activity (85.1% vs. 73.9%, $p < 0.001$) levels when there were more compared to less than 12 hours of daylight in the day. Visual inspection of the by hour plots in section 3.5.3 showed that moderate-to-vigorous physical activity levels were elevated in the mornings and evenings when the days were longer than 12 hours compared to days when there were less than 12 hours of daylight hours.

These Chapter 3 findings could be interpreted with the contextual data which emerged from the qualitative data in Chapter 4, where parents consistently described restricting outdoor play when the weather was more extreme (e.g. heavy rain, too hot) and less conducive to physical activity. This finding stresses the importance of incorporating sheltered and shaded areas to facilitate outdoor play as the weather becomes increasingly more extreme due to climate change[314]. The quantitative results from Chapter 3 may also be reflective of parents (particularly mothers) feeling safer in the daylight, which was discussed in Chapter 4. Thus, there is further need towards considering seasonal variations and countries which have reduced daylight hours with the promotion of physical activity in young children. It is clear from this thesis that season and weather are strong contributory factors to preschool-aged children's physical activity in the UK. Therefore, it is likely that interventions and policies cannot be transferred from other countries with different climates and daylight hours. Opportunities for physical activity in the summer should be maximised and, in the winter, accessible indoor activity options should be explored, particularly in an effort to reduce inequalities with many families not having access to space or structured activities.

6.4. Implications for research

Throughout the thesis I have referred to the issues that arise from processing accelerometry data. In section 3.3 of Chapter 3, I wrote a thorough comparison of the literature to inform the age-appropriate accelerometry wear time practices to apply to the ICAD analyses. This highlighted the vast range of data processing protocols which could be applied to accelerometry data, thus resulting in different magnitudes of results when different protocols are used and making it impossible to compare findings across studies. There is a need for a move towards using standardised accelerometery processing techniques to allow for comparison across different studies. This relates to suggestions from other physical activity researchers to apply Rosetta Stone equations, to reduce differences across studies which have used different accelerometry cut points and improve the interpretation of findings[315-318].

Researchers also need to measure contextual data such as activity types, sleep time and childcare attendance alongside accelerometry data, to allow for more accurate analysis and interpretation of the data. A breakdown of children's sedentary behaviours would be useful to assess how much sedentary time children spend engaging with beneficial or non-beneficial activities, in line with the WHO recommending that preschool-aged children should engage with activities such as reading and storytelling when sedentary[21]. Collecting sedentary behaviour and sleep data would also relate to the move towards 24-hour movement guidelines[319] which have been increasingly recommended in other countries over recent years[42]. Future data collection also needs to streamline categorisations of socioeconomic status and ethnicity variables across studies to facilitate comparisons and to allow for data pooling.

Several structural barriers and facilitators to 2-4-year-olds' activity behaviours were identified in Chapter 4 (e.g. garden access, maintenance of the built environment), but without knowing the barriers at policy making and local authority levels, it is not possible to know how changes can be made from these findings alone. Conducting qualitative research with relevant stakeholders nationally and locally in public health roles across England would help to ascertain the barriers to making structural changes and therefore inform future directions of intervention and policy development. Similarly, the data from Chapter 4 highlighted barriers to preschool-aged children's engagement with both organisation and community-run activity opportunities (e.g. waiting lists for swimming lessons, lack of toddler groups in the area), which is worth investigating further through conducting qualitative studies with relevant individuals to determine how such barriers can be overcome.

As discussed in Chapter 2, greater focus is needed on assessing factors associated with physical activity and sedentary time in preschool-aged children across different cultures, ethnic minorities, lower socioeconomic groups and in developing countries. Although it was not possible to address these gaps in the research in this thesis, some of the findings in Chapter 3 and Chapter 4 gave an insight into differences in factors across different groups, which require further research to better inform targeted interventions and policies for differing populations.

It was beyond the scope of the PhD to explore gender differences in activity behaviours and parents' behaviours towards them. There is an abundance of qualitative data generated from the study conducted in Chapter 4 to explore what parental behaviours may contribute to gender differences in activity levels, and therefore identify potential targets for behaviour change interventions and policies. Ethnographic and participant observation studies were too time consuming to conduct within the constraints of the PhD, but with future research they could provide the link between quantitative and qualitative literature. As suggested by the authors of the qualitative systematic review[75], such study designs could explore how preschool-aged children and caregivers think and act in relation to the physical activity behaviours of boys and girls.

6.5. Implications for policy and practice

Policies and practices which are relevant to physical activity in preschool-aged children can take place at international, national and local levels. At national levels, multiple stakeholders in different areas of government and society are involved in the development and implementation of physical activity policies and practices, such as: public health; health provision; parenting support; housing and urban planning; parks and leisure; education; employment; and early years. Given the nature of the UK policy structure, policies may span across different levels, for example, health visitors have both national and local policies and services that they follow. The areas I am going to cover include international and national surveillance, interventions, whole systems, structural drivers and societal shifts.

Although combinations of individual studies like the ICAD analyses have assessed activity levels of preschool-aged children, there is a need for larger representative samples of objectively measured activity levels for continual surveillance at a population level, and to determine high risk groups for inactivity. One commentary discussed the progress being made with the number of countries monitoring physical activity levels but that: data gaps still exist in low-to-middle-income countries; there are ongoing issues with differences in the processing of activity data; and there are issues with differing reporting procedures[320]. Although objectively measured activity measures are more reliable, in terms of facilitating more international level surveillance consistency, it may be more appropriate for countries to adopt more affordable validated and standardised questionnaires to monitor activity levels (such as the International Physical Activity Questionnaire or Global Physical Activity Questionnaire)[26, 320]. Without some degree of country-level surveillance of physical activity and sedentary time levels in under-fives, it is not possible to assess adherence to internationally recommended guidelines[21], or to monitor rates of inactivity in line with the WHO's global action plan to reduce rates by 15% by 2030[43].

In Chapter 3, conducting a cross-country comparison of the percentage of preschool-aged children achieving recommended total physical activity and moderate-to-vigorous physical activity levels in line with the relatively recent WHO guidelines[21], has given an indication of physical activity levels in high-income countries. The findings suggested that a proportion of 3-4-year-olds are not meeting recommended physical activity guidelines[1], providing some evidence for the need for public health interventions and policies to increase physical activity and decrease sedentary time in high-income countries in this population. As discussed in section 2.4.1., the components of physical activity interventions targeting 2-4-year-olds have been critiqued in previous reviews[100, 101]. These reviews suggest future interventions should: contain multiple components; be theory-driven; provide ongoing training and support to those delivering intervention; be culturally tailored; include environmental and policy changes; and include a structured activity component. The behaviour change theories and models outlined in Table 4 could be used to inform such future interventions. The data from my thesis would suggest that wider level theories that require interactions between different agents (e.g. socioecological model, general system theory etc), may be more effective in influencing behaviour changes which will benefit preschool-aged children's activity levels.

The evidence from this thesis has steered towards the need for a whole systems-based approach to be applied to physical activity interventions and policies in the bid to prevent childhood obesity and non-communicable diseases[321, 322]. An example of a whole systems approach is the Join Us Play More (JUMP) city wide physical activity strategy currently being evaluated in 5-16-year-old children in Bradford, UK[323]. Multisectoral interventions are needed to address the barriers and facilitators to increasing activity and decreasing sedentary time which were identified across the parents' social and structural environments in Chapter 4. The data signalled a need for more affordable, age-appropriate unstructured activities to be available for 2-4-year-old children engage with. Cost-related barriers to both unstructured and structured activities could be addressed through subsidising access to activities for low-income families. The findings identified a potentially important role for health visitors, charities and children's centres to provide information to parents from more deprived and ethnic minority communities in particular, regarding availability and access to activities. I exercise caution in suggesting these recommendations, given the over representation of white middle-class participants in my studies. However, the participants from low SES and ethnic minority backgrounds who I interviewed for my qualitative study provided examples that begin to illustrate the barriers to physical activity, and thus potential avenues for interventions and policies for these groups. Further research, specifically focused on marginalised groups would clarify these implications.

Structural drivers of inequality such as the design and maintenance of the home, built and natural environments may be addressed through changes in public health policies, urban planning policies (including housing) and funding to appropriate stakeholders to provide suitable and safe settings for parents to promote their children's physical activity (as discussed in Chapter 4). For such policy changes to be executed, governments need to acknowledge the health and economic importance of addressing physical inactivity through using a whole systems-based approach. There also needs to be a move towards more co-ordinated, cross-departmental, evidence-based policy and intervention implementation at local authority and government levels, which is currently lacking. These current barriers to policy changes illuminate the importance of academic researchers translating their research into an understandable context, for governments to understand the public health priority and economic implications, and for policy makers at a local authority level to implement evidence-based policies and interventions.

A societal shift in the division of work and childcare is required to allow for fathers and male caregivers to be more involved with facilitating their children's physical activities. This could involve the equal provision of maternity and paternity leave, to encourage an equal sharing of childcare responsibilities, which is in place in other countries such as Sweden[324]. The questionnaires assessed in Chapter 5 were deemed appropriate for use to measure nursery staff and parental self-efficacy, motivation and knowledge towards 2-4-year-old's activity behaviours. This indicates that the questionnaires can be used to measure the effectiveness of future interventions and policies which aim to improve theses mediating factors to improve preschool-aged children's activity behaviours. Without these measurement tools, it would not be possible to find out whether parental or childcare provider attitudes and abilities have changed, in response to policies such as societal changes in employment and childcare.

6.6. Strengths and limitations

The strengths and limitations of the individual studies conducted as part of the thesis are discussed in their respective chapters. In this section, I outline the overarching strengths and limitations of synthesising the study findings to address the overall aim of the thesis. The study presented in Chapter 3 is the first to assess adherence to the WHO guidelines on physical activity for under-fives[21] and the first to assess cross-country comparisons in high-income countries[1]. It is also the first study to explore associations between hours of daylight and activity measures for this age group[1]. In Chapter 4, I described the views and experiences of fathers regarding their preschool-aged children's activity behaviours, while also allowing for a comparison between mothers and fathers perspectives. The newly developed questionnaires assessed in Chapter 5 were deemed reliable for use and therefore provide an appropriate measurement tool for measuring mediating outcomes associated with 2-4-year-olds' activity behaviours. A common strength across the studies is the adequate participant sample sizes to conduct the relevant quantitative and qualitative analysis methods and therefore address the associated research questions: Chapter 3 (n=1052 3-4-year-old children); Chapter 4 (n=40 parents); and Chapter 5 (n=82 parents and n=69 nursery staff).

One of the key strengths of the thesis is the mixed methods approach of addressing the research questions through using the most appropriate study design. Using mixed methods allowed me to explore the topic area quantitatively and qualitatively, which when triangulated, addressed the overall aim of the thesis to provide evidence to inform future research and policy. One limitation of triangulating the thesis findings in the current chapter is that different participant samples were included across the studies. They had differing demographics and were conducted in different years and locations, so there is some degree of speculation regarding the synthesis of the findings across the studies. For example, the qualitative study in Chapter 4 was conducted with parents from the UK. Therefore, the interpretation of the qualitative data surrounding working patterns in relation to the weekday vs weekend activity differences may not be applicable to the quantitative differences observed in Belgium, Switzerland and the USA in the ICAD analyses (Chapter 3). Furthermore, in having two quantitative studies and one qualitative study in the thesis, I have created an unequal composition of evidence which may have subconsciously moved the qualitative research into a supporting role[325].

As I conducted secondary analyses on the ICAD in Chapter 3, I was limited with what data I had to work with and how it had already been processed. For instance, I was not able to analyse how often the participants spent more than one hour in sedentary time per day, to be able to measure adherence to the WHO sedentary time guidelines[21]. I was also limited in not having an adequate number of participants in the ICAD sample who were aged 2-years-old, so that age group was not represented in the findings, which would have been useful to synthesise with the findings from Chapter 4 and Chapter 5 to best reflect the 2-4-year-old population explored in the thesis.

6.7. Self-reflections

Throughout this PhD training degree, I have learnt several new skills which I will outline below, with reflections on what I would have done differently if I had the opportunity. In Table 17, I indicate which stages of the research process I had the main involvement with in the three thesis studies presented in Chapter 3, Chapter 4 and Chapter 5.

Table 17: Stages of the research process conducted by the PhD student according to study chapter

	Chapter 3	**Chapter 4**	**Chapter 5**
Conceptualisation	✓	✓	✓
Data use approval	✓		
Ethics application		✓	✓
Methodology	✓	✓	✓
Data collection		✓	✓
Data analyses	✓	✓	✓
Writing up research findings	✓	✓	✓
Publication	✓	✓	

One of the overarching skills I developed during this doctorate was adaptability to adjust my research in line with arising issues and developments. One of the initial research aims of the PhD proposal was to conduct a systematic review of quantitative data which had assessed factors associated sedentary time and physical activity in preschool-aged children. Upon performing the literature searches for Chapter 2, it became apparent that existing systematic reviews were conducted too recently to be updated, therefore I adjusted Research Question 2 to best use the findings from the reviews to inform the overall aim of the thesis. I had to adapt my initial ICAD project proposal (Chapter 3) to ensure that the analyses did not crossover with another proposed project, which a research team from another institution were applying to conduct on the same sample of participants. To conduct the qualitative study conducted in Chapter 4, I made sure to make myself available at all hours on any day for telephone interviews, to ensure that I could accommodate to parents' limited availability around work and childcare commitments. The study and associated publication[2] presented in Chapter 5 was the first study of the thesis to be completed in order to contribute to the NAP SACC UK monograph publication[326]. If I were to repeat this study, I would have made more of an effort to recruit fathers and male nursery staff; lower socioeconomic parents and nursery staff; and collect ethnicity data, in line with the gaps in the research which emerged from writing the literature review chapter throughout the PhD.

There were several participant recruitment skills and tips which I developed through undertaking the two studies presented in Chapter 4 and Chapter 5. Through trialling different recruitment methods for my qualitative study in Chapter 4, I found social media to be the most successful method for recruiting parents, particularly parents from different regions in England and socioeconomic backgrounds. Had I known this previously, I would have used social media to recruit participants for my quantitative study presented in Chapter 5, as recruiting parents through nurseries was more time consuming. If I could conduct the study in Chapter 5 differently, I would have outlined a more simplistic recruitment process in the ethics application, as the two-stage consent process of recruiting nursery managers to forward the invitation email to their nursery staff and parents was an unnecessary extra step which led to greater participant attrition. One advantage of undertaking the recruitment for the study in Chapter 5 first, is I learnt that it is harder to recruit nurseries and parents around Christmas time when they are busier, which I factored into my PhD timelines when recruiting parents for my qualitative study (Chapter 4).

My personal and academic backgrounds have informed my perspectives on my research. Being more experienced with conducting quantitative research during my Masters in Public Health degree and previous Research Associate position, it was difficult transitioning to analysing and interpreting the findings from my qualitative study in Chapter 4, without wanting to apply more quantitative approaches. I felt that not being a parent was advantageous in not applying pre-conceptions to my research, but I am aware that my own childhood upbringing and experiences with young children will have impacted on my interpretation of the study findings. For instance, I believe that being a second-generation immigrant helped guide my understanding of ethnic minority and cultural influences on children's activity behaviours through drawing from my own childhood. An example of which was my mum's motivations towards engaging me in physical activities from a young age, for not just her physiotherapist-based knowledge of the physical benefits, but the idea that it would promote my cognitive development and therefore my learning abilities.

My dad worked away from home, meaning that my mum essentially operated a single-parent household while working full-time. This meant that the majority of my time during the weekdays was spent at nursery when I was 2-4 years old, where there was an abundance of indoor and outdoor play opportunities and other children to play with. After work and on the weekends, mum would spend time facilitating arts and crafts when the weather was poor, and I would 'help out' with the gardening when the weather was nicer. Having an active teenage brother (15-17 years old) meant that I was often involved in rough and tumble play, but it also meant that my mum had to split her limited time between the different life stage needs for the two of us. Based on my own childhood experiences, I had some idea of the many factors which could impact children's activity behaviours and felt a great deal of empathy for families experiencing hardships and conflicting priorities. Financial and time restraints meant that it was difficult for my mum to commit to regular structured opportunities, which improved when I started school, allowing her to enrol me in dance classes at the age of four. I am grateful to have found activities that I enjoy in my early childhood such as spending time outdoors and dancing, which I subsequently established into my lifestyle, and naturally continued into adulthood. I therefore value the importance of exposure to and financial support towards engaging with a range of different activities, which I believe that all young children should experience, to have the same start in life.

Publishing and presenting my research has contributed to and addressed the gaps in the literature surrounding physical activity and sedentary time in 2-4-year-old children. At the time of submitting this thesis, the two published PhD studies have been cited by other researchers 16 (Chapter 3) and 6 (Chapter 5) times respectively. Articles which have cited the ICAD analyses[1] presented in Chapter 3 of the thesis referred to the study in either their rationales, data analysis methods used or in comparison to their own findings regarding levels or correlates of physical activity and sedentary time[327-339]. Similarly, researchers who cited the study[2] presented in Chapter 5, either replicated the methodology used to assess the reliability of their own newly developed self-report questionnaires, or compared the study findings to their own[340-344]. Following the

PhD, I hope to write up my qualitative study presented in Chapter 4 for publication and disseminate the study findings at relevant conferences. I hope that the dissemination of my research findings continues to have an impact in the field.

6.8. Conclusions

Overall, this thesis has established that there is a need within public health research, practice and policy to develop strategies to increase physical activity and decrease sedentary time in 2-4-year-old children. The quantitative findings here highlight that a proportion of preschool-aged children in high-income countries are not achieving adequate levels of physical activity to optimise the associated health benefits. Levels and daily patterns of activity were also observed to vary according to 10 potential correlates, which should be considered in the development of physical activity interventions and policies. The qualitative findings present a wealth of considerations in terms of intervention design, barriers and facilitators across parents' social and structural environments, for families from different backgrounds with differing needs and resources. Future research should measure key parental and childcare provider mediating factors, with the two outcome measurement tools which were deemed reliable in this thesis, to evaluate the effectiveness of children's physical activity interventions and policies. This thesis also concludes that an approach which involves cross-departmental co-ordination between local authority and government stakeholders, stands the best chance of improving preschool-aged children's activity behaviours without further exacerbating inequalities.

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Appendices

Appendix 1: Literature review search strategy

Topic		Search
Preschool aged children	1	Child, Preschool/ or Child/ or Infant/
	2	(child* or preschool* or infant* or toddler* or kid* or nurser* or playschool* or kindergarten* or prekindergarten*).ti,ab,kw.
	3	1 or 2
Physical activity and sedentary time	4	Accelerometry/ or Exercise/ or Locomotion/ or Physical Exertion/ or Physical Endurance/ or Physical Exertion/ or Sedentary Lifestyle/
	5	(acceleromet* or physical* activ* or inactiv* or exercis* or fitness or physical* fit* or physical exert* or indoor activit* or outdoor activit* or active lifestyle or lpa or mvpa or sedentary*).ti,ab,kw.
	6	4 or 5
Correlates and determinants	7	Epidemiology/ or Geographic Locations/ or Population Groups/ or Socioeconomic Factors/ or Maternal Deprivation/ or Paternal Deprivation/ or Family Characteristics/ or Sex Characteristics/ or Age Factors/ or Time Factors/ or Maternal Behavior/ or Paternal Behavior/ or Social Environment/ or Environment Design/ or Attitude to Health/ or "Social Determinants of Health"/ or Culture/ or Motivation/ or Self Efficacy/
	8	(countr* or socioeconomic* or sociodemographic* or deprivation or gender or sex or age or time of day or parent* physical activit* or environment or environment* factor* or determinant* or correlat* or factor* or predict* or associat* or interaction* or influence* or temperament or belief* or attitude* or knowledge or perception* or view* or intention* or motivation or self-efficacy or facilitator* or barrier* or experience* or prevent* or reduc* or increas* or promot*).ti,ab,kw.
	9	7 or 8
Systematic reviews and meta-analyses	10	"Review Literature as Topic"/ or Evidence-Based Practice/
	11	((overview$ or review or synthesis or summary or cochrane or analysis) and (reviews or meta-analyses or articles)).ti. or (meta-review or metareview).ti,ab. or ((overview$ or reviews) and (systematic or cochrane)).ti. or (reviews adj2 (meta or published or quality or included or summar$)).ab. or cochrane reviews.ab. or (evidence and (reviews or meta-analyses)).ti.
	12	10 or 11
Correlates and determinants of physical activity and sedentary time preschool-aged children	13	3 and 6 and 9 and 12

Appendix 2: Summary of systematic and narrative reviews looking at the correlates and determinants of physical activity and/or sedentary time in preschool-aged children, using the PRISMA guidelines

Title, Protocol and Objectives	Eligibility Criteria, Information Sources and Study Selection	Data Items and Synthesis Methods	Results, Conclusions and Limitations
Bingham et al (2016) Title: Physical Activity During the Early Years: A Systematic Review of Correlates and Determinants Objectives: To synthesize studies investigating potential correlates and determinants of TPA, MVPA, and LPA in children during the early	Inclusion: 1. Observational design; 2. Written in English; 3. Published in a peer-reviewed journal; 4. Explore potential associations between PA as a quantitatively measured outcome variable and independent variable/s; and 5. Have a sample (or subgroup) aged 0–6 years not in statutory/ school education. Information Sources: Web of Science, SCOPUS, SPORTDiscus, PubMed, Cochrane, ProQuest,	Data Items: If more than one instrument measured the same PA outcome in a study, only data from the most valid instrument were included. If validity data were not reported, the result from the most objective method was chosen. If two measures were used for separate outcomes, separate associations were included. Studies that used different PA contexts are highlighted in Appendices of reference. Results taken from bivariate and multivariate analyses were included together and marked accordingly. If potential correlates and determinants of MPA and VPA were reported separately but in the same direction, the results were combined for one overall association with MVPA. This same	Study Selection: 130 papers were included. Flowchart available in Figure 1 in the reference. Study Characteristics: A large number of studies were conducted in the U.S. (n=52, 40%). The age of participants within studies ranged from 0.590 to 5.95 years (mean, 4.3 years). Four studies (3%) investigated potential correlates of PA with infants, 35 (27%) with toddlers, and 92 (70%) with preschoolers. Sample sizes ranged from 2061 to 10,69453 (median, 208). Studies investigated between one and 5179 potential correlates (median, 3). Most studies (n=104, 80%) used objective measurements of PA, including: accelerometers (n=80, six determinant studies), direct observation (n=13, two determinant studies), pedometers (n=7), doubly labelled water (n=2), and heart rate monitoring (n=1). Twenty-four studies (one determinant study) used parental proxy–report. Of the nine high-quality studies, six (67%) used accelerometers, one (11%) used doubly labelled water, one used proxy-report, and one used accelerometer plus proxy-report.

years and investigate potential differences in associations by measurement method	PsycINFO, Embase, and CINAHL Search: Key words relating to behavior(s) (i.e., physical activity, exercise, play, physical fitness, physical inactivity, sedentary, sport, health behavior, motor movement) in conjunction with population (i.e., child, children, kindergarten, preschool, early years, infant, toddler) were used for the search. Authors' bibliographies and papers that had cited the De Craemer et al and Hinkley et al reviews were also searched. Study Selection: One author undertook the initial search of article titles. Two researchers then independently screened the article	process was used to report associations of potential correlates/determinants with TPA: If associations of a variable with LPA, moderate PA, and vigorous PA were reported separately, but in the same direction, the results were combined. If an association was found for one intensity of PA (e.g., vigorous PA) but not the other (e.g., moderate PA), associations were reported separately. Risk of Bias: Two authors independently assessed study quality using criteria adapted from the CONSORT and STROBE statements. A score for each study was completed on a 6-point scale by assigning a value of 0 (absent or insufficiently described) or 1 (present or clearly described) to six questions (see reference). Studies scoring 0–2 were regarded as low quality/high risk of bias; studies scoring 3–4 were considered moderate quality/risk of bias; and studies scoring 5–6 were considered high quality/low risk of bias. Synthesis Methods and Summary Measures: For correlates, if the	Risk of Bias: The intra-class correlation coefficient between the reviewers' quality scores was 0.97. Appendix 2 of the reference outlines the quality score (low, moderate, high) for each study. A total of 122 (93%) adequately described eligibility criteria, 103 (79%) adequately described their process of randomly selecting participants, 25 (19%) adequately described their assessment of PA, and 38 (29%) adequately described their assessment of correlates/determinants. No studies reported the use of a power calculation, whereas 90 (69%) reported the number of participants with complete measures. Nine (6%) studies were identified as high quality, two of which were determinant studies; 78 (60%) were classified as moderate quality of which six were determinant studies; and 43 (33%) were classified as low quality with only one determinant study (Appendix 2 of reference). Results of Individual Studies: Available in Tables 1-3 and Appendices in reference. Synthesis of Results and Summary: Correlates of total PA were sex (male, ++); parental PA (+); parental support (+); and time outdoors (+). Determinants of total PA were sex (+) and time spent playing with parents (+). The only correlate of moderate to vigorous PA was sex (male, ++). No determinants of moderate to vigorous or light PA were found. PA correlates/ determinants were relatively consistent between objective and subjective PA measures.

	abstracts. Any discrepancies between the reviewers were discussed until consensus was achieved. If consensus could not be achieved, further discussion was undertaken with a third reviewer (SEB) to achieve consensus. Data Collection: The above process was repeated when reviewing the full articles. Data extraction was undertaken using standardized forms (see Appendices of reference).	association with PA was tested four or fewer times, no classification was graded. If four or more studies had tested an association, and 0%–33% reported significant associations in a positive/negative direction, the result was categorized as no association (0). If 34%–59% reported significant associations in a consistent direction, the result was categorized as inconsistent (?). If 60%–100% reported a significant association in a consistent direction, the result was coded as (+) for positive or (-) for negative associations. For determinants, a classification was graded even if the potential association was assessed four or fewer times. The following coding procedure was used to incorporate the quality assessment outlined by Costigan et al. and Lubans et al: If 60%–100% of high-quality studies reported consistent findings (positive, negative, or null association), the result was coded as strong evidence in that direction (++,--,00). A potential correlate/determinant was considered a correlate/determinant when a positive or	Limitations: Small number of identified longitudinal studies, with findings largely based on cross-sectional research. Exclusion of non-English publications may in part account for the lack of studies found in low- and middle-income countries. Conclusions: Few studies of potential correlates/determinants of PA in the early years are of high quality. Studies included in the review focused predominantly on demographic/biological and social/cultural correlates and determinants. Future research should focus on: 1. Improved reporting of measurement methods so study quality can be accurately assessed; 2. Longitudinal/prospective studies to assess temporal associations (determinants); 3. Additional ecologic domains relevant for PA early in life (e.g., policies, macroeconomics); and 4. The inter-relationship of constructs within and between domains.

		negative association (+,++,-,--) was found.	
De Craemer et al (2012) Title: Correlates of energy balance-related behaviours in preschool children: a systematic review Objectives: To systematically review the correlates of physical activity, sedentary behaviour and eating behaviour in children between 4 and 6 years-old.	Inclusion: (a) studies that examined correlates or determinants of one of three behaviours: PA, ST or eating behaviour; (b) age range or mean age of children between 4 and 6 years-old, or results for preschoolers extracted separately; and (c) only full text articles, written in English. Exclusion: (a) reviews; (b) non-human studies; (c) studies addressing other behaviours and (d) studies addressing clinical populations. Information Sources: PubMed. The reference sections of the included articles were manually searched, and relevant articles were included. The search was conducted in	Data Items, Synthesis Methods and Summary Measures: The following scoring system was used to evaluate the associations between the correlates and PA: 0 (0-33% of studies supporting association, result was defined as no association); ? (34%-59% of studies supporting an association, indeterminate finding); + or - (60%-100% of studies supporting an association, positive/ negative association); ++, - - or 00 (where four or more studies supported an overall association, the result was coded as positive, negative or no association). The correlates of PA and ST were classified across four domains using the social-ecological framework (i) demographic and biological variables; (ii) behavioural variables; (iii) social and cultural variables and (iv) physical environmental variables. New categories for each behaviour were made: for PA, there was (i) total physical activity; (ii) MVPA; (iii) active transportation combining active transport and walking or cycling more than three times a week	Study Selection: 43 papers were included. Flowchart available in Figure 1 in the reference. Study Characteristics: Study designs included cross-sectional, longitudinal, and intervention. Most of the studies were conducted in the USA and the rest were conducted in Australia, Greece, Belgium, Canada, Scotland, New Zealand, Denmark and Turkey. Studies were published from 1990 onwards. Methods of data collection included parent questionnaires/ survey / diary, accelerometer, pedometer, direct observation and interviews. The sample size varied from 46 to 5652 participants. Risk of Bias: None. Results of Individual Studies: Available in Tables 3-7 in the reference. Synthesis of Results and Summary: <u>Correlates of PA:</u> Fifteen demographic and biological variables were investigated across 20 studies. Four behavioural variables were investigated across seven studies. Twenty-six social and cultural variables were investigated across 12 studies. Forty-seven physical environmental variables were investigated across 15 studies. ≥Four studies: No association between gender, age or equipment with TPA. No association between age or SES with MVPA and boys spent more time in MVPA than girls. ≤Four studies: Please see Tables 3- 5 in the

	August and September 2010. Search: Search strategy available in Table 1 in the reference. Behaviour keywords were combined with age-related keywords and exclusion terms. Study Selection: Titles and abstracts were screened for potential correlates of PA, ST or eating behaviour by the two researchers independently. During a second screening, the remaining papers were read by the same researchers to come to the final selection and these papers were included in the review after deliberation.	and (iv) PA during recess. For ST, the category was named screen viewing activities and was a combination of television viewing, DVD/ video viewing, playing electronic games, computer use and total media time.	reference for the associations between correlates and TPA, MVPA and active transport/ PA during recess respectively. Correlates of ST: Twelve demographic and biological variables of screen viewing in preschool children were investigated across 13 studies. Ten behavioural variables were investigated across six studies. Twelve social and cultural variables were investigated across six studies. Seven physical environmental variables were investigated across eight studies. ≥Four studies: No association between gender or family conflict and ST. ≤Four studies: Please see Table 6 in the reference for the associations between correlates and ST. Limitations: Small number of studies and stratification of gender and behaviours producing different results. Conclusions: Strategies aiming to influence EBRBs in 4–6 year-olds should target both boys and girls, all ethnic groups and parents of both low and high SES. On weekdays, there should be a focus on maintaining PA levels and decreasing ST levels. On weekends, the focus should be on increasing PA levels. Future studies should investigate similar correlates of PA, ST and eating behaviour. Future research should also be on interventions to predict whether interventions targeting these correlates will have an impact.
Hesketh et al (2017)	Inclusion: (a) Longitudinal observational study, RCT or controlled trial (CT); (b) quantified a within child	Data Items: First author; publication year; country; study design, setting and population; baseline descriptive characteristics; PA measurement and	Study Selection: 44 papers were included. Flowchart available in Figure 1 in the reference.

Title: Determinants of Change in Physical Activity in Children 0–6 years of Age: A Systematic Review of Quantitative Literature Protocol: Protocol for systematic reviews of determinants/ correlates of obesity related dietary and physical activity behaviors in young children (preschool 0 to 6 years): evidence mapping and syntheses. Prospective Register for Systematic Reviews	change in PA behaviour (as primary/ secondary outcome in interventions); (c) assessed at least one potential determinant of change; (d) children aged between 0-6 years at baseline; (e) studies assessing PA using objective or subjective measures; (f) any language; (g) published full texts. Exclusion: (a) Clinical populations; (b) non-human studies; (c) quantitative cross-sectional studies; (d) qualitative studies; and (e) laboratory-based studies. Information Sources: MEDLINE, Embase (via OVID), CINAHL, PsycINFO (via EBSCO), Web of Knowledge (via Thomson Reuters), British Nursing Index (BNI), Applied Social Sciences	outcome; potential determinants; method of analysis; duration of follow up; loss to follow up; and results. When more than one PA intensity reported they reported TPA/ counts per epoch followed by MVPA, LPA and MPA/ VPA. In some studies PA was only assessed during specific periods. Elements targeted in the interventional studies were extracted as potential determinants of change in PA; including sub samples and stratifications (largest time period when stratified by time of day). Differences for longitudinal studies, the latest data available before the children were 6 years-old were included. Where possible, results of multivariable rather than univariable models were included. Risk of Bias: Adapted critical appraisal assessment criteria found in Electronic Supplementary Material Table S2 in the reference. Criteria included: sample representativeness; size and retention; use of objective exposure and outcome measures; appropriateness of analysis strategy; and RCT randomisation method. Scores out of 6 (7 for RCTs) were	Study Characteristics: Study characteristics available in Tables 1-3 in the reference. 44 papers included for review (42 study samples: four prospective cohort and 38 intervention studies). Apart from one, all papers were published after 2003. Study samples originated in the USA, Australasia and Europe. Measures of PA included accelerometers, pedometers, heart-rate/Actiheart and proxy-report measures. Measurement period (from baseline to last contact) was a median of 2.5 years for prospective papers and 34.5 weeks for interventional papers. Risk of Bias: One prospective paper and 26 interventional papers (61%) were deemed to be of high quality, nine were of medium quality and six were low quality. Of the interventional studies, 28 (64%) randomised participants. Most study samples consisted of predominately White populations. A retention rate of 70% was reported in 20 papers (46%), and 27 interventional studies reported final analysis samples by study group, indicating similar levels of attrition. Results of Individual Studies and Synthesis of Results: Provided in Table 4 in the reference. Synthesis of Results and Summary: 44 potential determinants of change were reported. The 38 interventional studies targeted 28 potential (modifiable) determinants at intrapersonal (n = 6), interpersonal (n = 10), organisational (n = 10) and community levels (n = 1). No determinants at the policy level were identified across included studies. ≥Four studies: Parental monitoring was

(PROSPERO) registration number: CRD42012002881. Objectives: Synthesise quantitative literature from prospective and interventional studies to ascertain the determinants of change in PA in young children. Establish which modifiable determinants are associated with change and at which levels of the social-ecological model these factors operate. Identify where gaps in the	Index and Abstracts (ASSIA) and Sociological Abstracts (via ProQuest). Contacted experts to identify key publications to be included for each behaviour. Searches conducted in August 2012 and October 2015. Search: Search strategy available in Electronic Supplementary Material Table S1 in the reference. Study Selection: Titles and abstracts were screened by the three review leads and a forth reviewer checked for fidelity. Two random 5% samples were double screened by two additional reviewers. Additional texts retrieved in 2015 were screened by the review lead and a 15% subsample was reviewed by a second reviewer.	categorised as (high quality: ≥5; medium: 3–4; low: 1–2). Synthesis Methods and Summary Measures: Narrative data synthesis was undertaken. Determinants were scored as follows: '-' significant decrease in PA, '0' no significant association/ effect or '+' significant increase in PA. Evidence from cohort and interventional studies was weighted equally. Consistency across studies was coded as follows: '0' (no association) supported by 0–33% of individual studies; '?' (indeterminate/ possible) supported by 34–59%; and '?' or '-' supported by 60–100%. Where ≥four studies reported on a potential determinant, double indicators were used (e.g. '00', '??', '??' and '-'). Determinants, study score and consistency across studies were presented according to the social-ecological model.	positively associated with change in young children's PA. Provider training was positively associated with MVPA but no association with overall PA. Sex, motor skill training, parental goal setting, parental social support and increased time for PA showed no consistent associations. Child knowledge, parental knowledge, parenting skills, parental motivation, parental self-efficacy, curriculum materials and portable equipment showed no association. <Four studies: Child monitoring, parental role-modelling, maternal role modelling, increasing the number of care providers within the childcare setting, additional opportunities for play within the home, sibling co-participation, structured physical activity, lowering playground density were positively associated. Community awareness showed no association. Limitations: Publication bias due to restriction to published studies. Variability in studies (e.g. measures of PA, accelerometer cut-points and covariates in regression models). All the studies were conducted in high-income countries and about half had sample sizes n<50. Meta-analyses were not possible due to the variation in outcome measures. Conclusions: The review identified a range of predominantly interpersonal and organisational determinants of change in young children's PA. Only parental monitoring of their child's PA emerged as a consistently positive determinant of change and provider training was positively associated with change in MVPA. Maternal role modelling was also positively associated with change in all three studies in which it was examined. Future work

literature exist for future research.	Data Collection: Data was extracted by the two reviewers using a standardised form.		should investigate lesser-explored or overlooked modifiable family- and childcare-related determinants; explore how determinants influence physical activity throughout the day and week; and deconstruct how the multiple elements within an intervention result in positive behaviour change. Assessment of determinants in the community and policy domains, in addition to studies conducted in developing countries, is also required.
Hinkley et al (2008) Title: Preschool children and physical activity: a review of correlates Objectives: To investigate the correlates of preschool children's physical activity, to be grouped according to the five domains of the social-ecological model. Identify where	Inclusion: (a) contained quantitative research and had been published in an English-language, peer reviewed journal; (b) children aged 2–5 who had not commenced formal schooling; (c) included a measure of PA as the dependent outcome; (d) examined associations between PA and other variables. Exclusion: Intervention studies and studies that measured PA as the independent variable were not included unless they reported associations between PA and other variables.	Data Items: If a study reported more than one measure of PA, the most objective or inclusive measure was used. It was noted when studies reported on associations with PA of different intensities, or in different environments. The results from baseline measures only (when children aged 2–5) are included. For studies that used two objective measures of PA - usually observation and accelerometry, heart-rate monitoring, or pedometry – a combined result was reported when results from both methods were the same. The results from different measures were reported separately with appropriate notation. Results from multivariate models are included in the analyses. Synthesis Methods and Summary Measures: The following scoring system	Study Selection: 24 studies were included. Study Characteristics: Study characteristics available in Appendix A in the reference. Articles published between 1980 and March 2007. Mean sample size of 391 (30 - 3141). Most of the studies were conducted in the USA while the rest were conducted in Scotland, Sweden, Finland and Germany. One study used the theoretical model to guide the research. Risk of Bias: None. Results of Individual Studies: Table 2 in the reference indicates whether the study found that the determinant was related or unrelated to physical activity. Synthesis of Results and Summary: 39 correlates were identified. Boys were more active than girls, children with active parents were more active and that children who spent more time outdoors were more active than children who spent less time outdoors. Time spent in play spaces/outdoors and specific preschool attended were positively associated with PA. An indeterminate

gaps in the literature exist for future research.	Information Sources: MEDLINE, PubMed, CINAHL, SPORTDISCUS, PsycINFO, Health Source (nursing/ academic edition), and Sociological Abstracts. Bibliographies of retrieved articles and authors' personal collections were also searched. Data were collected and analysed in 2007. Search: Each key term (physical activity, exercise, health behaviour, play, physical inactivity and physical fitness) was searched in conjunction with each term in this group: child, kindergarten, childcare, preschool.	was used to evaluate the associations between the correlates and PA: 0 (0-33% of studies supporting association, result was defined as no association); ? (34%-59% of studies supporting an association, indeterminate finding); + or - (60%-100% of studies supporting an association, positive/negative association); ++, - - or 00 (where four or more studies supported an overall association, the result was coded as positive, negative or no association).	association was observed between TV viewing/ST and weather conditions with PA. No association was observed between age, BMI or parental encouragement with preschool children's PA. Other variables produced largely inconclusive results having not been assessed in many of studies to be able to draw conclusions. Limitations: Limited number of studies investigating some of the variables to be able to draw conclusions. Included studies generally consisted of small non-representative samples and were cross-sectional in design. Measurement and analysis tools may not have been sensitive enough to detect significant associations in the small study samples. Seven studies did not report reliability or validity of PA measurement tools. Conclusions: Boys are more active than girls; the children of parents who participate in physical activity with them are more active than the children of parents who do not participate; and children who spend more time in outdoor play spaces are more active than children who spend less time outdoors. Studies need to be conducted in different cultural, social and physical environments outside of the USA. Future studies need to consider the consistency in measurement of correlates and need to investigate multiple variables across multiple domains. The collection of PA data across a range of times, locations and contexts, using instruments validated in the preschool population, in larger sample sizes is needed.

Hinkley et al (2010) Title: Correlates of sedentary behaviours in preschool children: a review Objectives: To review the correlates of preschool children's sedentary behaviour, to be grouped according to the five domains of the social-ecological model. Identify where gaps in the literature exist for future research.	Inclusion: (a) children aged three to five years; (b) contained quantitative research and published in an English language, peer reviewed journal; (c) included a measure of ST as a dependent outcome; and (d) examined associations between explanatory variables and ST. Information Sources: Medline, Pubmed, ERIC, Australian Education Index, PsycINFO, Current Contents, Social Science Index, SportsDiscus, Child Development Abstracts, and Health Reference Center - Academic. Manual searches of the reference lists of recovered articles and the authors' extensive personal files were also conducted. Data were collected and	Data Items: Overall ST (generally measured by accelerometry), television viewing, DVD/ video viewing, electronic games, computer use and reading (measured by parental report). Results have been reported separately for individual behavioural outcomes to determine if correlates vary between behaviours. Synthesis Methods and Summary Measures: The following scoring system was used to evaluate the associations between the correlates and ST: 0 (0-33% of studies supporting association, result was defined as no association); ? (34% 59% of studies supporting an association, indeterminate finding); + or - (60%-100% of studies supporting an association, positive/ negative association); ++, - - or 00 (where four or more studies supported an overall association, the result was coded as positive, negative or no association).	Study Selection: 29 studies were included. Study Characteristics: Study characteristics available in Electronic supplementary material in the reference: Additional file 1. Studies published between 2002 and 2009. The studies used a variety of methods for data collection including accelerometry, parental checklist, parental time use diary, parental survey, direct observation, parent survey and accelerometry and combined heart rate and observation. Most of the studies were conducted in the USA and the remaining studies were conducted in Australia, Scotland, Germany, New Zealand, Greece and Belgium. Risk of Bias: Most studies failed to report reliability or validity results for their ST measures. Synthesis of Results and Summary: 63 potential correlates of ST were identified and categorised into four of the five domains of the social-ecologic model (no psychological, cognitive or emotional variables were identified). Television viewing was the most commonly examined ST. Child's gender had an indeterminate association with ST as measured by accelerometry and was not associated with television viewing. Outdoor playtime and variables identified as physical environmental variables were generally not associated with ST. The remaining potential correlates either found indeterminate associations or had not been assessed in many studies (less than four studies) therefore it was not possible to draw conclusions about associations.

	analysed between March 2008 and September 2009. Search: Each key term (television viewing, ST and PA) was searched in conjunction with each term in this group: early childhood; preschool; child; and kindergarten, childcare.		Limitations: Most included studies: were cross-sectional; had small non-representative sample sizes; and used various, proxy-report and/or less reliable data collection techniques. There was little consistency between studies in the variables examined within specific settings. Potential correlates such as SES, growth and maturation of the child (except for age), parental influences, social and physical environmental influences in preschools and childcare centres are under-researched. Conclusions: There is a lack of literature on correlates of ST and existing evidence is largely inconclusive. Sex and outdoor playtime were shown to have no association with television viewing, and sex had no association with overall ST. Recommend future studies to: look at potential influences across different settings/contexts to understand the multi-dimensionality of influences; use reliable and valid measures; look at different times of the day; and look at ST as the primary outcome.
Li et al (2015) Title: Determinants of Physical Activity during Early Childhood: A Systematic Review Objectives: To better identify the	Inclusion (to be screened): (a) Used a quantitative research design published in an English peer-review journal; (b) children between 2 and 6 years; (c) included any form of PA as the dependent variable; and (d) investigated the association between any biopsychosocial factor and	Risk of Bias: Two authors independently reviewed all included studies. 10-item checklist, which was specifically modified for prospective studies, spanning four domains: study attrition and follow up duration, assessment of determinants, assessment of outcome measures and data analyses. Two authors independently reviewed all included studies. A third author was consulted if both raters failed to reach a	Study Selection: Nine studies were included. Flowchart available in Figure 1 in the reference. Study characteristics: Study characteristics available in Table 2 in the reference. Eight studies were conducted between 2003 and 2013 and the other study was published prior to 2000. Six studies used accelerometers, one used pedometers, one used the actometer and one used heart rate telemetry. Sample size for the studies ranged from 17 to 314, with only three studies having fewer than 100 participants. On average, the studies followed participants over an 18-month period where two had a follow-up period of less

predictors of physical activity in preschool children using the following inclusion criteria of studies which: 1) used a prospective or longitudinal design; and 2) used objective measures of physical activity.	PA. Inclusion (in the review): (a) used objective measures of PA (i.e. accelerometers, pedometers); and (b) used longitudinal or prospective study designs (defined as having one or more follow-up periods where physical activity was assessed at least twice during the early years when the children were between the ages of 2 and 6). Information Sources: PubMed, SPORTdiscus, CINAHL and PsycINFO. References were checked, and targeted searches of all first authors were conducted. Search: Physical activity, determinant, correlate and preschool(er).	consensus. A score of "1" was given if the study met the specific criterion in each domain. If multiple determinants or correlates were measured, the score was calculated by dividing the number of reliable/ valid tools by the total number of tools used. A score of 0 indicated that the study failed to meet the criterion, and a question mark (?) indicated that the criterion was either unknown or not mentioned in the manuscript. The quality score is presented as the percentage of the sum of all ten item scores assessed, with higher scores indicating higher study quality. Using the cut-off point suggested, a score of <70% was considered low quality.	than 12 months. The studies were conducted in Europe (n = 4, 44.4%), North America (n = 4, 44.4%) and the Pacific region (n = 1, 11.1%). Risk of Bias: Scores can be found in Table 1 in the reference. Six high quality and three low quality studies. The reason for a low-quality assessment was primarily due to low response rates (<80%), and the lack of follow-up participation (<80%) or reporting insufficient information to calculate follow-up rates. Results of Individual Studies: Found in Table 2 in the reference. Synthesis of Results and Summary: 19 variables were identified. Aging (PA over time), gender, seasonality, parental behaviours and weight status were there five most common variables examine which the authors summarised in the results section. Limitations: Limited number of prospective or longitudinal physical activity studies using objective measures of PA among preschool aged children. Included studies were drawn from a convenience sample which affects generalizability and sample bias. None of the included studies explicitly state a theoretical framework that the determinants examined were based upon. Conclusions: Overall, environmental context such as parental behaviours and weather/ season appear to be factors that impact young children's PA behaviours. However, as the limited number of studies included in the current review, these findings must be

	Study Selection: Two authors independently conducted the initial search, examining titles and abstracts of identified studies. The reviewers compared studies identified to be potentially relevant for inclusion and a third author was consulted if consensus between the reviewers was not achieved.		interpreted with caution. Future research must repeatedly assess potentially time-varying (e.g. weather; parental behaviours) determinants of PA in children. More longitudinal research using objective assessments of preschoolers' PA, grounded in theory is needed. Future research must continue to investigate environmental contextual factors further. No studies to date have examined how interacting biopsychosocial (social and environmental) factors influence young children's PA.

Appendix 3: Average daily minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity by the 10 different correlates

Correlate	**N**	**Wear Time**		**Sedentary Time**		**Total Physical Activity**		**Moderate-to-Vigorous Physical Activity**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Overall	1052	697.27	70.18	490.18	72.33	207.08	51.97	87.33	34.09
Age									
3	343	696.34	72.37	492.10	74.18	204.23	54.24	85.20	35.82
4	709	697.71	69.14	489.25	71.45	208.46	50.82	88.36	33.19
Gender									
Male	528	699.57	70.46	482.89	73.40	216.68	52.36	94.90	35.37
Female	524	694.94	69.89	497.53	70.54	197.41	49.79	79.70	30.96
Country									
UK	426	660.05	54.92	454.21	65.13	205.84	51.58	85.42	32.06
Switzerland	142	703.97	63.24	501.78	69.96	202.19	44.77	80.14	27.22
Belgium	104	688.71	55.08	509.16	55.27	179.54	51.30	65.45	32.07

USA	380	738.82	68.10	520.97	67.41	217.85	52.07	98.13	35.25
Season									
Winter	136	704.25	74.07	507.03	63.18	197.22	53.52	80.96	35.88
Spring	110	727.96	68.44	512.26	66.62	215.70	58.45	90.60	41.96
Summer	117	719.82	57.91	502.55	61.64	217.27	44.52	95.79	29.55
Autumn	689	687.16	69.21	481.22	74.99	205.93	51.37	86.62	32.77
Ethnicity									
White	200	705.28	67.01	500.29	63.97	204.98	50.30	87.20	31.52
Other	219	752.72	69.08	530.27	69.66	222.45	54.12	102.72	37.96
Parental Education									
Up to and including completion of compulsory vocational training	86	744.30	74.22	511.20	71.47	233.10	50.32	105.95	33.17
Any post-compulsory education including vocational training	300	733.59	65.28	520.94	66.48	212.65	51.59	95.19	35.19
Weekday vs Weekend									
Weekday	1052	704.92	70.45	497.50	72.82	207.42	53.34	87.28	34.90
Weekend	626	652.92	86.97	452.40	93.93	200.52	64.36	81.42	39.12

Time of Sunrise									
Before 07:00	433	707.30	66.75	489.83	73.49	217.47	48.18	93.83	30.92
After 07:00	619	690.24	71.70	490.42	71.56	199.82	53.31	82.78	35.46
Time of Sunset									
Before 19:00	548	688.79	68.74	490.55	67.56	198.23	50.00	81.74	32.42
After 19:00	504	706.48	70.64	489.77	77.24	216.71	52.41	93.40	34.84
Length of Day									
Less than 12 hours	589	690.47	70.27	489.79	69.04	200.68	51.72	83.22	33.88
More than 12 hours	463	705.90	69.17	490.67	76.38	215.23	51.20	92.55	33.67

Note: SD: Standard Deviation

Appendix 4: Multi-level unadjusted associations between potential correlates and average daily minutes spent in sedentary time, total physical activity and moderate-to-vigorous physical activity in children aged 3-4-years-old

Correlate (reference category)	N	Sedentary Time					Total Physical Activity					Moderate-to-Vigorous Physical Activity				
		β	**(95% CI)**	***p***	**ICC**	**R^2**	**β**	**(95% CI)**	***p***	**ICC**	**R^2**	**β**	**(95% CI)**	***p***	**ICC**	**R^2**
Age (3-years)	1052	1.20	(-7.65, 10.05)	0.790	0.119	-0.001	6.60	(-0.20, 13.40)	0.057	0.098	0.028	6.42	(2.06, 10.78)	0.004	0.122	0.001
Gender (Male)	1052	14.43	(6.52, 22.35)	<0.001	0.121	-0.004	-19.39	(-25.41, -13.37)	<0.001	0.098	0.058	-15.58	(-19.41, -11.76)	<0.001	0.123	0.039
Country (UK)	1052				0.000	0.890				0.017	0.739				0.009	0.834
Switzerland		47.57	(35.11, 60.04)	<0.001			3.23	(-15.89, 22.35)	0.741			-2.23	(-12.21, 7.75)	0.661		
Belgium		54.95	(40.88, 69.02)	<0.001			-19.42	(-39.19, 0.35)	0.054			-16.92	(-27.41, -6.43)	0.002		
USA		66.76	(57.68, 75.83)	<0.001			21.57	(4.80, 38.33)	0.012			15.69	(7.05, 24.34)	<0.001		
Season (Winter)	1052				0.133	-0.118				0.123	-0.208				0.120	0.018
Spring		-3.18	(-20.40, 14.04)	0.717			19.26	(6.07, 32.44)	0.004			10.73	(2.24, 19.23)	0.013		
Summer		-10.76	(-28.73, 7.20)	0.240			10.76	(-2.99, 24.51)	0.125			10.96	(2.10, 19.82)	0.015		

Autumn		5.19	(-9.46, 19.85)	0.487			-1.30	(-12.51, 9.92)	0.821			3.16	(-4.06, 10.38)	0.391		
Ethnicity (White)	419	22.86	(9.39, 36.33)	0.001	0.058	0.356	14.03	(3.47, 24.58)	0.009	0.126	0.099	12.18	(5.12, 19.23)	0.001	0.094	0.247
Parental Education (Up to/including compulsory education)	386	8.96	(-7.18, 25.10)	0.277	0.019	0.032	-20.45	(-32.72, -8.18)	0.001	0.000	0.027	-10.76	(-19.07, -2.45)	0.011	0.000	0.016
Weekday vs Weekend (Weekday)	1678	-32.75	(-40.85, -24.65)	<0.001	0.088	0.180	-3.46	(-9.42, 2.49)	0.254	0.109	0.013	-1.53	(-5.25, 2.19)	0.421	0.120	0.016
Time of Sunrise (Before 07:00)	1052	14.69	(6.04, 23.35)	0.001	0.135	-0.127	-14.19	(-20.81, -7.57)	<0.001	0.068	0.312	-7.79	(-12.06, -3.51)	<0.001	0.097	0.201
Time of Sunset (Before 19:00)	1052	-10.02	(-19.10, -0.94)	0.031	0.128	-0.072	18.47	(11.58, 25.35)	<0.001	0.086	0.160	11.55	(7.10, 15.99)	<0.001	0.109	0.123
Length of Day (Less than 12 hours)	1052	-8.89	(-18.07, 0.28)	0.057	0.126	-0.060	14.76	(7.76, 21.75)	<0.001	0.090	0.110	9.72	(5.21, 14.22)	<0.001	0.113	0.080

Note: CI: Confidence Interval, ICC: Intraclass Correlation Coefficient. All models are adjusted for study clustering effects.

Appendix 5: Email, social media and poster study invitations for parents of 2-4-year-olds

Subject Line: Parents and carers of 2-4-year-olds needed for University of Bristol research study

Dear Sir/Madam

Do you have or look after children aged 2-4-years-old?

We are writing to invite you to take part in a new research study involving parents and carers of children aged 2-4-years-old across the South West of England. We would like to talk to you to explore your views on how we can get preschool aged children to move more and sit still less.

We would like to chat to you for about 30 minutes over the phone. Participants in the study will receive a **£10 Love2shop voucher** to thank you for your time.

If you have any further questions about the study or are interested in taking part, you can email Kaiseree Dias at **kaiseree.dias@bristol.ac.uk** or phone her on **+44 (0)1173 310076**. We look forward to hearing from you.

Yours sincerely,

[redacted]

Miss Kaiseree Dias

GW4 BioMed MRC PhD Student

***** Parents and carers of 2-4-year-olds needed for University of Bristol research study *****

We are a team of researchers who want to talk to parents and caregivers across the South West of England to explore your views on how we can get preschool aged children to move more and sit still less. We would like to chat to you for about 30 minutes over the phone. You will receive a **£10 Love2shop voucher** to thank you for your time.

If you have any further questions about the study or are interested in taking part, you can email Miss Kaiseree Dias at **kaiseree.dias@bristol.ac.uk** or phone her on **+44 (0)1173 310076**. We look forward to hearing from you.

Do you have or look after children aged 2-4-years-old?

Why not take part in a research study?

We are a team of researchers who want to talk to parents and caregivers across the South West of England to explore your views on how we can get preschool aged children to move more and sit still less!

30-minute chat

over the phone

GW4 BioMed Doctoral Training Partnership | University of Bristol | MRC Medical Research Council

Participant Information Sheet

A qualitative examination of caregivers' perspectives on increasing physical activity and decreasing sedentary time in preschool aged children

We are a team of researchers from the University of Bristol who want to talk to parents and caregivers about ways in which we could increase physical activity (active play and movement) levels and decrease sedentary (sitting) time in preschool aged children. Before you decide whether you want to take part, please read this information carefully. If you have any further questions please contact the researcher, Kaiseree Dias (contact details at the end) and she can tell you more about the study.

What is the purpose of the study?

The study is looking at the views of parents and caregivers of children aged 2-4-years-old on what helps and prevents them from increasing children's physical activity (active play and movement) levels and decreasing children's sedentary (sitting) time. We want to find out your views to help design future programmes which aim to increase physical activity (active play and movement) levels and decrease sedentary (sitting) time in preschool aged children.

Why have I been invited to take part in the study?

You are being invited to take part because you responded to an advert for the study and identify as a parent or caregiver of children aged between 2-4-years-old.

Do I have to take part?

It is your choice whether you wish to take part in the study or not.

What will happen to me if I take part and what will I have to do?

If you wish to take part in the study, you can contact Kaiseree Dias (see details at the end) to ask any further questions and to arrange a convenient date and time to conduct a telephone interview. The interview will last about 30 minutes and will be audio-recorded using an encrypted device. Before we start recording the interview, Kaiseree will ask you to confirm that you agree with the statements in the attached **Parent and caregiver participant consent form** dated 17.05.19 and she will complete the form on your behalf.

The recording will then be typed up so that we can remember what was said. After this, the audio-recording will be deleted and the typed-up copy will be anonymised, therefore you will not be identifiable. With your permission, anonymous quotes from the interviews may be published. If you wish, we will email you a summary of the main findings.

Reimbursement

You will receive a **£10 Love2shop** voucher to thank you for your time.

What will happen if I don't want to carry on with the study?

If you do decide to take part in the study, you are free to stop taking part at any time without giving a reason. If you conduct the interview and decide that you no longer wish to take part of the study, you have two weeks after the interview to inform the study team and we will delete any information relating to you.

Will my taking part in this study be kept confidential?

All information which is collected about you will be kept strictly confidential, and any information about you will have your name and address removed so that you cannot be recognised. Anonymised data will be stored in line with the General Data Protection Regulations (GDPR) 2018. More information about the University of Bristol's confidentiality policy can be found at the following link: http://www.bristol.ac.uk/secretary/data-protection/. Anonymised data from the study may be seen and used by other researchers, for ethically approved research projects, on the understanding that confidentiality will be maintained.

What will happen to the results of the research study?

The findings of the study will be published in a peer-reviewed journal and presented at relevant conferences. You will be emailed a summary of the main findings if you wish. You will not be identified in any publication or presentation.

What are the possible benefits of taking part?

We cannot promise the study will help you but the information we get from this study will help inform the design of programmes which aim to increase physical activity (active play and movement) and decrease sedentary (sitting) time in preschool aged children in the future.

What are the possible disadvantages and risks of taking part?

There are no risks associated with taking part in this study.

Who is organising and funding the research?

This work is supported by grant MR/N0137941/1 for the GW4 BIOMED DTP, awarded to the Universities of Bath, Bristol, Cardiff and Exeter from the Medical Research Council (MRC)/UKRI.

Who has reviewed the study?

This project has been reviewed and approved by the University of Bristol Faculty of Health Sciences Research Ethics Committee.

Contact details

Miss Kaiseree Dias will contact you in one week to talk to you about the study. If you would like to speak to Kaiseree sooner to ask any further questions or to arrange a convenient date and time to arrange a telephone interview, you can email her at **kaiseree.dias@bristol.ac.uk** or phone her on **+44 (0)1173 310076**.

If participants have any concerns about the study or wish to make a complaint to an independent party, they can email research-governance@bristol.ac.uk.

Thank you for taking the time to read this information

Appendix 7: Consent form for parents of 2-4-year-old children taking part in telephone interviews

Consent Form

A qualitative examination of caregivers' perspectives on increasing physical activity and decreasing sedentary time in preschool aged children

Principal Researchers: Kaiseree Dias, Ruth Kipping, Russell Jago and James White

Before we start recording your telephone interview, Kaiseree will ask you to confirm that you agree with the following statements and she will complete the form on your behalf

	Please initial box e.g. AB
I confirm that I have read and understand the **Parent and caregiver participant information sheet** dated 17.05.19 for the above study. I have had the opportunity to consider the information and I am aware that I can ask questions at any time.	
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.	
I understand that the study involves an in-depth interview. My interview will be recorded and the transcripts professionally transcribed.	
I give permission for the researchers to use anonymous quotes from these transcripts and written timelines in their report and/or publications and teaching materials from the research.	
I understand that after the study the data collected will be made "controlled data". I understand that this means the anonymised data will be available to other researchers who secure the necessary approvals. I understand that this means that the data may be used for purposes not related to the study, but it will not be possible to identify me from these data.	
I agree to take part in the above study.	

To be completed by the researcher

Name of contact (title, forename, surname)……………………………………………………………….

Date of telephone interview………………………………………………………………………...

Researcher taking consent…………………………………………………………………………

Signature…………………………………….…
Date…………………………………………

Interview Topic Guide

A qualitative examination of caregivers' perspectives on increasing physical activity and decreasing sedentary time in preschool aged children

Equipment

- *Encrypted audio-recorder (Olympus Digital Voice Recorder DS-3400)*
- *Telephone device (Olympus TP8)*
- *Spare batteries*
- *Pens*
- *Consent form*
- *Paper*
- *Post-it notes*
- *£10 Love2shop voucher*
- *Envelopes*
- *Stamps*

Introduction

- **Hello X, it's Kaiseree from the University of Bristol speaking, how are you doing? Are you still ok to chat to be for about half an hour?**
- **Thank you so much for sparing your time to speak to me today.**
- **So before starting the interview, I'm going to talk a bit about the study which is a part of my PhD. I'm then going to take your consent and ask a couple of background questions.**
- **So firstly just to give a bit of background of the study, we want to find out what sort of activities your 2-4-year-old children/or children in your care do when they're moving around or sat still and we want to explore your views on how we can get children to move more and stay still less.**
- **Feel free to ask questions at any time.**
- **There are no wrong or right answers and you don't have to answer all of the questions if you don't want to.**
- **Anything that you tell me is confidential and will not be linked to you. The only reason for me needing to break confidentiality would be if you say something where I am concerned about harm to you or someone else.**
- **You can stop at any time and if you decide in the next two weeks that you don't want me to include what you said, just let me know.**
- **So I've already sent you a copy of the consent form along with the participant information sheet. I'm just going to read out each statement on the consent form one by one and if you could let me know whether**

you're happy with them I will sign it for you. Really sorry that this seems a bit formal and lengthy but it's something we have to do as part of the University ethics regulations.

- **Thank you, after I start recording the interview, it might seem a bit strange but I will just ask you to reconfirm on the recording that you're happy to do the interview.**
- **I haven't started recording yet, before that I just wanted to ask you some background questions to tailor the questions to you.**
    1. **How many children do you have/care for and what are their ages and are they boys or girls?**
    2. **What is your relationship to the children i.e. are you the parent, caregiver etc?**
    3. **Who else lives in the home?**
    4. **Can I just ask, is your 2-4-year old able to walk by themselves? At what age did they start walking?**
- **Thank you for answering those questions. Do you have any further questions before starting the interview? If it's ok, I will start recording now.**

START RECORDING

Before I start asking you some questions, I just want you to reconfirm that you are happy to do this interview.

Questions

I am now going to ask some questions about your child(ren) who are aged 2-4-years old/the 2-4-year old child(ren) in your care in terms of the activities they do when they're moving around or sat still. By moving around, I mean anything from: (LPA) Pottering (e.g. Lego/Duplo, cooking or baking, helping around the house, small-world play, dressing up); (MPA) On the Go: (e.g. playing in the garden, dancing, hide and seek, playing on the furniture, rough and tumble, balloons & bubbles); and (VPA) Huff and Puff: (e.g. running games, trampolining, scooting, dancing, obstacle courses). I may refer to unstructured activities where the child is free to do what they want (such as playing, scooting, going to the park/soft play centres) and structured activities which usually involve an instructor who leads the session (such as swimming lessons, sports or dance classes). Activities which involve being still may include (e.g. reading, watching television, drawing, using a tablet or mobile phone, board games) even if your child is fidgeting or restless when doing these activities. We will also be exploring ways in which you think we could get children aged 2-4-years old to move more and stay still less.

Children's activities across a typical day

1. If you were to describe a typical day, what sort of activities are your 2-4-year old(s) child(ren)/the 2-4-year old(s) child(ren) in your care doing when they are pottering, on the go or huffing and puffing?

Probe: Unstructured (e.g. playing, scooting, going to the playground etc) or structured activities (e.g. swimming lessons, sports, dance lessons etc)? What sort of activities do they do at home, outdoors or at other settings (e.g. nursery)?

2. In a typical day, what sort of activities are they doing when they are sat still?
   Probe: Watching tv, painting etc. What sort of activities do they do at home, outdoors or at other settings (e.g. nursery)?

Outdoor play

3. [Refer to previously mentioned outdoor play if applicable] In terms of playing outdoors, what sort of places do(es) your child(ren)/the child(ren) in your care play?
   Probe: Playgrounds/parks, garden, front of the house etc.

   a. Do you have many playgrounds/parks near where you live? Is there anything that makes or stops your children from playing outside more often?
      Probe: Playgrounds, parks, gardens, front of the house etc more often?

Variation in children's activities by day of the week and time of year

4. Are there any differences in the types of activities that they do on a weekday compared to the weekend? Are there any differences in the types of activities that they do during different times of the year?
   Probe: Unstructured (e.g. playing, scooting, going to the playground etc), structured activities (e.g. swimming lessons, sports, dance lessons etc), staying still (e.g. watching tv, painting etc.)? Why is that?

   a. What would help you get the children to move more and stay still less on the (weekday/weekend)?

   b. What would help you get the children to move more and stay still less in (different times of the year)?

Child's influence

5. How much of an influence does your 2-4-year old child(ren)/the 2-4-year old child(ren) in your care have in terms of deciding whether they move around or stay still?
   Probe: Is it their decision what they do? Unstructured, structured or still activities?

Other children's' influence

6. Does having other children around impact on the amount of time your 2-4-year old(s)/the 2-4-year old(s) in your care spend(s) moving around and staying still?

   Probe: Siblings, stepbrothers/sisters, family, friends, friend's children etc. If so in what way? Unstructured, structured or still activities?

   a. What helps or prevents your child(ren)'s/the child(ren) in your care's from being around children more often?

Parent's activities across a typical day

7. What sort of things do you do when you're moving around yourself in a typical day? Do you have any hobbies which involve staying still?

   Probe: Both unstructured and structured (e.g. cycling, housework, sports, classes, etc)? Hobbies (e.g. watching tv, painting etc)?

8. [If there is more than one person living in the house] What sort of things do other adults in the household do when you're moving around on a typical day? Do they have any hobbies which involve staying still?

   Probe: Both unstructured and structured (e.g. cycling, housework, sports, classes, etc)? Hobbies (e.g. watching tv, painting etc)?

Parent/caregiver's influence

9. What do you think about your role as a parent/caregiver in terms of influencing what activities your child(ren)'s/the child(ren)'s do when they're moving around or staying still?

   Probe: Do you think you play a small or large role? How important is it to you?

   a. [If there is more than one person living in the house] Who do you think has more of an influence on your child(ren)'s/the child(ren) in your care's participation in activities? Why do[es] you/[the other person] have more of an influence and in what circumstances?

   b. What would help [the other person]/you to get your child(ren)/the child(ren) in your care to move more and stay still less?

Instructors' influence

10. [If participation in structured physical activity opportunities mentioned] Is there an instructor for the X lesson(s) you mentioned? Do you think the role of the person delivering the [session(s)] i.e. the instructor (e.g. football coach, dance instructor etc) is important in terms of getting the 2-4-year olds to get involved with the activity?

    a. What do you think/could these instructors do to encourage children to participate in these [session(s)]?

        Probe: Language, communication style, activities, enjoyment etc.

    b. How many adults deliver the [session(s)]? Does the number of adults delivering these [session(s)] matter?

        Probe: If no/yes why do you think this?

Desired activities

11. Are there any structured activities (e.g. sports or dance classes) that your child(ren)/the child(ren) in your care do not engage with but you would like to involve them in other than the ones you've previously mentioned?

    a. What helps or prevents your child(ren)'s/the child(ren) in your care's from participating in these (activities)?

12. Are there any unstructured activities (e.g. playing, scooting, going to the park/soft play centres, day events) that your child(ren)/the child(ren) in your care do not engage with but you would like to involve them in other than the ones you've previously mentioned?

    a. What helps or prevents your child(ren)'s/the child(ren) in your care's from participating in these (activities)?

Barriers to activity

13. What are the main things which stop your child/children from moving more and staying still less?

    Probe: Tired, illness etc.

14. Are there any other external factors which help or prevent the amount of time your child(ren)/the child(ren) in your care move around and stay still for?

    Probe: Weather, access to facilities, traffic, cost etc.

    a. [For each factor raised] What would help you get the children to move more and stay still less?

Closing

- **So that's all the questions I have for you today. Do you have any questions for me?**
- **I will stop recording the interview now.**

END RECORDING

- **Thank you so much for your time we really appreciate you sharing your views with us today.**
- **(If not already provided) Please could you let me know a postal address so that I can send you a £10 Love2shop voucher to thank you for your time.**
- **Before I let you go, I just wanted to ask you a few more quick questions. Some of the questions might sound a little odd when being asked over the phone but we just want to be able to describe the people who we've interviewed in general terms, e.g. 14 participants were male and 16 were female. As I've stopped recording it won't be possible to link this information to you.**
    1. **If you don't mind me asking, how old are you?**
    2. **What is your gender?**
    3. **How would you describe your ethnicity?**
    4. **Out of the following options, what is your current employment status?**
        - **Student**
        - **Stay at home parent/caregiver**
        - **Full-time**
        - **Part-time**
        - **Unemployed**
    5. **What is your highest level of education? Options: Up to GCSEs/GCEs/O levels or similar, A levels/NVQs/GNVQs, First degree/diploma/HNC/HND or Higher degree (e.g. MSc, PhD)**
    6. **What city or town do you live in?**
    7. **And finally, how did you find out about this research study i.e. where did you see the study advert?**
- **It was lovely speaking to you, thank you again, enjoy the rest of your day.**

Faculty of Health Sciences
Research Ethics Committee (FREC)

University of Bristol Faculty of Health Sciences,
First Floor South, Senate House,
Tyndall Avenue, Bristol
BS8 1TH
Tel: 0117 331 8197

Research Governance and Ethics Officer:
Liam McKervey
E-mail: Liam.McKervey@bristol.ac.uk
Tel: 0117 928 9089

Miss Kaiseree Dias
Bristol Medical School
Bristol

14th May 2019

Dear Miss Dias

ID: 84822
Title: A qualitative examination of caregivers' perspectives on increasing physical activity and decreasing sedentary time in preschool aged children

The above-named ethic application was reviewed by the Faculty of Health Sciences Research Ethics Committee (FREC) and has been granted a favourable ethical opinion. Please note however that the FREC observed the following minor issues to be addressed before beginning your research:

- The committee discussed the component of financial inducement related to the study, as outlined in 1h of the online ethics tool. They wanted to inform the researchers that the typical rate for 1 hours participation time is £15, so they suggested changing the voucher amount to £10 instead of £20.
- The committee suggested that applicants are aware of the universities confidentiality policy and have a link to it if they want further information about the process.

Please address the points above and provide the revised study documentation with the changes highlighted to Liam.McKervey@bristol.ac.uk or Nathan.Street@bristol.ac.uk who will update your online submission for our records.

Yours faithfully,
Dr Allison Fulford
Co-Chair, Faculty of Health Sciences Research Ethics Committee

Appendix 10: Excerpt of the qualitative codebook: barriers to 2-4-year-old children's physical activity under the 'accessibility and the environment' theme

Theme	Code	Definition and description	Qualifications or exclusions	Example
Accessibility and the environment	Car ownership and accessibility	Difficulties getting to physical activity opportunities due to access or logistics restrictions: cars, public transport, walking, pushchairs and distance/locations.	Barriers can relate to access (e.g. using the car when active travel options are possible) or limited access to transport (e.g. no car to travel to opportunity).	Mother 6: Well if I don't have the car, then that restricts whether we go to places. I do feel to get to a decent place, to get them outside, you have to drive. That obviously is a restriction. Father 26: [Place] is just about in walking distance, although we do drive just for logistics, but yeah, the others are all driving distance, really, but within, yeah, ten, 15 minutes.
Accessibility and the environment	Built environment	Issues with the built environment which limit physical activity: roads, traffic, parking, unenclosed spaces, pavements, pollution and locations.	Refers to issues which limit access to physical activity opportunities (e.g. uneven pavements putting parents off using pushchairs to take children to opportunities).	Mother 20: Parking as well, that one makes me a bit nervous. If I don't know there's a good car park, especially with the two of them, trying to get them out on a main road or something. Father 23: I suppose there is a percentage of the fact that in the daytime it's a busy road outside, yeah. We live upstairs in a flat. Straight out on the high street. To get

				to the park you've got to go through a busy high street and it's all… not one of them on its own but all together it was quite a substantial percentage of like 'oh, maybe I'll wait until later' or that type of thing so that's the issue of where we are.
Accessibility and the environment	Natural environment	Issues with the natural environment which limit physical activity: countryside, nature reserves, woodlands, forests, fields, farms, beaches and locations.	Issues can refer to access to natural environments (e.g. no green space nearby) or direct issues with the natural environments (e.g. excessive dog poo).	Mother 6: Dog poo is really I hate. There is a nature reserve at the end of our road but I have never been there because every time someone comes back with dog poo on, every single time and I just hate that. There is always dog poo there.
Accessibility and the environment	Weather and season	Seasonal or weather-related barriers to physical activity engagement: rain, wind, hot/cold temperature and reduced daylight hours.	Any reference to seasonal or weather-related factors which impact children's engagement in physical and sedentary activities (e.g. parents restricting outdoor play and facilitating screen time when it's raining).	Mother 12: If it's raining I'll think, okay, today we'll do some painting or we'll do playdoh, so I think of an indoor activity, like a rainy day activity. Father 35: In the winter obviously we don't go in the garden in the evenings, once I get home from work. It's dark now.

Appendix 11: Excerpt of the detailed summary of qualitative findings according to code: barriers to 2-4-year-old children's physical activity under the 'accessibility and the environment' theme

Themes and codes	Summary of findings
Accessibility and the environment	
Car ownership and accessibility	One mother does not own a car and finds the journeys to structured rugby classes as they are not in a walkable distance or near a bus route; this mother relies on getting lifts from other people to get to natural environments and rugby classes which therefore limits attendance. One mother is put off by an unstructured gymnastics class is in the centre of town and not local to her. One mother chooses to drive to places over choosing active travel options. One mother finds access in general to be a barrier to taking her child to swimming classes. One family live in a village and therefore have to drive to take her child to activities which are not in walking distance. One mother does not have the car during the week, which puts her off travelling to activities because she finds using a double pushchair difficult when getting on trains and being in the rain. One mother had to get a bus and walk for 20 minutes through a field to take her child to a park before she passed her driving test, and she was put off going regularly because of the cost of the bus (£6 per day). One mother believes that she has to drive to get to a 'decent' park or natural environment. One nursery is in driving distance which prevents one family choosing active travel options. One mother is put off a rugby class being in driving distance because of the additional travel costs. Mother 6: Well if I don't have the car, then that restricts whether we go to places. I do feel to get to a decent place, to get them outside, you have to drive. That obviously is a restriction. A couple of fathers choose to drive to shops, parks and woodlands for logistics reasons, over choosing active travel options. Neither parent being able to drive prevents one family from taking their child to activities where it is necessary to walk along a main road, from a safety and pollution point of view. One father is put off by activities like forest school which are not in the local area and take four-five hours out of the day to get there and back and do the activity. Swimming classes being too difficult to get to from where the family live limits the number of

	times one father takes his child to the classes. One park is a difficult six to seven-mile cycle ride away therefore one father travels by car. One child has car sickness issues which prevents their family from going to opportunities with a long driving distance. Father 26: [Place] is just about in walking distance, although we do drive just for logistics, but yeah, the others are all driving distance, really, but within, yeah, ten, 15 minutes.
Built environment	A few mothers do not allow their children to be outside the front of the house unsupervised because they live next to a main road, it is too steep or cars drive too fast nearby. The built environment being too steep and not having a guaranteed path causes issues when one mother goes outdoors with a pushchair. One mother does not take her child to a temporary sandpit because it is unenclosed in a car park near a bus lane. One mother dislikes traffic, which puts her off travelling to activities early in the morning. One mother feels nervous about travelling to activities when she does not know whether there will be a good car park. One mother does not allow her child to go to the park unsupervised because they live on a busy road and is concerned about traffic. One mother does not allow her child to cycle to school because she is not comfortable with how people drive. One mother finds the lack of car parking spaces an issue near parks which are in driving distance from their home. One mother is put off by both the availability and the cost of parking in certain places. One mother has an issue with the pavements near toddler-specific opportunities being inappropriate for pushchair use. Mother 20: Parking as well, that one makes me a bit nervous. If I don't know there's a good car park, especially with the two of them, trying to get them out on a main road or something. One father thinks twice before taking his child to the park because they live near a busy road and they have to cross a busy high street to get to there. One child is not allowed outside the front of the house unsupervised because of traffic concerns. Neither parent can drive which prevents them from taking their child to activities where it is necessary to walk along a main road, from a safety and pollution point of view. Father 23: I suppose there is a percentage of the fact that in the daytime it's a busy road outside, yeah. We live upstairs in a flat. Straight out on the high street. To get to the park you've got to go through a busy high street and it's all… not one of them on its own but all together it was quite a substantial percentage of like 'oh, maybe I'll wait until later' or that type of thing so that's the issue of where we are.
Natural environment	One mother does not take her child to natural environments often because she does not own a car and therefore relies on lifts to get to nature reserves as they are all a long driving distance away. One mother does not go to the nature reserve because their child often gets dog poo on them.

	Mother 6: Dog poo is really I hate. There is a nature reserve at the end of our road but I have never been there because every time someone comes back with dog poo on, every single time and I just hate that. There is always dog poo there.
Weather and season	A few mothers do more sedentary indoor activities or do not go outdoors with their children as much when it is raining, in the autumn/winter or when the weather is 'rubbish', 'poor', 'not good', 'bad', 'cold', 'too hot', 'windy'. A few mothers do not let their children go outside if it is raining or in the winter. A few mothers do not take their children to the park when it is raining because of the wet equipment. One child's father takes them outdoors less and does more sedentary indoor activities in the winter compared to the summer. One mother uses the bus instead of walking when the weather is 'bad' as she does not have a car. One mother rearranges playdates with other children when it is raining. One mother finds her infant's buggy hard to use when it is raining, and she does not have a car. One mother comments on her children spending less time outdoors in the winter because it gets darker compared to lighter evenings in summer. Mother 12: If it's raining I'll think, okay, today we'll do some painting or we'll do playdoh, so I think of an indoor activity, like a rainy day activity. A few fathers do more sedentary indoor activities or do not go outdoors with their children as much when it is raining, in the winter or when the weather is 'not good', 'too hot', 'cold', 'bad'. A few fathers do fewer outdoor activities with their children when the evenings are darker. A few fathers do not let their children go in the garden when it is raining. A couple of nurseries restrict the children's outdoor play when it is raining. A couple of fathers mention how soft play centres are too busy from autumn through to spring when they would be more likely to take their own children there. One father comments on his child being more tired in the evenings in the winter compared to the summer to engage with physical activity. Father 35: In the winter obviously we don't go in the garden in the evenings, once I get home from work. It's dark now.

Appendix 12: Postal study invitation for nursery managers

SCHOOL OF SOCIAL AND COMMUNITY MEDICINE
Canynge Hall, 39 Whatley Road, Bristol, BS8 2PS

Dr Ruth Kipping
Telephone: +44 (0)1173 314584
E-mail: ruth.kipping@bristol.ac.uk
http://www.epi.bris.ac.uk

Date: 15/11/16

Dear Nursery Manager

Invitation to take part in a research study

We are writing to invite your nursery to take part in a new research study involving nurseries in North Somerset and Bristol from November 2016. We have created a questionnaire which measures parents' and nursery staff's knowledge and attitudes towards children's physical activity, nutrition and oral health. This study tests whether completing the questionnaire twice with a one week interval will produce similar results.

Please read the attached information sheet entitled **'Participant Information Sheet'** which explains what participation in this study will involve. If you are interested in and would like to participate in the study please **also complete the attached 'NURSERY CONSENT FORM'**. An addressed prepaid envelope has been included for your convenience. Nurseries which take part in the study will be entered into a raffle draw to win a £50 cheque.

If you have any further questions about the study, please contact, Miss Kaiseree Dias, on +44 (0)1173 314589. We will be happy to assist with any queries.

Yours sincerely,

[redacted]

Dr Ruth Kipping
Senior Research Fellow

University of BRISTOL

'Participant Information Sheet'

Test-retest reliability study of parent and nursery staff mediators to improve 2-4 year-olds' physical activity, nutrition and oral health

What is the study?

There are lots of pre-school-aged children who do not eat a healthy diet or do not exercise enough in order to grow and develop healthily. One in five children who start primary school in England are overweight or obese. Intervention programmes have been designed for home and nursery environments to improve physical activity, nutrition and oral health for children aged 2 – 4 years. To see whether these intervention programmes are successful we need a reliable questionnaire to measure parents' and nursery staff's knowledge and abilities to make changes.

We have created a questionnaire which measures parents' and nursery staff's knowledge and attitudes towards children's physical activity, nutrition and oral health. This study wants to test whether completing the questionnaire twice with a one week interval will produce similar results.

Who is participating in the study?

Staff from nurseries in North Somerset and Bristol will participate in the study. Participating nurseries must provide childcare and a main meal for children aged 2 – 4 years.

We are aiming to recruit parents online to complete the questionnaire using the Netmums website. However, if we do not get enough responses we will ask you to send the questionnaire via email to parents of children aged 2 – 4 years at your nursery.

What do nursery staff have to do?

Nursery managers taking part in the study will be asked to send out the questionnaire via email to all nursery staff who work with children aged 2- 4 years to complete online. If we do not get enough responses from posting our questionnaire on Netmums then we will ask the nursery manager to send the questionnaire via email to all parents of children aged 2 – 4 years to complete online.

At the start of the questionnaire there will be information about the study and a statement asking for nursery staff to consent to completing the questionnaire. The questionnaire will take approximately 20 minutes to complete. The questionnaire will automatically be sent out to the nursery staff again, 1 week after completing it for the first time. Nursery staff will need to complete the questionnaire both times before receiving a £10 “Love2shop” gift voucher each.

What do parents have to do?

Parents will be sent the questionnaire via email by the nursery manager to complete online. At the start of the questionnaire there will be information about the study and a statement asking if the parents consent to completing the questionnaire. The questionnaire will take approximately 20 minutes to complete. The questionnaire will automatically be sent out to the parents again, 1 week after completing it for the first time. Parents will need to complete the questionnaire both times before receiving a £10 “Love2Shop” voucher.

Risks

The risks associated with taking part in the study are minimal. There is a potential for parents and nursery staff to feel uncomfortable when answering some of the questions but they will be reassured at the start of the questionnaire that they do not need to answer any question they do not wish to.

Benefits

The results from this study will help the evaluation of interventions in the future which aim to improve young children’s physical activity, nutrition and oral health in nursery and home settings.

Confidentiality

We will not be asking for study participants names which will make the questionnaires anonymous. Email addresses will only be used to send out the second questionnaire to participants and to request an address to send the £10 “Love2shop” vouchers. All information you provide us with during the study will remain confidential. No information will be passed on to members of your nursery staff, parents or other nurseries. No names or identifying information will be used in any results, publication or presentations. However, if anything is disclosed or observed where there is serious concern about the health or well-being of a child, either the nursery manager will be informed or the information will be shared with an appropriate organisation.

Who is leading the project?

The project is being led by Dr Ruth Kipping from the University of Bristol.
Ethical approval

This project has been reviewed and approved by the University of Bristol Faculty of Health Sciences Research Ethics Committee.

Who is funding the study?

NIHR Public Health Research Programme, DECIPHer and Families First.

What are the timescales?
The study starts in November 2016 and will end in March 2017.

Reimbursement for time

All participating nurseries will be entered into a draw to win a £50 cheque. Nursery staff and parents will each receive a £10 “Love2shop” voucher after completing both questionnaires.

What do I need to do next?

If you would like your nursery to take part in the study please **complete the attached ‘NURSERY CONSENT FORM’** and return it, at your earliest convenience, in the prepaid envelope enclosed. If you are interested, we will arrange a telephone call to talk to you further about the study.

What if I change my mind?

Your nursery's participation in the study is voluntary. You can choose not to take part, or you may withdraw your nursery at any time. Completion of the questionnaire is voluntary. Nursery staff and parents do not have to complete the questionnaire if they do not wish to. If you **do not** wish to take part in the study you do not need to do anything.

Questions

If you have any further questions about the study, please contact Miss Kaiseree Dias on +44 (0)1173 314589 or email kaiseree.dias@bristol.ac.uk. If participants wish to make a complaint to an independent party they can email research-governance@bristol.ac.uk.

University of BRISTOL

NURSERY CONSENT FORM
'Test-retest reliability study of parent and nursery staff mediators to improve 2-4 year-olds' physical activity, nutrition and oral health'

Name of lead researcher: Dr Ruth Kipping

Please complete all details and return in prepaid envelope:

*Please **initial** all boxes*

I confirm that I have read and understand the participant information sheet provided for the above study (dated 15/11/16). I have had the opportunity to ask questions and have had these answered satisfactorily.	Yes ☐
I understand that my nursery's participation is voluntary and that I am free to withdraw my nursery from the study at any time without giving any reason.	Yes ☐
I understand that the information collected will be used to support other research in the future, and may be shared openly and anonymously with other researchers.	Yes ☐
I do wish for my nursery to take part in the above study.	Yes ☐

Name of nursery manager……………………………………………………………………………..

Name of nursery…………………………..……………………………………….............................

Email address….……………………………………………………………………………………..

Best telephone number to contact (including code)
…………………………………….................

Signature .... Date ………………………………...

Please return form in **prepaid envelope provided.**
Dr Ruth Kipping, Room 4.02, Canynge Hall, 39 Whatley Road, Bristol, BS8 2PS

To be completed by researcher

Researcher name
....

Signature .... Date
…………………………....

Appendix 15: Email study invitations for parents and nursery staff who have/work with 2-4-year-old children

Dear Parent

Invitation to take part in a research study

We are writing to invite you to take part in a new research study involving parents of children aged 2 – 4 years in North Somerset and Bristol. We have created a questionnaire which measures parents' knowledge and attitudes towards children's physical activity, nutrition and oral health. This study tests whether completing the questionnaire **twice** with a **one week interval** will produce similar results.

The link to the online questionnaire is available here: https://brtcclinical.bris.ac.uk/redcap/surveys/?s=7W9K4K9DX9. Please read the information at the start of the questionnaire. If you wish to participate in the study please tick that you agree and complete the questionnaire. The questionnaire will take approximately 20 minutes to complete and we will send you a link to the second questionnaire one week later by email. Each participant who completes **both** questionnaires will receive a £10 "Love2shop" voucher.

If you have any further questions about the study, please contact Miss Kaiseree Dias on +44 (0)1173 314589 or email kaiseree.dias@bristol.ac.uk. We will be happy to assist with any queries.

Yours sincerely,

[redacted]

Dr Ruth Kipping
Senior Research Fellow

University of BRISTOL

Dear Nursery Staff

Invitation to take part in a research study

We are writing to invite you to take part in a new research study involving nursery staff who work with 2 – 4 year-olds in North Somerset and Bristol. We have created a questionnaire which measures nursery staff's knowledge and attitudes towards children's physical activity, nutrition and oral health. This study tests whether completing the questionnaire **twice** with a **one week interval** will produce similar results.

The link to the online questionnaire is available here: https://brtcclinical.bris.ac.uk/redcap/surveys/?s=WK7RMXTJK8. Please read the information at the start of the questionnaire. If you wish to participate in the study please tick that you agree and complete the questionnaire. The questionnaire will take approximately 20 minutes to complete and we will send you a link to the second questionnaire one week later by email. Each participant who completes **both** questionnaires will receive a £10 "Love2shop" voucher.

If you have any further questions about the study, please contact Miss Kaiseree Dias on +44 (0)1173 314589 or email kaiseree.dias@bristol.ac.uk. We will be happy to assist with any queries.

Yours sincerely,

[redacted]

Dr Ruth Kipping
Senior Research Fellow

University of BRISTOL

Appendix 16: Online study invitation for parents of 2-4-year-old children posted on www.netmums.com

Do you have a child aged 2 – 4 years? Complete our questionnaire and receive a £10 Love2shop voucher!

Hello Everyone,

We are from the University of Bristol and we have created a questionnaire which measures parents' knowledge and attitudes towards children's physical activity, nutrition and oral health.

We are conducting a study which tests whether completing the questionnaire twice with a one-week interval will produce similar results.

If you are a parent of children aged 2 – 4 years we would really appreciate you filling out our questionnaire. The questionnaire will take approximately 20 minutes to complete.

If you complete the questionnaire twice with a one-week interval we will send you a £10 Love2Shop voucher. Click on the link below for further information and to complete the questionnaire.

Questionnaire link.

Thank you for your time!

University of Bristol

Appendix 17: Participant information and consent for parents and nursery staff who have/work with 2-4-year-old children

Parent Questionnaire

You are invited to participate in this research study because you are a parent of a child aged 2 – 4 years. We have created a questionnaire at the University of Bristol which measures parents' knowledge and attitudes towards children's physical activity, nutrition and oral health. This study tests whether completing the questionnaire **twice** with a **one-week interval** will produce similar results.

The questionnaire will take approximately 20 minutes to complete and we will send the questionnaire to you again in one weeks' time to complete for a second time. Participants who complete **both** questionnaires will each receive a **£10 "Love2shop" voucher**. We will ask for your email address at the end of the questionnaire which will only be used to send out the second questionnaire and to request an address to send the £10 voucher.

Completion of the questionnaire is voluntary. You do not have to complete all questions if you do not wish to. All information you provide us with during the study will remain confidential. No information will be passed on to any individual outside of the research study team. No identifying information will be used in any results, publication or presentations. If you **do not** wish to take part in the study you do not need to do anything.

If you would like to ask questions before completing the questionnaire or would like to talk to someone about the questions, please contact Miss Kaiseree Dias on +44 (0)1173 314589 or email kaiseree.dias@bristol.ac.uk. If you wish to make a complaint to an independent party please email research-governance@bristol.ac.uk.

Electronic Consent:

Clicking on the "agree" button below indicates that:

- You have read the above information
- You voluntarily agree to participate in the research study

If you agree you will be taken to the questionnaire.

- ○ Agree

University of BRISTOL

Nursery Staff Questionnaire

You are invited to participate in this research study because you work with children aged 2 – 4 years in a nursery setting. We have created a questionnaire at the University of Bristol which measures nursery staff's knowledge and attitudes towards children's physical activity, nutrition and oral health. This study tests whether completing the questionnaire **twice** with a **one-week interval** will produce similar results.

The questionnaire will take approximately 20 minutes to complete and we will send the questionnaire to you again in one weeks' time to complete for a second time. Participants who complete **both** questionnaires will each receive a **£10 "Love2shop" voucher**. We will ask for your email address at the end of the questionnaire which will only be used to send out the second questionnaire and to request an address to send the £10 voucher.

Completion of the questionnaire is voluntary. You do not have to complete all questions if you do not wish to. All information you provide us with during the study will remain confidential. No information will be passed on to any individual outside of the research study team. No identifying information will be used in any results, publication or presentations. If you **do not** wish to take part in the study you do not need to do anything.

If you would like to ask questions before completing the questionnaire or would like to talk to someone about the questions, please contact Miss Kaiseree Dias on +44 (0)1173 314589 or email kaiseree.dias@bristol.ac.uk. If you wish to make a complaint to an independent party please email research-governance@bristol.ac.uk.

Electronic Consent:

Clicking on the "agree" button below indicates that:

- You have read the above information
- You voluntarily agree to participate in the research study

If you agree you will be taken to the questionnaire.

○ Agree

University of BRISTOL

Faculty of Health Sciences
Research Ethics Committee (FREC)

University of Bristol Faculty of Health Sciences,
First Floor South, Senate House,
Tyndall Avenue, Bristol
BS8 1TH
Tel: 0117 331 8197

Research Governance and Ethics Officer:
Liam McKervey
E-mail: Liam.McKervey@bristol.ac.uk
Tel: 0117 928 9089

Miss Kaiseree Dias
University of Bristol

27th September, 2016

Dear Miss Dias,

Re: Application 41585

Title: Test-retest reliability study of parent and nursery staff mediators to improve 2-4 year olds' physical activity, nutrition and oral health

The above named application was reviewed by the Faculty of Health Sciences Research Ethics Committee (FREC) and has been granted a **conditional ethical opinion.** This means that you should **not** commence your study until the issues raised by the FREC (as detailed below) are addressed:

- The committee noted that the primary method of recruiting parents was via Netmums and may bias the sample towards mothers and the committee queried if there was any way that the research team could sample fathers to gain a more representative sample? Furthermore care has been taken to ensure diversity in the nurseries, will this diversity be achieved in the parental group?
- The committee would like justification as to why the nursery staff receive £10 each yet the parents are only entered into a raffle? As all participants are equally important it would seem appropriate that they are offered the same incentive?
- The PIS should include the research-governance@bristol.ac.uk email address for complaints as an independent contact for participants.
- The committee would like clarification if permission to recruit via Netmums from a site administrator has been sought or if this is needed?
- The committee would find it helpful if some further information regarding how the study will be advertised on the website could be provided.
- The committee agreed that they would like some further information on what is the "small potential for distress? Some guidance regarding how this might be managed considering this is on-line should be provided. Will the research team provide any additional support information?
- The incentive to take part is too prominent in the invitation and should be removed but can be stated on the PIS.
- The PIS for the nursery managers and all the invitations should include a rough estimation of the time it would take to complete the questionnaire. Also it should be made explicitly clear to participants how they can ask any questions prior to completing the questionnaire.

Please cite the application number in your correspondence and highlight any changes to your study documentation in yellow with the FREC.

Yours faithfully,
Liam McKervey
pp
[redacted]

Dr Allison Fulford
Chair, Faculty of Health Sciences Research Ethics Committee

Appendix 19: Parent and nursery staff questionnaires developed for the NAP SACC UK feasability study

NAP SACC UK QUESTIONNAIRE

For Parents

Please tick ONE box under the statement that most closely describes how much you agree or disagree with each statement. There are no right or wrong answers, just your opinions about how you feel when caring for your child. These questions are about how much you feel able to do things relating to food and physical activity.

Food

1. I feel able to provide my children with fruit at all main meals	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
2. I feel able to provide my children with vegetables at all main meals	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
3. I feel able to reduce the amount of processed meat, fish or potato products served to my children at all main meals	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
4. I feel able to provide my children with home-cooked meals each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
5. I feel able to reduce the number of high-sugar or high-fat snacks served to my children each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

6. I feel able to reduce the amount of sugary breakfast cereals served to my children each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
7. I feel able to reduce the number of fizzy drinks and cordials served to my children each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
8. I feel able to increase the amount of water served to my children each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
9. I feel able to make changes to the portion sizes served to my children each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
10. I feel able to increase how often my children brush their teeth with fluoride toothpaste	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

Physical Activity and Play

11. I feel able to provide my children with time for indoor activities and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
12. I feel able to provide my children with space for indoor activities and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
13. I feel able to provide my children with toys/equipment for indoor activities and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
14. I feel able to provide my children with time for outdoor play and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
15. I feel able to provide my children with space for outdoor play and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
16. I feel able to provide my children with toys/equipment for outdoor play and games each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

17. I feel able to provide my children with opportunities for walking to/from nursery each week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
18. I feel able to provide my children with opportunities for outdoor play regardless of the weather	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
19. I feel able to reduce the amount of time the adults in my household spend using screens across the week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
20. I feel able to reduce the amount of time the children in my household spend using screens across the week	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

Please tick ONE box under the statement that most closely describes your level of motivation for each statement. There are no right or wrong answers, just your opinions about how you feel when caring for your child.

Food

21. I am motivated to provide my child with fruit at all main meals	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
22. I am motivated to provide my child with vegetables at all main meals	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
23. I am motivated to reduce the amount of processed meat, fish or potato products served to my child at all main meals	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
24. I am motivated to provide my child with home-cooked meals	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
25. I am motivated to reduce the number of high-sugar or high-fat snacks served to my child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
26. I am motivated to reduce the amount of sugary breakfast cereals served to my child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
27. I am motivated to reduce the number of fizzy drinks and cordials served to my child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
28. I am motivated to increase the amount of water served to my child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
29. I am motivated to make changes to the portion sizes served to my child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

30. I am motivated to increase how often my child brushes their teeth with fluoride toothpaste	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

Physical Activity and Play

31. I am motivated to provide my child with time for indoor activities and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
32. I am motivated to provide my child with space for indoor activities and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
33. I am motivated to provide my child with toys/equipment for indoor activities and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
34. I am motivated to provide my child with time for outdoor play and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
35. I am motivated to provide my child with space for outdoor play and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
36. I am motivated to provide my child with toys/equipment for outdoor play and games	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
37. I am motivated to provide my child with opportunities for walking to/from nursery	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
38. I am motivated to provide my child with opportunities for outdoor play regardless of the weather	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
39. I am motivated to reduce the amount of time the adults in my household spend using screens	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

40. I am motivated to reduce the amount of time the children in my household spend using screens	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

These questions are about what you think about children's food, teeth and physical activity. For each question, please tick all of the options which you agree with:

Child food and teeth:

41. Which of the following food groups should be eaten regularly by 2-4 year-old children?
- *Whole grains*
- *Low-fat dairy products*
- *Lean meat and beans*
- *All of the above*

42. How many portions of fruit and vegetables should 2-4 year-old children consume per day?
- *3*
- *4*
- *5*
- *More than 5*

43. What are suitable foods for 2-4 year-olds to eat at breakfast?
- Sweetened cereal (e.g. Cheerios, Coco Pops),
- Non-sweetened cereal (e.g. Weetabix, Cornflakes, Porridge),
- Sweetened cereal and toast
- Non-sweetened cereal and toast
- Toast
- Yogurt or fruit
- Milk
- Breakfast is not required

44. What type of puddings should be served to 2-4 year-olds?
- Puddings should not be served to children
- Hot fruit-based puddings e.g. crumbles, baked apples
- Milk-based puddings e.g. rice pudding, custard
- Yogurt or fromage frais
- Cakes and biscuits containing fruit e.g. fruit flapjack, carrot cake
- Cold puddings such as fruit salad, piece of fruit
- All of the above

45. What are the recommended drinks for 2-4 year-olds?
- Whole milk (full-fat)

- Semi-skimmed milk
- Skimmed milk
- Fruit juice
- Diluted fruit juice
- Water
- Fruit squash/cordial
- Fizzy sweet drinks

46. What are the recommended snacks for 2-4 year-olds?
- No snacks between meals
- Dried fruit
- Fresh fruit or vegetables
- Crisps
- Biscuits/cakes
- Breadsticks/sandwich/rice cakes
- Chocolate/sweets

47. How often should 2-4 year-old children brush their teeth?
- Twice per day
- Once per day
- After every meal

48. How long should 2-4 year-old children brush their teeth each time they brush them?
- 30 seconds
- 1 minute
- 2 minutes

49. At what age is a child able to brush their teeth unsupervised by an adult?
- Age 2
- Age 3
- Age 4
- Age 5
- Age 6
- Age 7
- Age 8

Child Physical Activity and Play:

50. How many minutes of active play each day do health professionals recommend for 2-4 year-olds?
- 30 minutes
- 45 minutes
- 60 minutes (1 hour)

- 90 minutes
- 120 minutes (2 hours)
- 150 minutes
- 180 minutes (3 hours)

51. When it is raining, children should:
    - Stay indoors
    - Continue to play outside in whatever they are wearing
    - Play outside in wet weather clothes

Sedentary Time:

52. How many minutes of screen-viewing each day do health professionals recommend for 2-4 year-olds?
    - None
    - Less than 1 hour
    - Between 1-2 hours
    - 2-3 hours
    - 3-4 hours
    - More than 4 hours

53. What are the recommendations for children having TVs in bedrooms
    - A TV in a child's bedroom is ok
    - TV in a child's bedroom helps them to sleep
    - Parents should limit the amount of TV watching in a child's bedroom
    - TV in a child's bedrooms promotes more TV watching
    - TVs in a child's bedrooms makes it more difficult for a child to sleep
    - TV in a child's bedroom can lead to less appropriate viewing

Thank you for completing the questionnaire. Please return it to the NAP SACC UK Study in the stamped addressed envelope to: NAP SACC UK Study (room 4.09), School of Social and Community Medicine, University of Bristol, Canynge Hall, 39 Whatley Road, Bristol BS8 2PS.

NAP SACC UK QUESTIONNAIRE
For Nursery Staff

Please tick ONE box under the statement that most closely describes how much you agree or disagree with each statement. There are no right or wrong answers, just your opinions about how you feel when working at your nursery. These questions are about how much you feel able to do things relating to child nutrition and physical activity.

Child Nutrition

1. I feel able to serve fruit and vegetables to children at all main meals	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
2. I feel able to limit the amount of processed meat, fish or potato products served to children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
3. I feel able to limit the amount of salt used in food for children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
4. I feel able to limit the number of high-sugar or high-fat snacks served to children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
5. I feel able to limit the use of cakes and/or other sweet or high fat foods to celebrate events	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
6. I feel able to make changes to the types of beverage provided to children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
7. I feel able to make changes to how we promote oral health at nursery	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
8. I feel able to make changes to how staff role-model healthy eating	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

foods served at meal and snack times					
9. I feel able to make changes to how staff incorporate healthy eating learning into children's daily activities	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
10. I feel able to increase staff access to professional development in child nutrition	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
11. I feel able to increase communication with parents about child nutrition	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
12. I feel able to make changes to our written policy on child nutrition	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

Child Physical Activity and Play

13. I feel able to provide an appropriately-sized indoor space for children's physical activity and play	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
14. I feel able to provide appropriate indoor toys and equipment for children's physical activity and play	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
15. I feel able to increase the amount of time provided for indoor physical activity and play for children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
16. I feel able to increase the amount of adult-led indoor physical activity and play for children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
17. I feel able to provide an appropriately-sized outdoor space for children's physical activity and play	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
18. I feel able to provide appropriate outdoor toys and equipment for children's physical activity and play	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

19. I feel able to increase the amount of time provided for outdoor physical activity and play for children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
20. I feel able to increase the amount of adult-led outdoor physical activity and play for children	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
21. I feel able to make changes to the amount of screen-time allowed in our nursery per child	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
22. I feel able to make changes to how staff role-model good physical activity habits	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
23. I feel able to make changes to how staff incorporate physical activity learning into children's daily activities	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
24. I feel able to increase staff access to professional development in children's physical activity	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
25. I feel able to increase communication with parents about children's physical activity	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5
26. I feel able to make changes to our written policy on children's physical activity	*Disagree a lot* ☐ 1	*Disagree a little* ☐ 2	*Not sure* ☐ 3	*Agree a little* ☐ 4	*Agree a lot* ☐ 5

Please tick ONE box under the statement that most closely describes your level of motivation for each statement. There are no right or wrong answers, just your opinions about how you feel when working at your nursery. These questions about your motivation relating to child nutrition and physical activity.

Child Nutrition

27. I am motivated to serve fruit and vegetables to children at all main meals	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

28. I am motivated to limit the amount of processed meat, fish or potato products served to children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
29. I am motivated to limit the amount of salt used in food for children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
30. I am motivated to limit the number of high-sugar or high-fat snacks served to children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
31. I am motivated to limit the use of cakes and/or other sweet or high fat foods to celebrate events	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
32. I am motivated to make changes to the types of beverage provided to children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
33. I am motivated to make changes to how we promote oral health at nursery	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
34. I am motivated to make changes to how staff role-model healthy eating foods served at meal and snack times	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
35. I am motivated to make changes to how staff incorporate healthy eating learning into children's daily activities	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
36. I am motivated to increase staff access to professional development in child nutrition	*Never*	*Sometimes*	*I don't know*	*Most of the time*	*Always*

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

37. I am motivated to increase communication with parents about child nutrition	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
38. I am motivated to make changes to our written policy on child nutrition	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

Child Physical Activity and Play

39. I am motivated to provide an appropriately-sized indoor space for children's physical activity and play	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
40. I am motivated to provide appropriate indoor toys and equipment for children's physical activity and play	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
41. I am motivated to increase the amount of time provided for indoor physical activity and play for children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
42. I am motivated to increase the amount of adult-led indoor physical activity and play for children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
43. I am motivated to provide an appropriately-sized outdoor space for children's physical activity and play	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
44. I am motivated to provide appropriate outdoor toys and equipment for children's physical activity and play	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
45. I am motivated to increase the amount of time provided for outdoor physical activity and play for children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
46. I am motivated to increase the amount of adult-led outdoor physical activity and play for children	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

47. I am motivated to make changes to the amount of screen-time allowed in our nursery per child	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
48. I am motivated to make changes to how staff role-model good physical activity habits	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
49. I am motivated to make changes to how staff incorporate physical activity learning into children's daily activities	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
50. I am motivated to increase staff access to professional development in children's physical activity	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
51. I am motivated to increase communication with parents about children's physical activity	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5
52. I am motivated to make changes to our written policy on children's physical activity	*Never* ☐ 1	*Sometimes* ☐ 2	*I don't know* ☐ 3	*Most of the time* ☐ 4	*Always* ☐ 5

These questions are about what you think about child nutrition, teeth and physical activity. For each question, please tick all of the options which you agree with:

Child Nutrition and Teeth:

53. Which of the following food groups should be eaten regularly by 2-4 year-old children?
- ○ *Whole grains*
- ○ *Low-fat dairy products*
- ○ *Lean meat and beans*
- ○ *All of the above*

54. How many portions of fruit and vegetables should 2-4 year-old children consume per day?
- ○ *3*
- ○ *4*
- ○ *5*
- ○ *More than 5*

55. What are suitable foods for 2-4 year-olds to eat at breakfast?
- ○ Sweetened cereal (e.g. Cheerios, Coco Pops),

- Non-sweetened cereal (e.g. Weetabix, Cornflakes, Porridge),
- Sweetened cereal and toast
- Non-sweetened cereal and toast
- Toast
- Yogurt or fruit
- Milk
- Breakfast is not required

56. What type of puddings should be served to 2-4 year-olds?
   - Puddings should not be served to children
   - Hot fruit-based puddings e.g. crumbles, baked apples
   - Milk-based puddings e.g. rice pudding, custard
   - Yogurt or fromage frais
   - Cakes and biscuits containing fruit e.g. fruit flapjack, carrot cake
   - Cold puddings such as fruit salad, piece of fruit
   - All of the above

57. What are the recommended drinks for 2-4 year-olds?
   - Whole milk (full-fat)
   - Semi-skimmed milk
   - Skimmed milk
   - Fruit juice
   - Diluted fruit juice
   - Water
   - Fruit squash/cordial
   - Fizzy sweet drinks

58. What are the recommended snacks for 2-4 year-olds?

- No snacks between meals
- Dried fruit
- Fresh fruit or vegetables
- Crisps
- Biscuits/cakes
- Breadsticks/sandwich/rice cakes
- Chocolate/sweets

59. How often should 2-4 year-old children brush their teeth?
   - Twice per day
   - Once per day
   - After every meal
60. How long should 2-4 year-old children brush their teeth each time they brush them?

- 30 seconds
- 1 minute
- 2 minutes

61. At what age is a child able to brush their teeth unsupervised by an adult?
- Age 2
- Age 3
- Age 4
- Age 5
- Age 6
- Age 7
- Age 8

Child Physical Activity and Play:

62. How many minutes of active play each day do health professionals recommend for 2-4 year-olds?
- 30 minutes
- 45 minutes
- 60 minutes (1 hour)
- 90 minutes
- 120 minutes (2 hours)
- 150 minutes
- 180 minutes (3 hours)

63. When it is raining, children should:
- Stay indoors
- Continue to play outside in whatever they are wearing
- Play outside in wet weather clothes

Sedentary Time:

64. How many minutes of screen-viewing each day do health professionals recommend for 2-4 year-olds?
- None
- Less than 1 hour
- Between 1-2 hours
- 2-3 hours
- 3-4 hours
- More than 4 hours

65. What are the recommendations for children having TVs in bedrooms
- A TV in a child’s bedroom is ok
- TV in a child’s bedroom helps them to sleep

- Parents should limit the amount of TV watching in a child's bedroom
- TV in a child's bedrooms promotes more TV watching
- TVs in a child's bedrooms makes it more difficult for a child to sleep
- TV in a child's bedroom can lead to less appropriate viewing

Thank you for completing the questionnaire. Please return it to the NAP SACC UK Study in the stamped addressed envelope to: NAP SACC UK Study (room 4.09), School of Social and Community Medicine, University of Bristol, Canynge Hall, 39 Whatley Road, Bristol BS8 2PS