

**Reducing sedentary behaviour and promoting
physical activity in children aged 7-9 years:
developing, feasibility and pilot testing a low-cost,
multicomponent, school- and home-based
intervention.**

Research conducted within

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Sarah Nally

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I can confirm that the word count of this thesis is less than 100,000 words

For my mum and dad

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Summary

Many primary school children in Northern Ireland (NI) are insufficiently active and spend long periods sitting. Cost-effective interventions, which increase childhood physical activity (PA) and reduce sedentary behaviour (SB) are needed to prevent future ill-health. Primary schools are a key setting for child activity promotion, yet few school-based interventions have been effective. Using a mixed-methods approach the aim of this PhD was to determine influences and approaches to reduce SB and promote PA in children aged 7-9 years, leading to the development, pilot testing and evaluation of a multicomponent primary school- and home-based intervention. A systematic review of the literature examined the effectiveness of school-based interventions at changing obesity-related behaviours in primary school children. Meta-analyses of the included interventions ($n = 37$) demonstrated that interventions in children when compared to controls resulted in a small positive treatment effect in moderate-to-vigorous physical activity (MVPA) in the control group (2.14; 95% CI = 0.77, 3.50). However, inconclusive results were found for SB, energy intake, and fruit and vegetable intake, and BMI kg/m^2 . A formative qualitative exploration involved write and draw tasks ($n = 50$) and semi-structured focus groups ($n = 10$) to examine the current views, barriers, facilitators, experiences, and perceptions of children in relation to PA in the classroom, school, and home environments, and to assess the acceptability of components for a school-based intervention. Peers and family were main influences on children's PA and could both facilitate and impede on PA participation. Collectively these findings highlight that elements of fun, social support, time, and space are likely to be central to the adaptation and maintenance of PA among primary-school children and that PA promotion strategies that are based around co-participation with peers and family members could be an effective means of engaging in PA. The findings emphasised social opportunities for PA may be effective activity promotion methods to provide the intrinsic enjoyment of PA that was expressed by these primary-school children. Semi-structured telephone interviews ($n = 12$) were conducted to explore current views, barriers, facilitators, knowledge, and perceptions of children's PA and SB, both at school and within the home environment, from the perspective of their parents and classroom teachers. Results highlighted several important factors that should be closely considered when designing future PA and SB interventions, including incorporating an element of choice, adaptability, and

flexibility in the intervention. Through series of iterative work, key intervention strategies were adapted from the *Transform-Us!* intervention to develop a context-specific school- and home-based intervention called the *Children – Sit Less, Move More* (C-SLAMM) intervention. A pilot cluster-randomised controlled trial (cRCT) evaluated the feasibility and effectiveness of the 8-week multicomponent school- and home-based C-SLAMM intervention, deriving estimates of the effects of the intervention on childrens' sitting time and PA outcomes between intervention and control groups. The C-SLAMM intervention was the first multicomponent school-and home-based intervention to be undertaken in primary school children (aged 7-9 years) in NI. Primary school children were randomised by school (cluster) to participate in an 8-week intervention that used innovative behavioural, pedagogical, and environmental strategies within the classroom, school, and home settings to get participants moving more and sitting less (the C-SLAMM intervention (n = 85, four schools) or to continue with their usual PA (n = 77, four schools). Changes in time spent sitting and standing between baseline (T0) and follow-up (week 8) (T1) were assessed using an activPAL monitor (*PAL Technologies, Glasgow, UK*). At baseline, children in both arms (n = 76) spent 8 hours on average in sedentary pursuits (479.04 ± 82.69 minutes) and over 6 hours of sitting (363.31 ± 73.38 minutes) per day. There was no observed effect of the intervention on the primary outcome (overall sitting time) between the intervention and control schools between baseline and at follow-up (week 8). High levels of PA observed in the control group and low compliance in activPAL wear time were limitations of the study. Evaluation of the C-SLAMM intervention highlighted the importance of stakeholder buy-in from teachers, parents and pupils if school-based health promotion programmes are to be successful. This is the first known series of studies to systematically adapt the successful *Transform-Us!* intervention to target PA and SB in NI primary schoolchildren (aged 7-9 years). Thus, this thesis contributes to the understanding of feasible and acceptable PA and SB strategies in the school- and home- setting.

Keywords

Physical activity; Sedentary Behaviour; Child Health; Schools; Health Promotion; Randomised Control Trial; Children.

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List of abbreviations

BMI	Body Mass Index
CG	Control Group
CONSORT	Consolidated Standards of Reporting Trials
COREQ	Consolidated Criteria for Reporting Qualitative Studies
COVID-19	Coronavirus disease 2019
cRCT	Cluster-randomised controlled trial
CRF	Cardiorespiratory fitness
C-SLAMM	Children- Sit Less, Move More
CSPPA	Children's Sport Participation and Physical Activity
CVD	Cardiovascular Disease
DoH	Department of Health
EE	Energy expenditure
FITT	Frequency, Intensity, Time, and Type
Hz	Hertz
IG	Intervention Group
ISPAH	International Society for Physical Activity and Health
LIPA	Light intensity physical activity
MD	Mean difference
MET	Metabolic equivalent
MMR	Mixed Method Research
MPA	Moderate physical activity
MRC	Medical Research Council
MVPA	Moderate to vigorous physical activity
NCD	Non-communicable disease

NI	Northern Ireland
NICE	National Institute of Clinical Excellence
NICHHS	Northern Ireland Chest, Heart and Stroke
PA	Physical activity
PE	Physical education
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomised controlled trial
RevMan	Review Manager
SB	Sedentary behaviour
SBRN	Sedentary Behaviour Research Network
SCT	Social cognitive theory
SD	Standard deviation
SDT	Self-Determination Theory
SEM	Socio-Ecological Model
SES	Socio-economic status
SPSS	Statistical Package for the Social Sciences
ST	Sedentary time
TEO	Theory of Expanded, Extended, and Enhanced Opportunities
TiDieR	Template for Intervention Description and Replication
TV	Television
US(A)	United States (of America)
UK	United Kingdom
VPA	Vigorous physical activity
WDST	Write, draw, show and tell
WHO	World Health Organization

Y-PATH Youth Physical Activity Towards Health

% Percentage

< Less than

$\leq$ Less than or equal to

> Greater than

$\geq$ Greater than or equal to

List of publications

PhD publications

Nally, S., Carlin, A., Blackburn, N. E., Baird, J. S., Salmon, J., Murphy, M. H., & Gallagher, A. M. (2021). The Effectiveness of School-Based Interventions on Obesity-Related Behaviours in Primary School Children: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *Children (Basel, Switzerland)*, 8(6), 489. <https://doi.org/10.3390/children8060489>

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Statement of contribution

Chapter 1: General introduction

The following work was conducted by S. Nally: literature review, evaluation of the literature and write-up. AM Gallagher, A Carlin and MH Murphy critically reviewed the chapter.

Chapter 2: Literature review

The following work was conducted by S. Nally: literature review, evaluation of the literature and write-up. AM Gallagher, A Carlin and MH Murphy critically reviewed the chapter.

Chapter 3: The Effectiveness of School-Based Interventions on Obesity-Related Behaviours in Primary School Children: A Systematic Review and Meta-Analysis of Randomised Controlled Trials

The following work was conceptualised by S Nally, AM Gallagher, A Carlin and MH Murphy. The systematic search of the literature, screening, data extraction and synthesis was conducted by S Nally. JS Baird and A Carlin assisted data extraction and synthesis. S Nally and AM Gallagher performed the quality assessment. S Nally and N Blackburn conducted the meta-analysis. S Nally prepared a manuscript for publication under the supervision of MH Murphy, AM Gallagher and A Carlin.

Chapter 4: “When You Move You Have Fun”: Perceived barriers, and facilitators of physical activity from a child’s perspective

The following work was conducted by S Nally: study execution and collection of data, transcription of focus group recordings, statistical analysis, interpretation of results and write-up. S Nally and N Ridgers completed the analysis and interpretation of the data. S Nally prepared a manuscript for publication under the supervision of MH Murphy, N Ridgers, A Carlin, and AM Gallagher.

Chapter 5: Investigating Parents’ and Teachers’ Perceptions of the Factors Influencing Children’s School- and Home-Based Physical Activity

The following work was conducted by S Nally: study execution and collection of data, transcription of focus group recordings, statistical analysis, interpretation of results and write-up. S Nally prepared a manuscript for publication under the supervision of A Carlin, AM Gallagher and MH Murphy.

Chapter 6: The impact of the *Children – Sit Less, Move More* intervention to reduce sedentary behaviour and increase physical activity in primary-school children

The following work was conceptualised by S Nally, AM Gallagher, A Carlin, J Salmon and MH Murphy. S Nally adapted the intervention components, completed the development phase, developed the resources and delivered the teacher training. S Nally collected and inputted the data. S Nally conducted statistical analysis, interpretation of results and write-up. MH Murphy, AM Gallagher, and A Carlin critically reviewed the chapter.

Chapter 7: Process evaluation of the *Children- Sit Less, Move More* intervention

The following work was conducted by S Nally: study execution and collection of data, transcription of interviews and focus group recordings, statistical analysis, interpretation of results and write-up. S Nally completed the analysis and interpretation of the data and write-up. MH Murphy, AM Gallagher, and A Carlin critically reviewed the chapter.

Chapter 8: General Discussion and Conclusions

The chapter was entirely written by S Nally. The following work was conducted by S Nally: all arguments/discussion points were developed, summarised each of the chapters, described how the results of this thesis fits in the current scientific literature and what it means for future research. AM Gallagher, MH Murphy and A Carlin critically reviewed the chapter.

Chapter 1: General Introduction

1.1.The research problem

Prolonged sedentary time is negatively associated with a range of health and well-being outcomes in children (Carson *et al.* 2016) and is a risk factor for all-cause mortality and chronic disease morbidity in adults (Biswas *et al.* 2015; Ekelund *et al.* 2016). Children spend most of their waking hours engaged in sedentary behaviour (SB) (Geidl *et al.* 2020; Guthold *et al.* 2020). Children spend prolonged periods of time sitting throughout the day (McManus *et al.* 2015; Lobenius-Palmér *et al.* 2018) especially during school hours (Sherry *et al.* 2019). Regular physical activity (PA) is associated with many health benefits for children, including improved cardiometabolic health, promotion of healthy weight and enhanced psychological well-being (Janssen & LeBlanc, 2010; Poitras *et al.* 2016). Recent evidence suggests that the effects of SB and PA are not as ‘*independent*’ as previously considered and may interact to influence health (Rosenberger *et al.* 2019; Dempsey *et al.* 2020). Both movement behaviours (e.g., PA and SB), are associated with health outcomes in children (Julian *et al.* 2022). Despite this, latest global PA figures suggest that children’s PA “*remains a serious public health concern*” (Aubert *et al.* 2022). The latest data in Northern Ireland (NI) indicates that 79% of primary schoolchildren (aged 9 to 11 years) are insufficiently active (Woods *et al.* 2022) and spend long periods sitting (Connolly *et al.* 2020). Thus, effective strategies that increase childhood PA and reduce SB are imperative to tackle the rise of physical inactivity and SB (Bull *et al.* 2022).

Whole school approaches are identified as one of the ‘*Eight investments that work for physical activity*’ by the International Society for Physical Activity and Health (ISPAH) (Milton *et al.* 2021) reflecting the importance of the school environment in offering an opportunity to accumulate PA and reduce sedentary time. School based interventions are helpful in overcoming inequalities sometimes associated with other intervention as all children can be targeted irrespective of socioeconomic status (Kriemler *et al.* 2011). In recent years there have been a range of interventions targeting children that aim to address SB along with PA, with some research indicating that targeting both health behaviours simultaneously achieve maximum health benefits (Tremblay *et al.* 2011; Salmon *et al.* 2023). To effectively address children’s inactivity, several approaches to reduce prolonged sitting time and increase children’s opportunities to be physically active within the school environment have been

examined (e.g., classroom-based activity breaks, incorporating changes to the school environment, prescribing active homework) (Salmon *et al.* 2011). Although research suggests that some of these approaches can reduce class time sitting (Daly-Smith *et al.* 2018), inconsistent findings have been reported regarding the effectiveness of primary school-based interventions at improving PA and reducing SB (Dobbins *et al.* 2013). Furthermore, researchers have found some positive intervention effects on health behaviours during specific parts of a school day, including during play/recess (Parrish *et al.* 2013), within school physical education (PE) classes (Lonsdale *et al.* 2013) and after-school (Mears & Jago, 2016), however, these specific components have not been evaluated in the NI primary school setting.

Recent systematic reviews have concluded that efforts to increase PA in most schools typically fail due to several reasons including; suboptimal implementation of the programme; well-designed interventions not reaching the target populations; poor adherence to the intervention at the student level; and effects not maintained across the school day (Love *et al.* 2019; Neil-Sztramko *et al.* 2021). However, one intervention that has been successful, is the multi-component school- and home-based ‘*Transform-Us!*’ intervention (Salmon *et al.* 2011). Briefly, the intervention uses innovative behavioural, pedagogical, and environmental strategies within the classroom, school, and home settings to promote PA and reduce SB in Australian children (aged 8-9 years) (Salmon *et al.* 2011). The *Transform-Us!* cluster-randomised controlled trial (cRCT) was deemed appropriate for the school setting (Koorts *et al.* 2022), effectively reduced children’s SB (Salmon *et al.* 2023) and demonstrated that the “*break up your sitting*” statement may be more impactful than the “*move more*” statement in schoolchildren aged 8-9 years (Verswijveren *et al.* 2022).

Conversely, within the NI school and home setting we do not have similar multi-component interventions which have been subjected to rigorous evaluation. Due to numerous local contextual differences between Australia and NI, the thesis will address this gap in evidence and adapt the *Transform-Us!* intervention accordingly. If a feasible intervention, developed to target PA and SB in schoolchildren could be scaled-up across all primary schools in NI, it would have significant potential to impact population health (Connolly *et al.* 2020). Subsequently, this thesis aims to address the gap in the literature and includes a series of studies that intends to evaluate

current influences and approaches to reduce SB and promote PA in children (aged 7-9 years) leading to the adaption of a multicomponent school- and home-based pilot test in NI.

1.2. Conceptual framework

Recent recommendations highlight the importance of systematic development of interventions, using appropriate evidence and theory (O’Cathain *et al.* 2019; Fernandez *et al.* 2019). The Medical Research Council (MRC) framework is based on a paradigm in which the primary research question is to identify whether an intervention was effective (Craig *et al.* 2008). The framework aims to help researchers work with stakeholders to identify key research questions, to design and conduct complex interventions with suitable choice of methodologies. The original MRC framework (2008) described a four-stage process of developing complex interventions: (1) development, (2) feasibility/piloting, (3) evaluation and (4) implementation (Craig *et al.* 2008). The framework has been widely used; however, several theoretical and methodological developments have occurred since the formation of this framework (Moore *et al.* 2015). Consequently, a new MRC framework (2021) (Figure 1.1.) expands on the pre-existing framework (Craig *et al.* 2008), taking a more diverse approach and identifying the importance of whole system interventions (Skivington *et al.* 2021).

The MRC framework supports the development of this thesis and the methodological approaches used. The MRC framework identifies three broad stages of intervention development: developing theory, modelling process and outcomes and assessing feasibility (Skivington *et al.* 2021). The framework suggests that a research intervention may begin at any phase, depending on the specific research question(s). Six core elements are positioned in the centre of the figure and consist of: (1) context, (2) develop refine and (re)test programme theory, (3) engage stakeholders, (4) identify key uncertainties, (5) refine intervention, and (6) economic considerations (Skivington *et al.* 2021). The MRC framework recognises the importance of conducting feasibility/pilot studies and recommends an evaluation to support the implementation and development of future interventions.

Evidence-informed and well-implemented school-based interventions can influence PA and reduce SB in children (Kriemler *et al.* 2011; Jago *et al.* 2015). However, systematic reviews have reported various reasons for intervention inconsistencies including varying levels of robust measures and methodology, selection bias, limited intervention exposure and implementation, as well as the quality and quantity of intervention components (Dobbins *et al.* 2013; Naylor *et al.* 2015). One possible reason for this, is the omission of stakeholders, school educators and pupils from the development of school-based interventions (Christian *et al.* 2015). An ineffective planning process may have a detrimental impact on intervention implementation, sustainability, and effectiveness (Christian *et al.* 2015; Naylor *et al.* 2015).

Following a standardised phased approach to intervention development and understanding the mechanisms behind intervention effectiveness is important for scale-up (Skivington *et al.* 2021). Stakeholder and pupil engagement in future research is warranted to understand the factors influencing children's PA and SB and to help inform future intervention design (Hidding *et al.* 2017; Emm-Collison *et al.* 2022). Subsequently, this thesis will focus on some (identification/development, feasibility, evaluation but not all implementation) stages of the MRC framework for the evaluation of complex intervention.

1.3.Thesis aims and objectives

This PhD was funded by *Northern Ireland Chest Heart and Stroke* (NICHs) and intended to use current research evidence and international best practice to design, and pilot test a classroom, school, and home-based intervention in primary school-aged children. Therefore, the overarching aim of the research programme was to evaluate current influences and approaches to reduce SB and promote PA in children (aged 7-9 years) leading to the development and pilot testing of a multicomponent school- and home-based intervention in primary school-aged children, using a mixed-methods approach.

Specifically, the studies presented in this PhD aim to:

1. Review the published literature to assess the effectiveness of school-based interventions at changing obesity-related behaviours in primary school children (**Chapter Three**).
2. Explore the current views, barriers, and facilitators to PA in children and how best to promote activity and decrease sitting time in this population (**Chapter Four**).
3. Explore the current views, barriers, and facilitators to PA in parents and teachers of children aged 7-9 years and determine the best method to promote activity and decrease sitting time in children (**Chapter Five**).
4. Test the feasibility and effectiveness of an 8-week multicomponent school- and home-based PA intervention, based on an adapted version of the efficacious *Transform-Us!* intervention (**Chapter Six**).
5. Evaluate the processes influencing the feasibility, reach, and acceptability of implementing the *Children- Sit Less, Move More* (C-SLAMM) intervention and generate recommendations to inform a future fully powered cRCT (**Chapter Seven**).

1.4. Thesis structure

The thesis is composed of eight chapters, of which this introduction is first. The current section establishes the thesis structure. Chapter Two is a literature review which synthesises the current evidence relating to PA, SB, and health in children. The review provides a definition of key terms, current trends in PA and SB, summarises methods of PA and SB measurement, identifies influences on PA, evaluates previous interventions to change PA, and links behaviour change theory into practice. As the review is focused on children, emphasis will be placed on the best way to prevent the decline of PA often observed as individuals move from childhood through to adolescence and how best to encourage PA. Also, the review describes the *Transform-*

Us! programme, a successful intervention that has been trialled in Australian primary schools and upon which this thesis is based. The literature review critiques the current literature and highlights a rationale for the programme of research. Chapter Three presents a systematic review on the effectiveness of school-based interventions for primary-school children and summarises the effectiveness of previous RCTs/cRCTs and highlighting the changes in obesity-related behaviours (Study 1).

Chapter Four presents an exploratory investigation into children's perceptions of PA at home and at school. This chapter illustrates the formative work conducted to inform development of the *C-SLAMM* intervention (Study 2). Chapter Five presents an exploratory investigation into parents' and teachers' perceptions of PA in the classroom, school, and home environment, to inform the design of a future PA intervention in NI (Study 3). Chapter Six demonstrates the impact of the *C-SLAMM* intervention has on the primary outcome (sitting time) and PA levels of primary-school children. This chapter provides detail on the study design, the development of the multicomponent intervention, recruitment and selection of participants, data collection methods and techniques, and data analysis. Study-specific data reduction methodology for sitting time and PA are described in detail in this chapter (Study 4). Chapter Seven presents the process evaluations of the *C-SLAMM* intervention. The feasibility, reach and acceptability of the intervention in primary school settings is examined. The qualitative findings highlight key aspects influencing the implementation of the intervention in the school setting and evaluates whether the intervention was feasible and acceptable to primary school children and their teachers (Study 5).

Chapter Eight provides a general discussion of the overall findings, together with recommendations for future practice and research. The strengths and limitations of the programme of research are considered, as well as future practical implications for disseminating and adopting the *C-SLAMM* intervention at scale. The chapter synthesises the main findings of the experimental chapters in order to consider the wider implications of thesis findings and make suggestions for future practice and research.

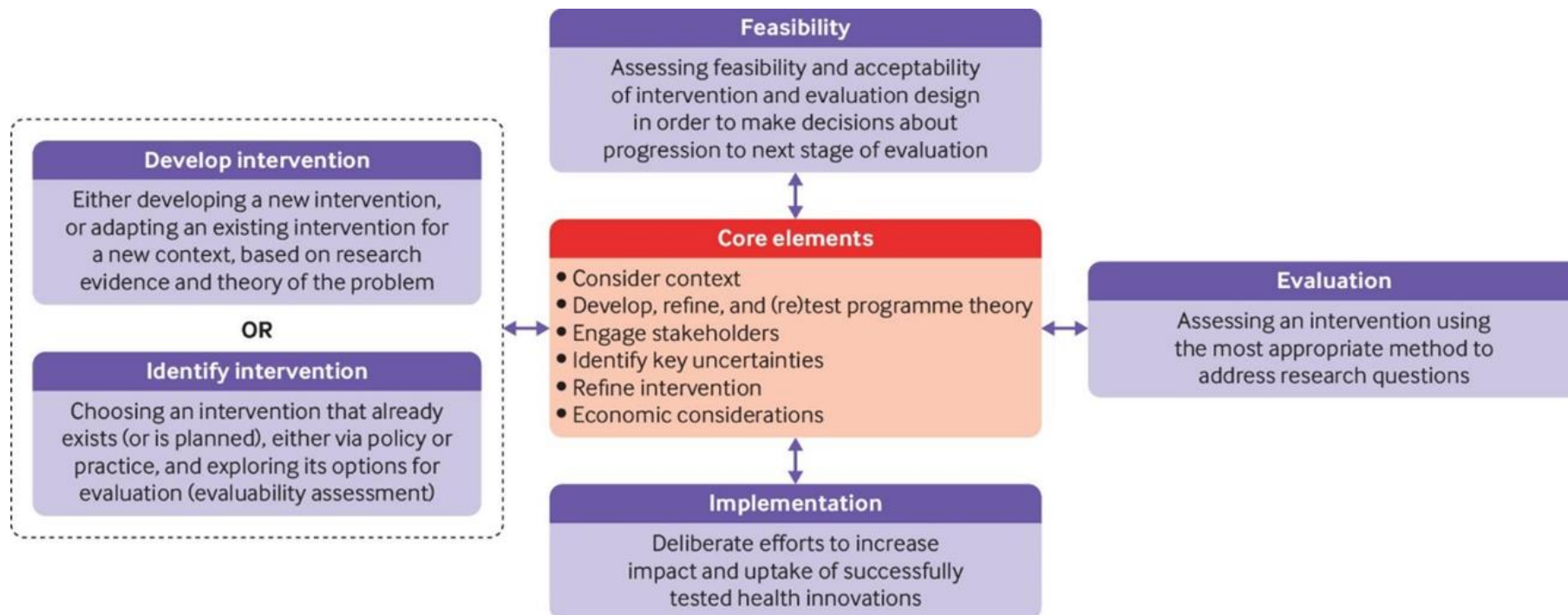


Figure 1.1. Framework for developing and evaluating complex interventions from Skivington *et al.* (2021).

Chapter 2: Literature review

Overview of Literature Review

The aim of this chapter is to review the evidence on physical activity (PA) and sedentary behaviour (SB) in children. Current trends in PA and SB will be examined, and associated health and social consequences of the observed decline of PA will be reviewed. A summary of the evidence to date on the assessment of PA and SB in this population will be provided. As the review is focused on children, emphasis will be placed on the best way to prevent the decline of PA often observed when individuals move from childhood through to adolescence and how best to encourage PA. PA and SB in schools will be reviewed as the school environment represents an opportunity to modify unhealthy behaviours and model healthy behaviours. Additionally, the review will focus on the *Transform-Us!* programme, a successful intervention that has been trialled in Australian primary schools and has beneficial intervention effects on total weekday sedentary time and children's PA. The latter sections discuss important literature related to key theoretical frameworks used to develop interventions, and ways to assess intervention feasibility. The final section provides an overview of the mixed-methodological research approach used throughout this thesis.

2.0. Physical activity and sedentary behaviour in children

The World Health Organization (WHO) defines '*pre-schoolers*' as a child under 5 years, '*children*' as 5-to-9 years old, '*adolescents*' as 10–19-year-olds and '*youth*' as the 15–24-year age group. The term '*childhood*' refers to a period in the human lifespan from the acquisition of language to the onset of adolescence at 12 or 13 years. In Northern Ireland (NI), the Children NI Order 1995, defines a '*child*' as a person under the age of 18. As variations in definitions exist between countries regarding the age of children and adolescents (i.e., up to 17 years or up to 18 years), this thesis will focus on the WHO definition unless otherwise stated.

2.1. Physical activity, sedentary behaviour, and inactivity definitions

PA commonly defined as '*any bodily movement produced by skeletal muscle that results in energy expenditure*' (Caspersen *et al.* 1985). Energy expenditure (EE) refers to the '*amount of energy an individual uses to maintain essential body functions (e.g., respiration, digestion) and as a result of physical activity*' (Heaney 2013). Piggin (2020) claims that the definition of PA by Caspersen *et al.* (1985), and similar definitions of PA are too simplistic, use specific epidemiological and biomedical terms

and subsequently are not inclusive beyond the disciplines they have been defined by (e.g., academic disciplines that study PA). Furthermore, Piggin (2020) urges teachers, researchers, and policymakers to reflect upon the ‘*orthodox*’ definition of PA. The conceptual analysis by Piggins, highlights that a new definition of PA is warranted as it is imperative that a PA definition should refer to a variety of essential descriptions and affords a deeper appreciation of the complexities surrounding PA participation (e.g., psychological, social, political). Thus, the broader, holistic proposed PA definition states: ‘*people moving, acting, and performing within culturally specific spaces and contexts, and influenced by a unique array of interests, emotions, ideas, instructions, and relationships*’ (Piggin 2020). According to the WHO, PA can be carried out during leisure time, for transport to and from places, and may be planned or spontaneous (e.g., structured or play) (WHO 2019). Exercise is a subset of PA, defined as PA that is ‘*planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective*’ (Caspersen *et al.* 1985). Although sometimes used interchangeably, physical fitness relates to a ‘*set of attributes that people have or achieve...concerning flexibility, body composition, muscular strength, muscular and cardiorespiratory endurance*’ (Caspersen *et al.* 1985). Despite important distinctions between these constructs, PA does not equate to exercise and physical fitness.

PA is a complex construct that can be classified both qualitatively and quantitatively (Butte *et al.* 2012). According to the FITT classification, PA consists of four main dimensions: (1) *frequency* of the activity (number of PA events in a specific period), (2) *intensity* (rates of EE), (3) *time* (duration of PA event), and (4) *type* of activity (Montoye 2000; Cavill *et al.* 2006); all of which influence the amount of energy expended by being physically active (Barisic *et al.* 2011). One metabolic equivalent (MET) refers to the amount of oxygen consumed while sitting at rest and is equal to an oxygen uptake of $3.5 \text{ ml/kg}^{-1}/\text{min}^{-1}$, or $1 \text{ kcal/kg/hr}^{-1}$ (Ainsworth *et al.* 1993). Exercise intensity can be quantified in METs (i.e., refers to the EE associated with the physical activities compared to or as multiples of resting metabolic rate) (Ainsworth *et al.* 2011). The *Adult Compendium of Physical Activities*, developed by Ainsworth *et al.* (2011), is used globally to quantify the intensities of various forms of PA and consists of 821 activities. In adults, the intensity classifications have been devised based on MET values: light-intensity PA (1.6-2.9 METs), moderate-intensity (3-5.9

METs) and vigorous-intensity (≥ 6 METs) PA (Ainsworth *et al.* 2011). However, adult MET values are not valid for children, as they would underestimate basal metabolic rate (BMR) of children (McMurray *et al.* 2014). Following an extensive literature review of pooled data investigating EE in youth, (Butte *et al.* 2018) developed the *Youth Compendium of Physical Activities* (Youth Compendium). As the review addressed the age dependency of MET_y values, the Youth Compendium is a valuable resource for standardising and interpreting PA data (e.g., for health research and public health surveillance applications). The review determined MET_y values for 196 activities by combining data that was measured previously (51%) and by using numerous imputation mixed model for each PA (49%) for missing MET_y values (Butte *et al.* 2018).

SB is defined as ‘*any waking behaviour characterized by an energy expenditure ≤ 1.5 METs while in a sitting or reclining posture*’ (Tremblay *et al.* 2017). SB is an important indicator for quantifying health and should not be confused with physical inactivity or insufficient PA, it is vital that a clear distinction is made in health research between the last two terms as they are often used interchangeably in the literature (WHO 2010). Physical inactivity is defined as ‘*insufficient levels of physical activity to meet physical activity guidelines*’ (Tremblay *et al.* 2017), while insufficient PA relates to levels of PA that are not sufficient to gain health-related benefits (e.g., an average of at least 60 min/day) (WHO 2020). Thus, being physically inactive does not automatically constitute a person as ‘sedentary’. It is possible to meet or exceed the public health guidelines for moderate-to-vigorous physical activity (MVPA), and yet also spend most waking hours sedentary. Individuals can be both physically active and spend a large proportion of their day in sedentary pursuits (Owen *et al.* 2010). Achieving a better understanding of quantified guidance for amounts of SB, especially in the context of different levels of PA is essential. Instead of exploring the benefits of reducing or increasing the time in movement behaviours in isolation, research efforts have focused on the combined effects of PA and SB during a 24-hour period on health outcomes.

2.2. Children’s physical activity, sedentary behaviour and health

There is unequivocal evidence for the importance of regular PA during all stages of life (Strain *et al.* 2020a). A dose-response relationship exists between PA and the risk

of all-cause mortality in adults (Geidl *et al.* 2020). Research also indicates that PA has been proposed as a form of primary prevention for at least 35 chronic conditions in individuals, including obesity, osteoporosis, and cystic fibrosis (Booth *et al.* 2012) and as front-line treatment of several non-communicable diseases (NCDs) (Pedersen & Saltin, 2015). Regular PA is associated with a variety of health benefits for children and averts the onset of a range of NCDs, including obesity, type II diabetes and cardiovascular disease (CVD) (Jeon *et al.* 2007; Lee *et al.* 2012). PA is widely noted for health benefits including the following health outcomes; improved physical fitness (cardiorespiratory and muscular fitness), metabolic and cardiometabolic health (blood pressure, dyslipidaemia, and insulin resistance), cognitive outcomes (academic performance, executive function), mental health (reduced symptoms of depression); and reduced adiposity (Gabel *et al.* 2017; Rodriguez-Ayllon *et al.* 2019; Strain *et al.* 2020a). A review specifically investigating PA and exercise in children and adolescents, found that participating in PA improves mental health, sleep quality, brain development, and social, psychological, and cognitive health (Alvarez-Pitti *et al.* 2020). Poitras *et al.* (2016), found PA was favourably associated with adiposity, bone health, motor skills, cardiometabolic biomarkers and physical fitness school-aged children and youth. Furthermore, there is consistent evidence that children who engage in higher levels of PA are associated with improvements in motor performance, muscular strength and cognitive development (e.g., academic achievement) (Morgan *et al.* 2013; Zeng *et al.* 2017).

The WHO indicates that 80% of major NCDs (for example, cancer and CVD) may be prevented by targeting lifestyle risk factors such as physical inactivity, unhealthy diets and obesity (WHO 2017). By 2030, it is anticipated that over one billion adults globally will be obese (Lobstein *et al.* 2022). In this review, obesity will be examined rather than other NCDs as PA plays a fundamental role in energy balance and weight control (Manore *et al.* 2017). Increasing PA is important for preventing and treating overweight and obesity in children. The fundamental cause of childhood overweight and obesity is an energy imbalance between energy intake and EE (Westerterp 2017). Obesity is a chronic disease and is defined as an ‘*abnormal or excessive accumulation of fat*’ that presents a risk to health (WHO 2022). It is important to note that optimal levels of PA in children is associated with a wide range of benefits, it is not limited to its role in weight management (Cesa *et al.* 2014; Donnelly *et al.* 2016).

Across the lifespan levels of PA remain low (WHO 2019) and obesity levels continue to escalate (Lobstein *et al.* 2022). The epidemic of childhood obesity is worsening at a dramatic rate, with 124 million children and adolescents estimated to suffer with obesity worldwide in 2016 (Abarca-Gómez *et al.* 2017). Furthermore, approximately 25% of obese children (aged 6–9-years) across 21 European countries have severe obesity (Spinelli *et al.* 2019). Childhood obesity is a multifactorial disease (Swinburn *et al.* 2011), only PA and SB will be discussed in this review as other factors (e.g., energy intake) are beyond the scope of this thesis. Obesity can affect the child's ability to play or engage in PA and subsequently it can limit participation (Vandewater *et al.* 2015). Children who are overweight or obese carry more body mass and this could negatively affect their fundamental movement skills and physical fitness levels (Sahoo *et al.* 2015). Equally, children who engage in PA are less likely to become or be overweight or obese (Poitras *et al.* 2016). Thus, adiposity and PA are interrelated (Jiménez-Pavón *et al.* 2010).

Researchers have found that, independent of PA, prolonged sitting time adversely affects children's health (Mitchell & Byun, 2014). Emerging evidence suggests that an increase in SB and a decline in PA starts from a young age, probably at 7-9-years old and then tracks through adolescence into adulthood, with inactive, sedentary children becoming inactive, sedentary adults (Cooper *et al.* 2015). SB is a complicated behaviour, the type of SB and how it is accumulated during the day has varying impacts on health. Consequently, while the message of reducing sitting time is a simple message, the impact on health outcomes may depend on how it is reduced and what is replaced with. Replacing SBs with increased amounts of light-intensity-physical activity (LIPA) is oftentimes overlooked as a strategy for mitigating excessive adiposity in children (Carson *et al.* 2013; Loprinzi *et al.* 2015). Research suggests that SB is one of the most prevalent health-related behaviour demonstrated by children (e.g., as they accumulate 8 h/day of sedentary time) (Bauman *et al.* 2018).

During childhood, engaging in SB, such as playing games on an electronic device (e.g., tablet), watching television (TV), and using a computer are highly prevalent, with children spending most of their waking hours sedentary (Verloigne *et al.* 2016; Larouche *et al.* 2016). Accumulating high levels of SB is associated with adverse cardio-metabolic health risk-markers, reduced self-esteem, and academic performance

in children (Carson *et al.* 2016; Chaput *et al.* 2020). Epidemiological studies have revealed that higher amounts of screen time are correlated to increased body mass and adiposity in children (Prentice *et al.* 2012; Biddle *et al.* 2018). Higher amounts of SB are associated with the following poor health outcomes: increased adiposity; poorer cardiometabolic health, fitness, behavioural conduct/pro-social behaviour; and reduced sleep duration (Biddle & Asare, 2011; Suchert *et al.* 2015; Stanczykiewicz *et al.* 2019). Furthermore, research demonstrates the negative impact SB has on childhood obesity (Carson *et al.* 2016).

2.3. Children's physical activity and sedentary behaviour guidelines

As rates of NCD's escalate globally, prevention is imperative and evidence-based PA and SB guidelines are necessary to guide policy makers. In 2020, the WHO updated their PA guidelines to recommend children and adolescents to engage in on average 60 minutes of MVPA per day (WHO 2020). Additionally, children and adolescents (aged 5-17 years) are recommended to limit the amount of sedentary time, specifically the amount of recreational screen time (WHO 2020). Previously the WHO (2010) recommendations did not include SB, however over the past few years there has been a substantial increase in research examining SB (Rhodes *et al.* 2020; Kuzik *et al.* 2022). Furthermore, it is recommended that vigorous-physical activity (VPA), and muscle and bone strengthening activities are incorporated at least three days per week. The WHO encourages countries to adopt the global guidelines to develop national health policies in support of the WHO *Global action plan on physical activity 2018-2030* (WHO 2019). The plan was agreed by global health leaders to reduce physical inactivity by 15% by 2030. Nonetheless, research suggests that there are still several countries without PA and SB guidelines guiding policy and practice (Parrish *et al.* 2020).

Australia and Canada take a different approach to other countries, by opting for 24-hour movement guidelines, emphasizing the potential importance of health opportunities across the entire day (Tremblay *et al.* 2016; Santos *et al.* 2017). For example, in Canada the guidelines combine recommendations for PA, SB and sleep for a 24-hour period rather than a set of isolated guidelines (Tremblay *et al.* 2016). Evidence suggests that each of the three movement behaviours (e.g., PA, SB and sleep), is associated with health outcomes in children (Julian *et al.* 2022). Furthermore,

as these behaviours are interdependent (e.g., time spent sleeping reduces the time spent being active), it is sensible to provide combined movement behaviours across the entire 24-hour period. However, up until now Canada and Australia are the only countries that have adopted 24-hour guidelines for children (Australian Department of Health 2017; Tremblay *et al.* 2017). The United Kingdom (UK) take a different approach to Australia and Canada, as the recommendations include children (aged 5-18 years) and state that they should: (1) engage in an average of at least 60 minutes of MVPA per day across the week; (2) participate in a variety of types and intensities of PA across the week to develop movement skills, muscular fitness and bone strength; and (3) encourage SB to be broken up with regular bouts of LIPA, and to minimise the amount of time spent being sedentary (Davies *et al.* 2019). In NI and Ireland, children and adolescents (6-17 years) are recommended to accumulate at least 60 minutes per day of MVPA (UK Chief Medical Officers' Physical Activity Guidelines, 2019), or an average of at least 60 minutes of MVPA per day across the week, for health (Department of Health and Children HSE 2009).

Due to considerable cross-country variability regarding PA guidelines, a systematic review was undertaken to identify and compare national and international PA guidelines for children and adolescents (Parrish *et al.* 2020). The review identified 50 national/international PA guidelines, highlighted varying guidelines in reference to time spent being physically active and found that low-income countries might not have the resources for guideline development (Parrish *et al.* 2020). Although the risk of SB in childhood is now mentioned in the PA guidelines (WHO 2020), a threshold value is yet to be provided. Consequently, variations in the development and wording of PA and SB recommendations have generated substantial variability in global PA and SB guidelines for children.

2.4. Prevalence and trends of activity in children

2.4.1. Global prevalence and trends

As discussed previously (see **Section 2.2.**), PA is associated with many health benefits in children. Despite these well-established health outcomes, data suggests that only a third of primary school aged children meet the international public health PA recommendations (WHO 2020). Global trends indicate that there is an urgent need for

national and global action to address the decreasing levels of PA in children (Parrish *et al.* 2020). Globally, an analysis conducted by the WHO pooled 298 school-based surveys from 146 countries ($n = 1.6$ million students; aged 11-17 years), found that 81% did not meet current recommendations of daily PA (Guthold *et al.* 2020). Both self-report and device-measured data was used to assess global trends in children (aged 5-to 17 years) PA levels, resulting in the '*Global Matrix 4.0*' (Aubert *et al.* 2022). The organisation *Active Healthy Kids Global Alliance* (AHKGA) led the global comparison and gathered evidence from 57 countries to provide a standardised grade reflecting PA levels. Findings from the *Global Matrix 4.0* reveal that the overall situation regarding youth PA is worrying, as only 27-33% of children (aged 5-17 years) are sufficiently active worldwide (e.g., accumulate at least 60 min of MVPA per day on average) (Aubert *et al.* 2022). In contrast with findings from the *Global Matrix 3.0* ($n = 49$ countries), 34-46% of children were sufficiently active worldwide (e.g., engage in at least 60 minutes of MVPA per day) (Aubert *et al.* 2018).

The *Global Matrix 4.0* used screen time as a proxy for SB, as global SB recommendations commonly refer to reducing or limiting screen time in children. Data revealed that high levels of screen time were of concern in high human development index (HDI) countries, in comparison to the low and medium HDI countries (Aubert *et al.* 2022). The observed decline in PA and high levels of SB among youth, may be due to the variation in recommendations and/or the challenge of prioritising PA during the COVID-19 pandemic (Xiang *et al.* 2020). Nevertheless, global levels of inactivity remain a serious public health concern and urgent action is required to increase PA opportunities for children across the globe (WHO 2018).

Steene-Johannessen *et al.* (2020) pooled together and harmonised individual-level Actigraph data from 18 different European countries and found that boys were more active (13 minutes more MVPA per day) and less sedentary than girls (8 minutes less per day). Of the 47,497 children and adolescents (2-to-18 years) measured, 29% (95% confidence interval 25 to 33) were considered as sufficiently physically active (e.g., engaging an average of 60 minutes or more of MVPA per day) and participants spent 49.2% of their measured time sedentary (Steene-Johannessen *et al.* 2020). It is important to note that, time spent sedentary increased gradually from childhood (4–5 years) to adolescence (16–17 years) (Steene-Johannessen *et al.* 2020). In contrast, a

cross-sectional analysis based on International Children's Accelerometry Database (ICAD) reported a significantly lower prevalence, with 9% of boys and 2% of girls achieving no more than 60 minutes of MVPA per day (Cooper *et al.* 2015). The ICAD synthesises accelerometer data from cross-sectional and longitudinal studies across 10 countries (Cooper *et al.* 2015). The synthesis revealed a 4.2% decline in MVPA per year in children, which occurred from the age of five years, and not during adolescence as previously thought (Cooper *et al.* 2015). A reviewed conducted by LeBlanc *et al.* (2015) assessed the prevalence of sedentariness, in a global sample of 5,844 children (9–11-year-old children) from 12 different countries and found that children accumulate on average 8.6 hours of sedentary time daily. The review also found 54.2% of children failed to meet sedentary time guidelines of ≤ 2 hours/day (Tremblay *et al.* 2011; LeBlanc *et al.* 2015). An additional systematic review investigating the prevalence of SB among children and adolescents (aged 5–18 years) concluded that children spend between 40% and 60% of their time sitting (Arundell *et al.* 2016). It is important to note that although the robust systematic reviews (LeBlanc *et al.* 2015; Arundell *et al.* 2016) included a geographically and culturally diverse study sample, the reviews predominantly relied on a proxy measure of sedentary time (e.g., screen time) which can be subject to considerable recall bias in children (Arts *et al.* 2022).

In line with global trends (Guthold *et al.* 2020; Inchley *et al.* 2020), many young people in the UK are not meeting the current recommendations (Davies *et al.* 2019). Previous studies have highlighted that approximately 50% of children (between five to eight years of age) met the PA guidelines in the UK (Griffiths *et al.* 2013; Jago *et al.* 2014). A study conducted in England, UK, assessing PA levels using accelerometers, involving 886 school children (9-to 10-year-old) from 32 schools (53 classes) found a significantly higher portion of boys than girls met the PA recommendations (Price *et al.* 2018). Jago *et al.* (2020) found that daily sedentary time ranged between six and eight hours for 6-to-11-year-old children in the UK ($n = 2,132$). Recent findings from Hesketh *et al.* (2022), found that 6-year-old British children ($n = 712$) were sedentary for an average of 316 minutes (five hours) per day. Although there was substantial variability in the estimated prevalence of children adhering to the recommendations, the difference of device-based compared to self-report measures and the variation in data reduction methodology, may explain the contrasting PA and SB levels reported. It is challenging to accurately capture the

prevalence of children meeting the guidelines due to the varying nature of PA and SB measurements across the aforementioned studies. Research suggests that previous studies may be overestimating prevalence of PA in the population due to inconsistencies in PA measurement methodologies (e.g., methodological variations linked to the reduction, processing, and analysis of data) (Bai *et al.* 2016).

A systematic review examining longitudinal changes in PA found that MVPA declines occur more rapidly in girls than boys (-5.3% versus -3.5%) (Farooq *et al.* 2020). Findings from the meta-analysis subgroup-analysis found that MVPA declines when children get older, specifically from around 6 years old in girls and from the age of 9 among boys (Farooq *et al.* 2020). Results from other European studies found that boys are more active than girls (Konstabel *et al.* 2014; Cooper *et al.* 2015). Data from the Bristol B-Proac1v cohort study examined PA and sedentary time in approximately 2,000 British children from 57 schools in England, UK (Jago *et al.* 2020). The longitudinal findings demonstrated that mean minutes of MVPA per day on weekdays declined by 2.2 minutes per annum (95% confidence interval 1.9 to 2.5) and the average sedentary time increased at a rate of 12.9 minutes per annum, between 6 and 11 years of age (95% confidence interval 12.2 to 13.6). Furthermore, the study also found gender differences regarding PA and sedentary time (Jago *et al.* 2020). Girls' MVPA declined at a faster rate, engaged in less MVPA and were more sedentary on both weekdays and weekends than boys at age six (Jago *et al.* 2020). Furthermore, a review published by Pearson *et al.* (2017), examined 11 articles (19 independent samples) and found that screen use increased as children transition to adolescence ($r = 0.3$ to 0.5). Thus, research indicates that a particular emphasis to increase PA and reduce SB is required in primary school children, particularly at the time children transition into primary school (Pearson *et al.* 2017). Future research should focus on primary-school children as it is an important opportunity to ensure a much higher proportion of children (aged 6-11 years) achieve the recommended levels of PA.

Amongst the studies that investigated SB using device-based measures (e.g., accelerometers measuring total sedentary time), Janssen *et al.* (2016) found an increase across the age range (6 to 15 years), displacing MVPA and LIPA over time. Another longitudinal analysis was conducted using accelerometer data and found that children aged six were more sedentary (accumulating on average 30 minutes more

sedentary time per day) compared to when they were four (Hesketh *et al.* 2022). Findings from the Millennium Cohort Study (n = 6497), included a national representative sample of UK children (aged 7 years), found that children exceed an average of 6 hours of sedentary time per day (Griffiths *et al.* 2013). Furthermore, results detected children in NI were less active and less likely to achieve the PA recommendation (compared to the rest of the countries in the UK) (Griffiths *et al.* 2013). It is important to note, that although Griffiths *et al.* (2013) was the first UK-wide study of children's objectively measured PA, data was collected over twenty years ago, and since then, data reduction methods and accelerometer research has improved (Griffiths *et al.* 2013). Device-based measurements of PA and sedentary time should be interpreted with caution as different devices, cut points and data-reduction methods were used to obtain the data and no gold-standard data processing method is currently available (Troiano *et al.* 2014).

In summary, the evidence suggests that globally, many children are insufficiently active and sedentary time increases on average for children as they get older (between the ages 6 and 11). Overall, the prevalence and trends of PA and SB in children suggests that boys are more active than girls, MVPA levels decline with age and obese children are less active than normal weight children (Dorsey *et al.* 2011). Studies in 7-to-9-year-old school children demonstrate a clear need to develop new approaches to increase the MVPA levels and reduce overall sedentary time in primary school children.

2.4.2. Prevalence and trends in Ireland

Across the island of Ireland, the most recent data for PA and SB in children and adolescents were collated from research papers (2016-2020), to assign grades for the *2022 Ireland North and South Report Card* which was produced as part of the AHKGA to monitor changes in PA. Difference in PA patterns were observed as boys were more active than girls, and younger children were more likely to meet the PA recommendations than adolescents (Murphy *et al.* 2016; Woods *et al.* 2018). For overall PA participation, the *2022 Ireland North and South Report Card* examined eight data sets and found positive trends regarding children's PA across the island of Ireland (Ng *et al.* 2022). Nevertheless, among the eligible data sets that examined PA across the island of Ireland, only one longitudinal study used accelerometer-based

measurements to measure PA (Belton *et al.* 2019). Furthermore, four studies that measured SB were included in the review, with only one using accelerometer-based measurement to measure sedentary time (Keane *et al.* 2014). However, this study was conducted in one location in Ireland and is not representative of the Northern Irish or Irish cohort. Thus, further research is warranted using accelerometer-based measurement to assess PA and SB primary-school children, particularly in NI. The Children's Sport Participation and Physical Activity (CSPPA) study was conducted to investigate PA, sports participation, and physical education (PE) among children and adolescents (aged 10-18 years) across the island of Ireland (n = 6,651). Results found that only 17% of primary school children in Ireland and 20% of primary school children in NI meet the recommended 60 minutes of MVPA a day (Connolly *et al.* 2020). Previously, Woods *et al.* (2018) found that primary school children in NI accumulated on average 5 hours of screen time per day, with 58.5% of children meeting the recommendations of no more than 2 hours of screen time per day (in comparison to 63% of primary school children in Ireland) (Woods *et al.* 2018).

Overall, the 2022 *Ireland North and South Report Card* identified key gaps in the literature and has highlighted that further research is required to ensure all children in Ireland meet the current PA guidelines. Across the island of Ireland, a team of investigators awarded a C- grade for overall PA in children, indicating a slight improvement on the D grade awarded in 2016 (Harrington *et al.* 2016). There was no change for SB from the 2016 report card (Harrington *et al.* 2016). Strain *et al.* (2020) observed that surveillance of PA in the UK is complex and could be improved as inconsistencies in how PA is measured remain. Similarly, across the island of Ireland, further research to better understand the prevalence and trends of PA in children is required as discrepancies in PA and SB measurements remain.

2.5. Correlates and determinants of children's physical activity and sedentary behaviour

It is important to understand the factors affecting PA and SB during childhood, to inform future interventions. Research suggests that there are multiple factors that lead to physical inactivity amongst primary school children (van Stralen *et al.* 2011). As PA and SB are behaviours with considerable variability, specifically individual variability, numerous individual correlates/determinants are influential (Butcher *et al.*

2008). To identify the key factors that influence people's level of participation in PA and understand the relationships between these factors, the application of a social-ecological model (SEM) as an organisational framework has been advocated by many researchers (Boulton *et al.* 2018; Hu *et al.* 2021). The social-ecological approach suggests that no single factor influences behaviour change. The approach categorises factors influencing PA as individual/intrapersonal (e.g., age, genetics), social (e.g., family), environmental (e.g., playgrounds), and policy-related (e.g., within school rules and policies) (Hu *et al.* 2021). Although previous literature has tried to identify and understand factors leading to inadequate PA levels and high levels of SB in children and adolescents, they predominantly focused on the factors at the individual level such as autonomy, competence and self-efficacy (Sallis *et al.* 2000; D'Angelo *et al.* 2017). Early PA interventions have typically focused on intrapersonal factors as predictors of PA participation. Taking an ecological perspective directs attention to the wider political and environmental factors in schools that influence intrapersonal and interpersonal characteristics (Sallis *et al.* 2006; Langille and Rodgers, 2010).

There is consistent evidence to show that boys spend more time being active than girls (Telford *et al.* 2016) and that it is a challenge to support girls PA in schools (O'Reilly *et al.* 2023). As previously mentioned in **Section 2.4**, research indicates that PA levels decline during childhood and adolescence with a greater decline for girls than boys (Nader *et al.* 2008; Cooper *et al.* 2015). In a cross-sectional study investigating the associations between perceptions of the physical/social environment and MVPA, Moore *et al.* (2014) found that environmental correlates (e.g., parental support) and MVPA may vary between boys and girls ($n = 711$; aged 8-to-17 years). Research has shown that girls receive less social support (i.e., from parents and/or peers) than boys ($p < 0.01$) (Reimers *et al.* 2019). Findings from the Australian *Lifestyle of our Kids* (LOOK) study demonstrated that there was a lack of influence of the school on girls' PA (Telford *et al.* 2016). One possible explanation for these findings is that some schools provide more opportunities for children to be physically active, though they are more desirable or more readily accessed by boys (Ridgers *et al.* 2012; Telford *et al.* 2016). Therefore, future research should identify the factors that influence and enhance PA in primary schools, bearing in mind that these factors may differ among boys and girls. Gaining a better understanding about the influences underlying gender differences in PA among primary school children has the potential to guide

intervention strategies predominantly in school-based settings, where boys and girls are most commonly taught together (Walker *et al.* 2020). As a result of the gap in the observed trends in relation to PA and gender influence, gender disparities in PA are a key target area for policymakers in the UK (UK Chief Medical Officers' Physical Activity Guidelines, 2019).

Parents play a significant role in facilitating and regulating their children's movement behaviours (Rhodes *et al.* 2020). Given the importance and complexity of parental influence on children's activity levels, several studies have examined the role of parental support on youth PA (Beets *et al.* 2010; Mutz and Ablrecht, 2017). Parents can serve as role models through their parenting practices (Maric *et al.* 2020) and sources of support as they have the ability to both facilitate and impede PA opportunities (Lindsay *et al.* 2006; Mitchell *et al.* 2012). Studies have observed parent and child PA levels are correlated with one another, with parent-child interaction (Knowles *et al.* 2015), parental encouragement and support (Xu *et al.* 2015; Hidding *et al.* 2017) and parental PA associated with higher PA levels in children (Lu *et al.* 2017; Su *et al.* 2022). In addition, evidence has found parental practices, such as role-modelling, rules, and restrictions influence the type of sedentary activities children engage in. For example, previous studies found that parents' screen time and parental rules regarding screen time, were associated with children's SB (Jago *et al.* 2010; Downing *et al.* 2015). Considering that parents are important for children's health behaviours, research also suggests that in order to increase PA in children, parents need to be active themselves (Edwardson and Gorely, 2010; Lu *et al.* 2017). Furthermore, parents also govern the home environment and can impact PA behaviour through the provision of opportunities to be physically active (e.g., accessibility of play and sports equipment) (Maitland *et al.* 2013).

Several systematic reviews have investigated the biological, behavioural, psychological, socio-cultural and socio-economic contributing factors of PA in children and adolescents (Condello *et al.* 2017; O'Donoghue *et al.* 2018; Aleksovska *et al.* 2019). Emerging research based on social determinants of health perspectives, reveals that engaging in PA is anything but only a matter of an individual's decision or intention but also influenced by social and physical environments (Aleksovska *et al.* 2019). PA patterns for individuals are largely the result of environmental and

societal environments that constrain personal choice (Lobstein *et al.* 2022). Ultimately, research has shown factors that influence primary-school children are potentially modifiable, hence, future intervention strategies to increase PA and reduce SB should focus on the contributing factors simultaneously and focus on providing the same opportunities for girls and boys.

2.6. Behaviour change theory

Research highlights that behaviour change is challenging to achieve and difficult to maintain (Kwasnicka *et al.* 2016). Behavioural theories are utilised in research as they can help to explain children's PA and SB behaviour and can assist in the development of intervention programmes (Kriemler *et al.* 2011). An important aspect of intervention development of effective behavioural interventions is the use of theoretical framework, as they can be used to explain the likely processes and mechanisms of a targeted behaviour and enhance the likelihood of intervention effectiveness (Dobbins *et al.* 2013; Cassar *et al.* 2019). PA and SB interventions that base their strategies on behavioural theories are more likely to be effective than atheoretical approaches (Taylor *et al.* 2012; Rodrigues *et al.* 2023). Nevertheless, although it is well recognised that the use of established theory is important to the successful design and development of behaviour-change curricula and intervention, few studies explicitly design and evaluate intervention based on the respective theory (Liang *et al.* 2017). Researchers can utilise a wide variety of behaviour change theories, models, and frameworks. The following section will provide a brief overview on ecological models and the social cognitive theory (SCT), due to their significance within the current thesis, as the intervention outlined in **Chapter 6**, is based on the social cognitive theory (SCT) (Bandura, 1986), behavioural choice theory (Rachlin, 1989) and ecological systems theory (Bronfenbrenner, 1977).

2.6.1. Ecological Models

Bronfenbrenner's (1977) ecological systems theory is related to how individuals are influenced by multiple levels and systems of interaction. The ecological model indicates that an individual is embedded within, and interacts with, varying levels of a changing environment (Bronfenbrenner 1979). Also, the model suggests that settings-based approach may be an effective method for intervening with children's health behaviours (Bronfenbrenner *et al.* 2001). Health promotion has most commonly

been explained through a three-level social-ecological approach examining individual, societal and environmental factors (Stokols 1992). In the area of behavioural PA, ecological models have informed the development of surveys to identify correlates of PA in adults (Trost *et al.* 2002) and in children and adolescents (Sallis *et al.* 2000) as well as to assist with intervention development. More recently, but less frequently, ecological models such as the SEM of health promotion have been employed in interventions to promote children's PA with mixed success (Mehtälä *et al.* 2014). Taking an ecological perspective however directs attention to the wider political and environmental factors in schools that influence intrapersonal and interpersonal characteristics (Sallis *et al.* 2006; Langille & Rodgers, 2010). As previously described (see **Section 2.5.** above), the application of ecological models of health behaviour is used to understand factors influencing SB and PA and in interventions that target places in which large number of children are sedentary or active are likely to have a greater public health impact than approaches that involve one-to-one programme delivery.

2.6.2. *Social Cognitive Theory*

The SCT is based on triadic reciprocal determination, where human cognition, behaviour and environmental events all operate as interacting determinants of each other (Bandura 1986). It is a theoretical paradigm which suggest that people are both producers and products of their social system; they are not entirely driven by internal forces not automatically shaped and controlled by their environment. The SCT been utilised to guide PA interventions (Salmon *et al.* 2011) due to the interactions between individual, environment, and behaviour (Bandura 1986). The major construct regulating SCT is self-efficacy, or the belief in one's ability to produce a desired effect. Several systematic reviews examining PA intervention studies, found that the most beneficial mediator has been PA self-efficacy (Lubans *et al.* 2008; van Stralen *et al.* 2011). In general, perceived self-efficacy relates to an individual's beliefs in ones' capabilities to organise and perform the courses of action required to produce given levels of attainments (Bandura 1986). To note, these influences are not always of equal strength, nor do they happen at the same time, but rather they may happen independently or in response to each other's actions. Thus, self-efficacy is an important prerequisite for behaviour change.

Other constructs of the theory are task, planning, goal setting, coping self-efficacy, and outcome expectancy. Task self-efficacy is a contributing factor influencing one's level to complete a given task (Bandura 1986). Coping self-efficacy is an individual's ability to complete the given tasks under affective states, such as stress or negative emotions. Goal setting enhances self-regulation and outcome expectancy suggests beliefs related to a distinct behaviour, which has an impact on self-efficacy. A meta-analysis of 44 studies containing 55 SCT models, found that the models accounted for 31% of the variance in PA, highlighting that SCT is a useful framework to explain PA behaviour (Young *et al.* 2014).

2.7. Physical activity and sedentary behaviour in school

The *WHO's action plan on PA 2018-2030* recognises the school environment as a key setting for implementing PA initiatives in children (WHO 2019). The school setting is used to promote and increase opportunities for PA in children, as it can target 100% of students in the classroom and can increase the reach of health promoting interventions (Kriemler *et al.* 2011). Implementing PA in the classroom will give primary school children the chance to get regular exposure to activity daily (Kolimechkov *et al.* 2017). Nevertheless, recent systematic reviews that examined school-based PA randomised controlled trials (RCT) and/or cluster-randomised controlled trials (cRCT), observed that the interventions to date have little or no impact on overall time spent in MVPA and time spent sedentary (Love *et al.* 2019; Neil-Sztramko *et al.* 2021). Love *et al.* (2019), found moderate evidence of intervention effect during intervention period only in the included studies (n = 17 studies, published up to February 2017), however, intervention effects in MVPA across the school day were inconclusive. Likewise, results from Neil-Sztramko *et al.* (2021) revealed that school-based PA interventions (n = 89 studies; published between October 2011 to June 2020) may have a small impact on time spent in MVPA and may lead to no decrease in sedentary time in children and adolescents aged 6 to 18 years (Neil-Sztramko *et al.* 2021). Among the school-based interventions in children (n = 56) methodologies varied considerably, specifically by lack of blinding of participants/outcome assessors and due to variations in implementation (such as failure to deliver the intended intervention) (Neil-Sztramko *et al.* 2021).

The school setting offers an invaluable opportunity to accumulate active minutes and reduce sedentary time among students (e.g., lunchtime/recess, PE, active classroom breaks) (Tassitano *et al.* 2020). However, even though children spend most of their waking day at school (WHO 2019), a meta-analysis observed that children spend approximately 223.9 minutes of their time at school in sedentary time and engage in as few as 4 minutes of MVPA per hour (Tassitano *et al.* 2020). A study conducted in primary school children (n = 1025, aged 10-12 years) from five European countries highlighted that children spend on average 65% of their school time in sedentary pursuits and only 16 minutes per school day engaged in MVPA (Van Stralen *et al.* 2014). Furthermore, the amount of PA acquired in school diminishes (Burns *et al.* 2016; Hubbard *et al.* 2016) and sedentary time increase as children age (Mooses *et al.* 2017). In the UK, children spend around 70% of their school-day sitting (Clemes *et al.* 2015). Similarly, Fairclough *et al.* (2018) observed children spend large portions (up to 69%) at school in sedentary time. Thus, more research should be done to break up sitting time and increase PA across the school day in the UK (Sherry *et al.* 2019).

School-based PA promotion interventions have used different strategies to incorporate PA and/or reduce SB across the school day, including before and after school interventions, multi-component interventions, adapting PE lessons and during school time (i.e., during breaktime and changing classroom lesson delivery). Inconsistent findings have been reported regarding the effectiveness of primary school-based interventions at improving PA and reducing SB. Several systematic reviews examined the effects of interventions in the classroom (McMichan *et al.* 2018; Watson *et al.* 2017) and during breaktime/recess (Parrish *et al.* 2020). In recent years, the impact of 'standing desks' as a classroom-based intervention strategy to increase PA and reduce SB has been examined (Minges *et al.* 2016; Sherry *et al.* 2016; Guirado *et al.* 2021). Guirado *et al.* (2021) noted an increase in EE of between 15% and 25.7% for upright active desks (i.e., standing desk, sit-to-stand desk, and stand-biased desk) use for intervention groups compared to control groups (n = 20 studies). Similarly, Sherry *et al.* (2016) found that EE (measured over 2 h during school day mornings) demonstrated positive results in standing desk interventions (n = 3 studies). Furthermore, Minges *et al.* (2016) found that overall time spent standing increased in all studies using standing desks (n = 8) (effect size ranging from 0.38 to 0.71). The aforementioned reviews suggest that implementing environmental changes to the

classroom, specifically standing desks, could be an effective way of reducing children's sitting time. Nevertheless, findings from all three systematic reviews should be interpreted with caution as the majority of studies included varied in intervention type (e.g., non-randomised) and used a variety of methods to evaluate similar parameters (e.g., evaluation of PA using accelerometers or questionnaires or inclinometers and stated as counts, standing time, activity) (Minges *et al.* 2016; Sherry *et al.* 2016; Guirado *et al.* 2021). Additionally, the reviews were unable to decipher the most effective intervention approach as positive changes were found across the implemented interventions (e.g. increased standing time with multi-user workstations (Hinckson *et al.* 2013) and with adjustable sit-to-stand desks) (Clemes *et al.* 2015). Thus, additional research is required. As standing desk interventions within these reviews were implemented in several ways, researchers should clearly articulate detail in regard to active desks use, to enable comparisons regarding the effects of the active desks in the school setting on PA and SB.

The classroom has been identified as an important environment to promote PA at various opportunities throughout the school day, particularly in those who are less physically active (Weaver *et al.* 2016). Research suggests that delivering active breaks during class time to increase activity across the school day may have beneficial impacts on children's sedentary time at school (Watson *et al.* 2017). A recent review examined the effects of active school-based programmes to interrupt prolonged sitting in daily PA and SB in children (Amor-Barbosa *et al.* 2022). The review assessed six PA interventions with a sample of 976 children (between the ages of 6-14 years) from three different countries (specifically; Ireland (n =1), USA (n = 3), Spain (n =1), and Italy (n =1). Quantitative analyses demonstrated that school-based interventions (n = 3) for interrupting prolonged sitting significantly increased levels of PA (MD = 0.58; 95% confidence interval 0.33 to 0.83) and levels of MVPA (MD = 12.57; 95% confidence interval 7.91 to 17.24) (Amor-Barbosa *et al.* 2022). The review found that interrupting prolonged sitting with active school-based interventions had no significant impact on SB (MD = -0.26; 95% confidence interval -0.93 to 0.42). However, it is important to note, only two studies were included in the specific analysis for SB and the methods used to measure SB were not homogenous (e.g., studies employed different data collection methods; monitoring periods and various data processing methods) (Amor-Barbosa *et al.* 2022).

PE lessons and PA opportunities in school contribute to increased PA participation in children (Woods *et al.* 2018). In the UK, the *Association of Physical Education (afPE)*, (2008) recommend that primary school children should engage in MVPA for at least 50% of PE lessons. A systematic review that examined 13 studies (published between 2005 and 2014), assessed MVPA levels of primary school children during PE lessons and found that the percentage time spent in MVPA during PE varied (ranging from 11.4% to 88.5%) (Hollis *et al.* 2016). Wong *et al.* (2021) systematically reviewed five studies (n = 1452) that aimed to increase MVPA content of PE in children aged 8 to 11. The review found favourable intervention effects in all the included interventions, demonstrating a mean difference (MD) of an additional 14.3% of lesson time in MVPA in the intervention groups (95% confidence interval 2.7 to 25.8) (Wong *et al.* 2021). Notably, the successful components utilised in the interventions were based on a theoretical framework (e.g., the socio-ecological model), an emphasis on enjoyment in the intervention lessons to enhance students' engagement and a focus on active learning (e.g., game centred) (Wong *et al.* 2021). Nevertheless, due to the relatively small number of eligible interventions in this age group, further studies are advised in order to evaluate the effects of PE lesson interventions to increase MVPA levels and/or reduce sedentary time in primary school children (Wong *et al.* 2021).

Making small changes to the school environment, such as equipment provision, and the incorporation of playground line-markings can increase PA in children (Ridgers *et al.* 2007; Hyndman *et al.* 2014). Whereas the addition of height-adjustable standing desks or classroom-based PA equipment (e.g., bean bags to facilitate movement) can reduce sedentary time (Aminian *et al.* 2015; Hinckson *et al.* 2016). Considering the positive impacts of PA on cognitive development and academic outcomes (Salmon *et al.* 2023), and that children enjoy movement integration in school (McMullen *et al.* 2018), there is a need for a change in schools towards more active pedagogies (Vazou 2019).

Despite a growing evidence base, it is not known how best to successfully implement school-based interventions at scale (Naylor *et al.* 2015). This is likely due to the complex nature and challenges of assessing implementation in large-scale, real-world interventions and the difficulties PA researchers face conducting dissemination and

implementation research (Koorts *et al.* 2020). A recent evaluation by Jago *et al.* (2023) stated that a greater consideration of ‘*school-specific context*’ is important in the design and analysis of school-based PA interventions. Public health research specifically examining school-based PA interventions should opt for a more flexible approach that enables schools to tailor content to their specific school setting (Jago *et al.* 2023). To date, evidence proposes that multi-component interventions that incorporate PA and aim to reduce SB across the whole-school environment and throughout the school day, may have the strongest impact on time spent in MVPA and SB (Van Kann *et al.* 2016; Hegarty *et al.* 2018; Neil-Sztramko *et al.* 2021). Multidimensional intervention approaches are likely required to achieve sustained effects across the whole-school day (Love *et al.* 2019). To conclude, alternative approaches to both the design and evaluation of school-based interventions are necessary to increase PA in primary school children. Further research investigating the effectiveness of school-based interventions on obesity-related behaviour, including PA and SB is examined in **Chapter 3**.

2.8. Measuring physical activity and sedentary behaviour in children

Quantifying movement behaviour(s) in children is particularly problematic to quantify due to the complexity of children's SB and PA behaviour (e.g., intermittent bouts of PA), recall bias, cognitive competence (e.g., to correctly interpret terminology used in a questionnaire) (Kelly *et al.* 2016; Kirkpatrick *et al.* 2019). Research into movement behaviour is often hindered by the challenge of employing a valid, reliable measure that also sufficiently satisfies the research question or design. To be able to establish the prevalence of PA and SB in children, it is vital that accurate measurements are used (Ridgers *et al.* 2012). Direct assessment methods of PA and/or sedentary time such as device-based measures (by a measure of movement or postural allocation e.g., accelerometers) can improve estimates of intensity and duration (Milton *et al.* 2011). The following section will provide a brief overview of the most commonly used PA and SB measures in research in children (accelerometers, wearable activity monitors and self-reported questionnaires). These measures were chosen due to their significance within the current thesis, e.g., it is essential to discuss the use of accelerometers given their use in **Chapter 6** and to consider whether it would be an applicable measurement tool, along with an intervention/feasibility tool. Each measure

assesses various components of PA and SB, has a selection of outcome variables, and linked strengths and weaknesses.

2.8.1. Self-report and proxy-measure of physical activity and sedentary behaviour

The assessment of activity behaviour in children has traditionally been assessed via subjective measurements where instruments are used which require the recalling of PA and SB by the participant or a proxy (such as a parent or teacher for a child). PA and SB can be measured using self-report methods for example questionnaires, diaries, or activity logs (Ainsworth *et al.* 2015; Phillips *et al.* 2021). The self-report and proxy-report tool ask about the frequency, type, context and/or the time spent taking part in PA and/or time spent in common SBs (e.g., screen time) (Biddle *et al.* 2011). The prevalence of screen time is often measured by self/proxy report and studies commonly report their outcome in relation to meeting or exceeding recommendations for children, however, as previously stated to date a specific recommendation for screen time has not been set in the UK and Ireland. Examples of subjective measures of PA and SB include questionnaires and activity diaries. Data derived from subjective methods, have a relatively low level of precision and are more susceptible to measurement bias, whereas laboratory methods such as calorimetry tend to have a high level of validity (Prince *et al.* 2008; Philips *et al.* 2021). Self-report methods are subject to considerable recall bias and should be used with caution particularly in children (Arts *et al.* 2022). Although convenient, the accuracy of the collected data by subjective techniques is influenced by the participant's ability to accurately recall the pattern and type of movement retrospectively (Hidding *et al.* 2017). Thus, subjective reporting may lead to the over or underestimation of PA and/or SB in children (Prince *et al.* 2008; Ainsworth *et al.* 2015). Questionnaires can be used to assess PA and SB in children on a large scale, in a relatively cheap, affordable, and convenient way (Chinapaw *et al.* 2010). There are many different types of questionnaires and recall logs available to assess PA in children (Hidding *et al.* 2018). It is important to note when determining a PA measurement based on questionnaires, there is no single "gold standard" (Nigg *et al.* 2020). The appropriateness of a questionnaire varies depending on the specific research purpose, the target population and the available resources (e.g., staffing, budget, time) (Copeland *et al.* 2018; Nigg *et al.* 2020). A variety of questionnaires measuring PA and/or SB are used in school and public health surveillance to capture information regarding movement behaviour patterns in

children. However, the questionnaires vary considerably (e.g., number of questions, formatting, recall periods), and few produce acceptable PA and SB estimates (Hidding *et al.* 2018). A systematic review conducted by Hidding *et al.* (2018) examined the available literature on the measurement properties of 89 different PA questionnaires in children. The methodological quality of the included studies was rated using a standardised tool, i.e. the COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist. Some examples of PA questionnaires used in children include the Energy-child questionnaire (Singh *et al.* 2011), the Children's Physical Activity Questionnaire (CPAQ) (Corder *et al.* 2009) and the Youth Activity Profile (YAP) (Saint-Maurice & Welk, 2015). However, despite the wide range and variation of questionnaires measuring PA in children, no valid and reliable questionnaire was identified (Hidding *et al.* 2018). Upon assessment, the majority of studies exhibited a fair or poor methodological study (e.g., mainly due to the lack of *a priori* formulated hypotheses and unknown or improper measurement approaches) (Hidding *et al.* 2018). Consequently, research indicates that childhood PA questionnaires do not accurately reflect childrens' PA and SB levels as they lack appropriate validity and/or reliability (Chinpaw *et al.* 2010; Hidding *et al.* 2017). High-quality studies are required to develop proxy-report questionnaires that can be considered both reliable and valid for assessing PA and SB in primary school children.

2.8.2. Pedometers

School-based interventions incorporating pedometers have been used to increase PA and/or reduce sedentary time in children (Lubans *et al.* 2014; Sigmundová *et al.* 2014). Pedometers are extensively used as a surveillance tool in large-scale epidemiological studies, to provide PA outcomes in terms of quantity steps (e.g., steps per day) (Clemes and Biddle, 2013). It is recommended that children should use a pedometer with a 7-day memory capacity (e.g., the Yamax CW-700) in conjunction with a wear time diary (e.g., to record when the device is removed) to limit data loss (Lubans *et al.* 2014). The main advantages of pedometers are that they are relatively simple electronic devices, inexpensive, re-useable, and output data can be used to raise awareness regarding level of PA, including motivation for increased PA (Tudor-Locke *et al.* 2009; McNamara *et al.* 2010). Nevertheless, pedometers cannot measure the intensity of activities performed and readings can also vary according to the positioning of the device (Abel *et al.* 2011). For a more accurate measurement of PA and sedentary time,

the use of accelerometers is required as they enable greater precision and accuracy than pedometers (Cuberek *et al.* 2010). Pedometers do not consider intra-individual variability and differences in height and leg length (O'Brien *et al.* 2018). Therefore, it is important when researchers are interpreting data from pedometers that gender and anthropometric measurements should be considered (Armstrong *et al.* 2019).

2.6.3. Accelerometers

Accelerometers are a widely used tool that can capture a whole continuum of behaviours (SB, LPA, MPA, VPA). Moreover, accelerometers enable several components of PA to be measured, for example: intensity, frequency and duration of PA can be determined (Troiano *et al.* 2014). The devices (data types; see Figure 2.1.) can quantify body movement of human beings, specifically measuring acceleration which is defined as a change of velocity overtime (Douglas *et al.* 2011). Accelerometers are the most highly utilised method of device-based PA assessment in children (Corder *et al.* 2008; Cain *et al.* 2013). Despite the technical advances and the diversity in monitor hardware, logistical challenges of storing and analysing raw acceleration signal data remain (Troiano *et al.* 2014; Karas *et al.* 2019).

Briefly, accelerometers work by integrating a filtered electronic acceleration signal over a user-specified time interval, frequently known as an epoch (Trost *et al.* 2005). Accelerometers quantify accelerations and detect movement in up to three orthogonal planes. The devices work off the assumption that force is created when performing PA is linear to accelerations. Accelerometers collect high resolution signals, most used data outputs consist of summary measures user-defined epochs (e.g., 1 minute). Epoch duration can range from between one second to several minutes depending on the manufacturer's software as well as researcher decisions used. In order to quantify the amount of time spent in different intensities (e.g., MVPA) and sedentary time, researchers have developed a cut point approach by calibrating accelerometer data against a criterion measure (e.g., indirect calorimetry) (Migueles *et al.* 2019). Different cut-points exist, and the various cut-point results provide different estimates of PA and sedentary time (Pedišić *et al.* 2015). Moreover, there is no consensus on what the "correct" cut points is and on which accelerometer cut-points are most appropriate as researcher-driven decisions (e.g., analysis pathway in Figure 2.1.) can significantly affect the results (e.g., choice of cut-points, wear location, wear time criteria)

(Hagströmer *et al.* 2010; Migueles *et al.* 2019). Consequently, researchers must use a method and justify several decisions when using accelerometers to measure PA and SB (Cain *et al.* 2013; Migueles *et al.* 2017). In light of the limitations of cut points, methodological and analytical advances have been developed. These are described in the Granada Consensus Statement (Migueles *et al.* 2021).

Accelerometer based assessments require researchers to select key data collection and determine reduction decisions to measure PA and sedentary/stationary behaviour. For example, researchers should carefully consider the following decisions: (1) the most appropriate type of accelerometer to use; (2) placement of accelerometer; (3) the most appropriate epoch length; (4) establish the most accurate PA and/or SB intensity cut points to use; (5) duration of monitoring; (6) determining minimum wear-time criteria; and (7) classification of non-wear time (Edwardson *et al.* 2016; Fairclough *et al.* 2020). At present, there is no fixed consensus on how best to use accelerometers for data collection and data analysis in children. Figure 2.1 specifies that most analysis pathways rely on summary measures. The sampling capabilities and various analysis pathways of accelerometers allow researchers to investigate different periods of the day or week (Edwardson *et al.* 2015; Bai *et al.* 2016). The duration of monitoring chosen depends on the design and purpose of the study. Troiano *et al.* (2014) has highlighted the diversity of measurements and data reduction methods for accelerometry data and notes that it makes it difficult to compare results across different studies. Therefore, there is a need for standardisation of measurement and pre-processing across studies (Wu *et al.* 2022).

Several wearable devices can be used to monitor PA and sedentariness in children (Fairclough *et al.* 2020). There are a range of accelerometers available, therefore, to select an appropriate model, a variety of factors must be taken into consideration (e.g., the cost involved) (Wu *et al.* 2022). Uniaxial accelerometers measure in one direction, the vertical plane (e.g., Actigraph GT1M and 7164 models). Biaxial accelerometers, measure movement in 2 plans (e.g., ActivWatch AW16) and triaxial accelerometers, measurement movement in 3 planes (e.g., ActiGraph GT3X). Traditionally, gold standard cut points are established using data derived from accelerometers placed on the right hip of the body (Freedson *et al.* 2012), recently epidemiological studies have focused on acceleration data from wrist-worn accelerometers for increased protocol

compliance of study participants, improved sensitivity to detect certain types of movements, and sleep measurement (Ellis *et al.* 2016; Full *et al.* 2018). Variable compliance to accelerometer monitoring protocols influences the application of minimum wear time criteria (e.g., number of minutes worn that constitutes a “*valid*” day of measurement and the minimum number of days necessary for a reliable estimate of PA levels), which are dependent on data reductive methods employed by the researcher regarding how “*nonwear*” time is defined (Tudor-Locke *et al.* 2015; Ridley *et al.* 2016). Therefore, better compliance gives greater confidence that PA data are representative of actual daily PA due to the association between duration of monitoring and reliability of PA data (Edwardson *et al.* 2017). Fairclough and colleagues (2016) were the first to assess children’s free-living PA derived from raw wrist and hip accelerations using the GENEActiv and ActiGraph GT3X+ accelerometers, respectively. The study reported that wrist-worn accelerometers had at least 10% higher compliance rate than hip-worn ones, regardless of the data processing criteria in school-age children. Furthermore, findings indicated that wrist-worn accelerometers had a much lower study drop-off rate compared to hip-worn ones, regardless of the number of monitoring days (Fairclough *et al.* 2016). Thus, the wrist, instead of the hip, might be an ideal accelerometer placement site for primary-school children.

For studies interested in the assessment of postures the activPAL™ is recommended (Hänggi *et al.* 2013), as research has found that it is an acceptable, valid and reliable measurement of posture during free-living activities (Davies *et al.* 2011; Dowd *et al.* 2012; Wu *et al.* 2022). A systematic review evaluated 11 studies (n = 570 children aged 3-18 years) to establish the accuracy of triaxial and omnidirectional accelerometers for measuring PA and SB children (Lynch *et al.* 2019). Diagnostic accuracy measures were determined using area under the curve values across studies and found that the; (1) accuracy was greatest when detecting SB and lowest when detecting LIPA and, (2) accuracy was higher when the accelerometer was placed on the hip compared with the wrist (Lynch *et al.* 2019). Therefore, the findings from this research suggests that monitors placed on the hip are more accurate than wrist placement for measuring PA and SB. The activPAL™ accelerometer (thigh worn) is used in this thesis and accelerometer measurement considerations (e.g., the key data

collection and reduction decisions and the rationale for measuring PA and SB) are discussed in detail in **Chapter 6**.

2.9. The Transform-Us! programme

‘[Transform-Us!] is an investment in future generations, informing health policy and practice programs. Finding ways to get kids moving when their world is designed to help them conserve energy is a major global research challenge’. Professor Jo Salmon, Director of the Institute for Physical Activity and Nutrition (IPAN).

After a decade of research, a ‘*revolutionary school programme*’ has been expanded across hundreds of schools in Australia, to improve the physical health of children. *Transform-Us!* (Salmon *et al.* 2011) was first developed in 2008 by researchers in Deakin University, Australia, through a substantive series of extensive iterative work, to address concerns over excessive sitting time in the classroom (Salmon 2010). Unique to the intervention is its approach to delivery of school curriculum and homework in less sedentary and more active ways, with the overarching aim being to develop an effective and sustainable ‘*programme*’ (rather than an ‘*intervention*’) in the longer-term. Rather than focusing on sport or PE, the programme creates a supportive school environment that aims to integrate movement into everyday lessons in classrooms, recess/lunch breaks and homework (Salmon *et al.* 2011). *Transform-Us!* has been funded by the National Health and Medical Research Council and VicHealth. The intervention is designed to be integrated into existing class lessons, is aligned to the Australian state curriculum, and does not replace PE within the school. Teachers are not required to be PA specialists – any classroom teacher can deliver the intervention upon completion of a training session.

Transform-Us! comprises of several components including: (i) health lessons incorporating key PA/SB messages, (ii) active lessons, (iii) active breaks, (iii) encouragement and use of playground markings, (iv) promotional signage and class sets of sports/PA equipment for use during class time, recess and lunch, (v) active homework, and (vi) parent newsletters promoting PA/reducing sitting time (Salmon *et al.* 2011). The components were based on SCT (Bandura 1986), behavioural choice theory (Freeman 1989) and ecological systems theory (Bronfenbrenner 1986).

Teachers and staff from the Department of Education and Training in Victoria, Australia and the Australian Council for Health, Physical Education and Recreation Victoria were involved in the design of the intervention content for schools and the development of the professional development for teachers (Salmon *et al.* 2011). Further details of *Transform-Us!* has been described in detail in the published study protocol (Salmon *et al.* 2011). The primary hypothesis was that the intervention would lead to behaviour change by targeting behavioural and environmental mediators.

2.9.1. Transform-Us! school- and home-based cluster randomised controlled trial

The *Transform-Us!* trial was tested in a 4-arm cRCT which included three different intervention arms: (1) targeted reductions in SB (SB-I group), (2) increases in PA (PA-I group), and (3) a combination of both (SB+PAI group) across the school day incorporating a mixture of educational, pedagogical, behavioural, and environmental approaches to integrate movement into everyday class lessons, recess/lunchtime, and homework (Salmon *et al.* 2011). Table 2.1. illustrates the core components and key strategies used in the *Transform-Us!* intervention.

Australian primary schools with >300 students, with at least two Year 3 (aged 8-9 years) classes and within 50km of the Melbourne Central Business District were recruited from socioeconomic strata and randomly ordered (Salmon *et al.* 2011). At baseline, 37% (n = 599) of potential participants (n = 1606) consented to participate with varying number of children giving consent to evaluation outcomes e.g., had consent for at least one *Transform-Us!* outcome (n = 599) (e.g., BMI), had consent for accelerometer (n = 547), had consent for survey (n = 544), consent for both survey and accelerometers assessments (n = 512). The cRCT comprised of five schools per intervention arm with a 2×2 factorial design comprised of an 18-month intervention and 12-month booster maintenance periods. The trial was tested in a large two and a half year RCT (2010-2013) involving over 220 teachers, 1,600 children and parents from 20 government primary school around Victoria (Salmon *et al.* 2023). Teachers in each of the intervention groups were trained and attended a half-day face-to-face professional development session. Teacher training included strategies on how to incorporate the intervention into regular teaching styles (e.g., how to deliver active breaks) (Salmon *et al.* 2011). Mid-intervention effects (5–9 months) showed beneficial intervention effects on total weekday sedentary time (n = 293 children) (Carson *et al.*

2013) and children's MVPA and LPA ($n = 268$ children) in the SB-I and PA-I groups during school breaktime (recess) (Yildirim *et al.* 2014). Furthermore, there was a significant reduction in sitting time after 5-9 months of intervention. The SB+PA-I group spent an average of 13.3 min/day less in sedentary time on weekdays compared to the control group (Carson *et al.* 2013).

In total, 342 children (43% boys) were included in the final analyses (Salmon *et al.* 2023). Over 2.5 years, the *Transform-Us!* intervention demonstrated stronger effects on children's SB than PA, and there were beneficial effects on children's BMI z-scores in the PA-I and SB-I groups compared with the usual practice group (Salmon *et al.* 2023). Children in the SB-I group had spent on average, 63 min/weekday less sedentary time compared to usual practice. Furthermore, children who received the SB and/or PA strategies showed; lower average BMI z-scores (-0.14 and -0.13, respectively), and lower waist circumference (among children exposed to the SB strategies only: -1.65 cm) (Salmon *et al.* 2023). The intervention was effective in lowering the total daily duration of children's sedentary time (by 27 min at 18-months and 33 min at 30-months compared to usual practice) and increasing daily MVPA (by 5 minutes at 18-months) (Salmon *et al.* 2023). Thus, *Transform-Us!* demonstrated favourable behavioural effects at 30 months than 18 months, demonstrating the need for longer time follow-ups and timeframes to determine intervention benefits (Salmon *et al.* 2023). Verswijveren *et al.* (2022) investigated the effect of the *Transform-Us!* school- and home-based intervention program on children's movement behaviour accumulation patterns at baseline and post-intervention (18 months). Results indicated that accumulating LIPA in shorter bursts may be more favourable than longer bouts of the same intensity, for reducing waist circumference and BMI (Verswijveren *et al.* 2022). The novel compositional data analysis approach that only considered activity intensity, demonstrated that activity patterns may possibly play a role in children's cardiometabolic health, outside of total volumes of PA and SB (Verswijveren *et al.* 2022).

In line with the UK Medical Research Council (MRC) recommendations for process evaluation of complex interventions (Skivington *et al.* 2021), a mixed method analysis was adopted to investigate the unanticipated barriers and facilitators to implementation of *Transform-Us!* Process evaluation data collection took place at four time points

specifically at baseline (T1; Feb-June 2010), 6-months (T2; Nov-Dec 2010), 18-months (T3; Nov-Dec 2011) and 30-months (T4; Nov-Dec 2012) and collected surveys from parents, teachers and children (Koorts *et al.* 2022). The evaluation revealed that at 18 months, responding teachers (52% response rate) delivered 70% of the nine key learning messages and 56% delivered active breaks per day. Additionally, almost all teachers (96%) provided access to the PA/sports equipment during recess/lunch breaks as well as during class lessons (Koorts *et al.* 2022).

Generally, *Transform-Us!* was perceived as being appropriate according to teachers, due to low amounts of preparation required to implement, ease of delivery and integration into teachers' current lesson plans (Koorts *et al.* 2022). A key finding was the substantial variability in implementation among responding teachers, which varied both by intervention group and intervention component. For instance, the environmental aspects of *Transform-Us!* (e.g., PA equipment) were provided more frequently compared to the curriculum-related components (Koorts *et al.* 2022). One possible explanation for differences in dose delivered and received could be that some *Transform-Us!* components may have been easier to adopt by the teachers and children than others. The process evaluation highlights that the *Transform-Us!* intervention was suitable for the school setting, and responding teachers, parents and children were pleased with the strategies involved (Koorts *et al.* 2022).

2.9.2. *TransformUs! type II hybrid effectiveness-implementation trial*

To impact population health interventions such as *Transform-Us!*, they must be scaled up in practice (Wight *et al.* 2016). Subsequently, following the completion of the efficacy trial, the programme was adapted for real-world implementation at scale (<https://transformus.com.au/>) and was offered to all primary schools and students in Victoria, Australia. The program has been adapted and refined for scale-up as per findings from previous *Transform-Us!* trials and recommendations from implementation and scale-up literature. Due to its ongoing success, a type II hybrid implementation-effectiveness trial was adapted for at scale implementation and was rolled-out across the state of Victoria to all Government, independent and Catholic primary schools (n=1906) during 2018-2022 in partnership with 16 key stakeholder organisations, including the Victorian Department of Education and Training. The state-wide roll-out is aligned with the Victorian State government target of 20% more

students being physical active for an hour a day, five times a week (Department of Education and Training, 2019). To determine short- and long-term changes in children's levels of PA and SB under '*real world*' conditions, an embedded effectiveness trial is currently being conducted with 20 intervention schools in Victoria and 20 control schools in New South Wales. Data will be collected at baseline (T1), 12-months (T2), and 24-months (T3), and will contribute to assessing program effectiveness and individual-level maintenance. *Transform-Us!* is being disseminated by program partner organisations via newsletters, professional networks, conferences and workshops, and bulk email distribution) to promote teacher and school adoption of the program. Preliminary results indicate that the COVID-19 pandemic has a significant impact on the trial, with home school days in the state of Victoria totalling to 267 days (unpublished results).

In 2021, the *Transform-Us!* website was developed which includes a substantial range of resources. In terms of resources available on the website; there are over 300 active academic lessons, over 100 active breaks, over 200 active-homework tasks and over 20 health-based lessons offered. At present, the programme is being extended nationally, as well as into secondary schools and to children with additional needs. Currently, 17 partners have been recruited to help promote the programme. The *Transform-Us!* model supports general classroom teachers to alter their teaching practice and their environment to create a positive, engaging classroom. To date, there is no equivalent evidence-based resource platform globally to support school educators to improve both health and education outcomes of their pupils. Within NI setting we do not have similar multi-component programme which have been subjected to rigorous evaluation.

2.10. Summary of literature review

Many countries have developed guidelines for children's PA and SB. Overall, there is an agreement that children should accumulate at least 60 minutes of daily MVPA on average and reduce time spent in SB. Schools are (often) a sedentary environment but the school environment represent an opportunity to modify unhealthy behaviours and model healthy behaviours. At present, current school-based interventions to increase PA and reduce SB have shown limited effectiveness (Love *et al.* 2019; Neil-Sztramko *et al.* 2021). Further research is required to design and evaluate context-specific

school-based interventions, to improve future PA intervention development (Jago *et al.* 2023). In addition, it is essential that researchers design effective interventions to increase the PA levels and reduce SB of primary school children as PA habits during childhood may impact health behaviours and health outcomes during adulthood (Hayes *et al.* 2019). It is well recognised that the use of established theory is important to the successful design and development of behaviour-change curricula and intervention. *Transform-Us!* is a successful school and home-based intervention and evidence indicates that it is an efficacious trial for decreasing SB and increasing PA in Australian schoolchildren. Nevertheless, research is lacking in NI and there has not been a similar intervention in place in schools across NI. Considering the positive independent effects of increasing PA and reducing SB can have for health and school related outcomes in primary school children (Carson *et al.* 2016; Donnelly *et al.* 2016), effective school-based interventions are required in NI.

2.11. Theoretical underpinning of PhD

A mixed-methodological research approach whereby researchers can collect and analyse quantitative and qualitative data within the same study (Creswell *et al.* 2017), draws on possible strengths of both quantitative and qualitative methods, enabling researchers to explore various perspectives (Greene *et al.* 1989). This mixed-methodological approach allows for a more comprehensive analysis and the ability to answer a broader range of research questions (Tariq & Woodman, 2013). Notably, a mixed-methodological approach can add insights and understanding that may be otherwise missed with a singular research approach (Tariq & Woodman, 2013). Mixed methods research can facilitate both the device-based measurement of PA in the school setting (quantitative measure) and personal accounts from children regarding the meaning behind their PA behaviours (qualitative measure). The thesis focuses on some (development, feasibility, evaluation but not all implementation) stages of the MRC model for the evaluation of complex intervention. The thesis takes the pre-existing successful evidence-based *Transform-Us!* programme and adapt it to schools based in NI. Within the NI/UK setting we do not have similar multi-component programme which have been subjected to rigorous evaluation. Due to numerous local contextual differences between Australia and NI, the thesis will address this gap in the evidence and adapt the intervention accordingly. Prior to evaluating the intervention for effectiveness, the authors sought to assess the acceptability and feasibility of the

intervention. This is important for identifying potential problems with the acceptability, compliance and delivery of the intervention, plus recruitment and retention rates (Craig *et al.* 2008; Feeley *et al.* 2009). Previously, feasibility testing was overlooked in the design of complex interventions (Eldridge *et al.* 2004), however in recent years feasibility testing has become more commonplace within PA research and intervention evaluation (Yardley *et al.* 2015; Eldridge *et al.* 2016).

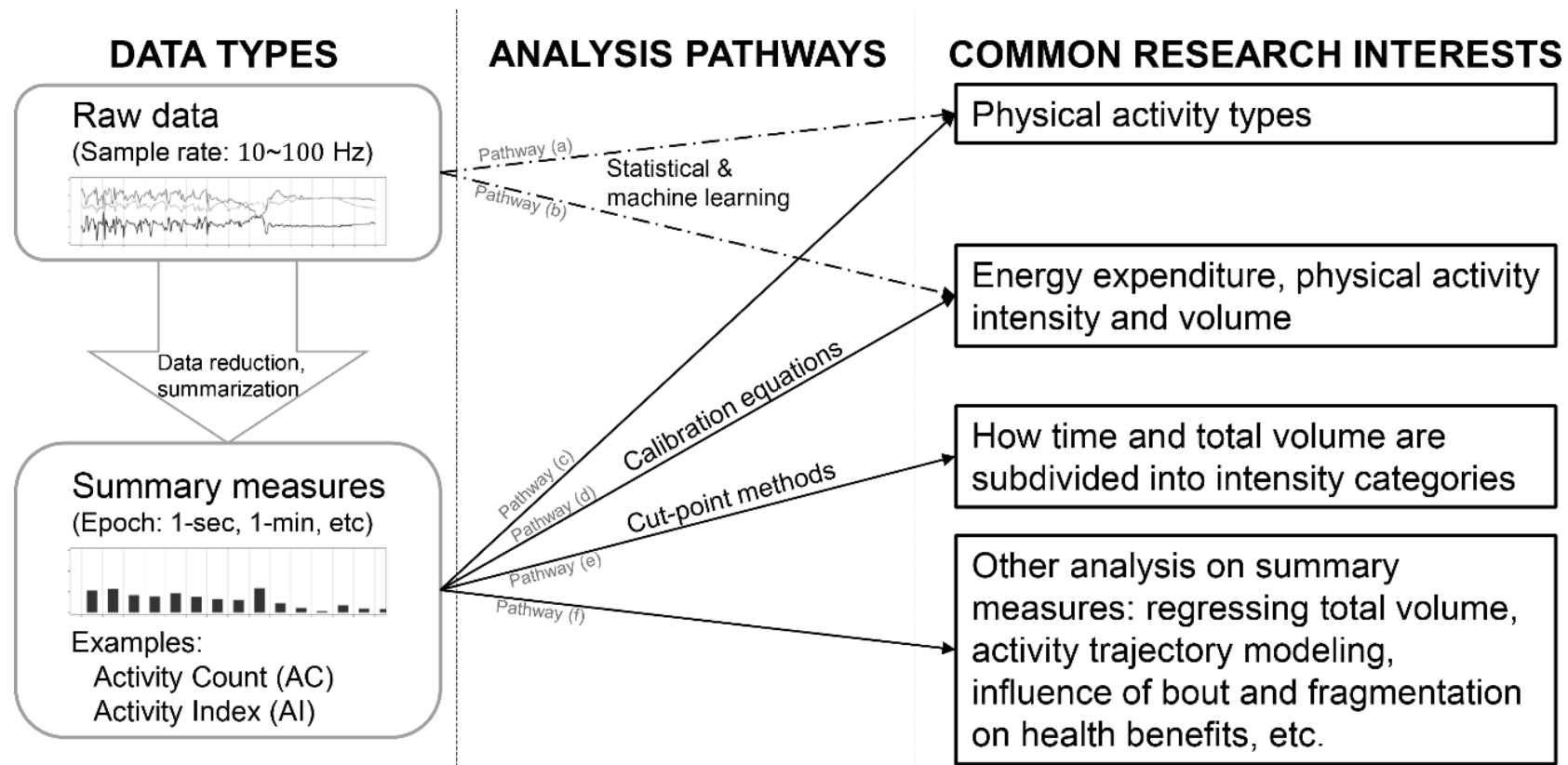


Figure 2.1. sourced from Bai *et al.* (2016). Provides an overview of the stages used in accelerometry processing in physical activity studies.

Hz = Hertz.

Table 2.1. The *Transform-Us!* intervention (Salmon *et al.* 2011) strategies

Core components	Transform-Us! strategies
Curriculum	9 health lessons per academic year For each intervention arm, key learning messages were adapted from <i>Switch-Play</i> materials (Salmon et al. 2011) incorporating key principles of behaviour change and delivered by classroom teachers in 18 lessons with learning messages. Class lessons aimed to build skills and increase knowledge about the importance of being active to enhance health and wellbeing.
	Modify the delivery of one 30–45-minute standing lesson/day Teachers were provided with several standing lessons delivery methods (e.g., utilise incidental activity as part of the lesson standing desks, moving stations, collaborating at easels or white boards and embodied and / or experiential learning where the body or the movement itself becomes a vehicle for learning).
Class strategies	Evert two-hour classroom teaching block to be interrupted with a 2-minute active break Every two-hour classroom teaching block will be interrupted every 30 minutes with a 2-minute guided light-intensity activity break - teachers will be provided with a menu of activities to deliver during the 2-minute breaks. A novelty timer was given to each class so that teachers can monitor 2-minute standing breaks and every 30-minutes of sitting class time.
	Active Breaks: interrupt prolonged periods of sitting and can be used to: complement lesson content using physical and visual reinforcement, introduce or summarise lesson content, re-energise and re-engage students in learning, structure the lesson, proactively manage the class, and create a positive classroom environment.
Physical environment	Standing easels Children could rotate learning activities at standing stations.
	Active environment (e.g., sports/circus equipment, line markings, promotional signage)

	To use in recess/lunch breaks, and teachers and peers were asked to provide encouragement and support for active games. Schools selected and received novel line markings promoting active play in asphalt areas in the school playground. Includes signage, equipment, facilities, resources, policies, teacher encouragement and support to promote physical activity inside the classroom and at recess and lunchtime.
Physical environment	Class set of pedometers Each class was provided with a provision of pedometers for use during the key learning messages based on PA capability. Pedometers could be rotated throughout the class for children to gain awareness of their steps in different environments (e.g., weekend, weekday etc.).
Home environment	Active homework assignments Children were given homework tasks to complete with their parents. For example, to switch off the TV for a whole weekend day and do something with their parent/s (a menu of alternative light-intensity activities will be provided). Homework tasks were modified to reduce sitting time while completing them (e.g., complete worksheets while standing at the table). Newsletters to parents (8 newsletters, per year) To reduce sitting time and promote PA at home, support the key learning messages in the active lessons and incorporate family-based activities. Engaging families: information and home-based activities for parents and children to engage with at home, to engage students in homebased learning and reinforce the importance of children being active.

PA: Physical Activity; SB: Sedentary Behaviour

Chapter 3: The Effectiveness of School-Based Interventions on
Obesity-Related Behaviours in Primary School Children: A Systematic
Review and Meta-Analysis of Randomised Controlled Trials

Abstract

Background

School-based interventions are promising for targeting a change in obesity-related behaviours in children. However, the efficacy of school-based interventions to prevent obesity remains unclear. This review examined the effectiveness of school-based interventions at changing obesity-related behaviours (increased physical activity, decreased sedentary behaviour and improved nutrition behaviour) and/or a change in BMI/BMI z-score.

Methods

Following PRISMA guidelines, seven databases were systematically searched from 1 January 2009 to 31 December 2020. Two review authors independently screened studies for eligibility, completed data extraction and assessed the risk of bias of each of the included studies.

Results

Forty-eight studies met the inclusion criteria and were included in a narrative synthesis. Thirty-seven studies were eligible for inclusion in a meta-analysis. The findings demonstrate that interventions in children when compared to controls resulted in a small positive treatment effect in moderate-to-vigorous physical activity (MVPA) in the control group (2.14; 95% CI = 0.77, 3.50). There was no significant effect on sedentary behaviour, energy intake, and fruit and vegetable intake, and BMI kg/m². A small significant reduction was found between groups in BMI z-score (−0.04; 95% CI = −0.07, −0.01) in favour of the intervention.

Conclusions

The findings have important implications for future intervention research in terms of the effectiveness of intervention components and characteristics.

3.1. Introduction

Childhood obesity is one of the leading public health challenges of the 21st century (Bhadoria *et al.* 2015). The prevalence of childhood obesity has risen over the past four decades with 50 million girls and 74 million boys globally, aged 5–19 years, estimated to be affected by obesity (Abarca-Gómez *et al.* 2017). Childhood obesity is a major economic concern and has serious health care and social costs and consequences in adulthood, with increased burdens on health systems (Tremmel *et al.* 2017). The specific causes of obesity are varied and complex, however, at a population level are consistent with sustained positive energy balance (Hill *et al.* 2012; Romieu *et al.* 2017).

Sedentary behaviour (SB) and low levels of physical activity (PA), combined with excess caloric consumption, are significant modifiable factors for the prevention of childhood obesity (Thivel *et al.* 2013). Childhood obesity is associated with adverse health outcomes, including greater adiposity, and associated adverse cardiometabolic risk factors (Andersen *et al.* 2006; Ekelund *et al.* 2012), behavioural problems (Hills *et al.* 2007) and poorer academic performance (Janssen and LeBlanc, 2010). Overconsumption and poor food choices are associated with a higher risk of developing childhood obesity (Ng *et al.* 2014; Luque *et al.* 2018; Kim and Lim, 2019). Furthermore, dietary patterns during childhood that are high in energy-dense, high-fat and low-fibre foods will have an impact on the later obesity risk (Ambrosini 2014). In addition to the well-recognised health benefits of PA, prolonged uninterrupted periods of sitting or SB are an independent risk for poor cardiovascular and metabolic health (Gibbs *et al.* 2015; Young *et al.* 2016). Increased sedentary time has been linked with changes in adiposity across childhood (Mann *et al.* 2017). The 2018 *Global Matrix PA Report Card*, in 49 countries, indicated that only 27–33% of school-aged children were obtaining the recommended guidelines of 60 min of moderate-to-vigorous PA (MVPA) per day, and only 34–39% of those children adhered to the two hours of recommended screen time daily (Aubert *et al.* 2018). Therefore, evidence unequivocally highlights the beneficial effects of changes in PA, SB and nutrition behaviour for the prevention of childhood obesity (Hancox *et al.* 2005; Timperio *et al.* 2008; Prentice-Dunn *et al.* 2012; Dooyema *et al.* 2017). When obesity is established in childhood, it is challenging to reverse through interventions and tracks into adulthood (Craigie *et al.*

2011; Llewellyn *et al.* 2016). Thus, effective primary prevention is imperative. PA, SB, nutrition behaviour and food preferences are determined in early childhood and continue into adulthood (Mikkilä *et al.* 2007; Singh *et al.* 2008; Jones *et al.* 2013). By intervening at an early age, it may be possible to reduce health inequalities and prevent the increase in obesity levels (Flynn *et al.* 2006).

Because of the prevalence, health consequences and associated costs of childhood obesity, there has been significant interest in identifying the effective interventions for preventing childhood obesity. Empirical evidence demonstrates that the school environment is ideal for tackling change in obesity-related behaviours as they provide concentrated contact, teach health education, provide meals and can model health-promoting settings (Kelishadi and Azizi-Soleiman, 2014). It is a logical choice as a context for implementing obesity prevention interventions since children spend 40% of their waking time at school (Fox 2004). School-based interventions can also reach all pupils, irrespective of socioeconomic status (Kriemler *et al.* 2011; Hillier-Brown *et al.* 2014) providing access to those who may benefit most and thereby overcoming potential health inequalities (Dobbins *et al.* 2009). Multi-country data indicated that local school contexts have a significant impact on children's daily MVPA accumulation pattern (Gomes *et al.* 2017). Recent systematic reviews and meta-analysis suggest that nutrition interventions can have a positive influence on children's nutritional knowledge and children's energy intake (Murimi *et al.* 2018; Cottona *et al.* 2020). However, the National Institute of Clinical Excellence (NICE) has highlighted disparities in the evidence, specifically the need for evaluation of multi-component interventions that aim to reduce obesity-related behaviours in children (NICE 2009).

Several reviews have considered the effectiveness of interventions promoting PA within the school setting (Dobbins *et al.* 2009; Metcalf *et al.* 2012) and during specific parts of a school day, including during play/recess (Parrish *et al.* 2013), within-school physical education (PE) classes (Lonsdale *et al.* 2013), and after-school (Mears *et al.* 2016; Demetriou *et al.* 2017). The evidence is inconsistent and suggests that interventions promoting PA within-school, during play/recess and after-school may contribute to children's PA accrual. Conversely, only a few systematic reviews have considered the effectiveness of SB interventions within the school setting (Van Grieken *et al.* 2012; Muthuri *et al.* 2014). A systematic review examining interventions

for preventing obesity in children aged 6 to 12 years found no evidence to suggest that interventions that only focus on diet were effective (Brown *et al.* 2019). Previous systematic reviews considering the effectiveness of school-based PA and dietary interventions have suggested that combined diet and PA interventions may help prevent childhood obesity (Brown *et al.* 2009; Kelishadi *et al.* 2017). However, these reviews of obesity prevention interventions in children and adolescents did not consider whether outcomes were influenced by methodological quality, characteristics of intervention components, intervention length and whether or not the interventions were theoretically driven. Further research is needed, to better understand how implementation of multi-component interventions deals with various intervention targets.

This review assesses the effectiveness of school-based interventions on primary school children at changing obesity-related behaviours and/or a change in BMI/BMI z-score, taking into account the methodological quality of the included studies. Secondary aims were to identify the most effective elements (e.g., PA, SB and/or nutrition), used in these interventions, to examine the characteristics of the interventions and to quantify their effect through meta-analysis.

3.2. Materials and methods

This systematic review is reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria (Moher *et al.* 2009) and was registered with PROSPERO (Registration number: CRD42019147930).

3.2.1. Search Strategy

A comprehensive search of seven electronic databases and online registers—Medline OVID (1946–2020), EMBASE (1980–2020), PsycINFO (1806–2020), SPORTDiscus (1984–2020), Scopus (1966–2020), CINAHL (1934–2020) and Cochrane Central Register of Controlled Trials (CENTRAL)—was conducted to identify peer-reviewed intervention studies published in English between 1 January 2009 and 25 December 2020. Searches were limited to that time period since a comprehensive review investigating the moderators of school-based intervention programmes on energy balance-related behaviours from inception to October 2009 was previously conducted

by Yildirim *et al.* (2011). A research librarian (JA) was consulted during the development and testing of search terms. The search strategies combined multiple keyword search terms agreed to a priori and were developed by breaking down the research question. The search terms focused on four key elements: (1) study population; (2) outcome measure; (3) study type; and (4) setting. As an illustration, the search strategy used in Medline is included in the appendices (**Appendix 1**). Reference lists of included studies were hand-searched for eligible interventions. The components of each of the searches were combined into a RefWorks library (bibliographic software).

3.2.2. Inclusion and Exclusion Criteria

Studies were eligible if they targeted children aged 5 to 12 years of any nationality, attending primary school on a full-time basis. If the ages of participants fell outside of this range, the mean age had to be within this range to warrant inclusion. Participants were only included if they were under 13 years at the commencement of the intervention. Studies were also eligible if they: (1) included an intervention that lasted at least 12 weeks; (2) were written in the English language and published after 2009; (3) targeted a change in at least two measures of BMI and/or obesity-related behaviours including PA behaviour and/or SB and/or nutrition behaviour; (4) randomised controlled trials (RCTs) or cluster-randomised controlled trials (cRCTs) with a comparison or control arm that consisted of either no intervention, an alternative treatment condition or ‘usual care’, i.e., existing PE programme. Studies were excluded if they: (1) included children with medical conditions known to affect weight status, children with eating disorders, critical illness, asthma or other chronic conditions or children with mental or physical disabilities; (2) were based primarily outside of the school setting (e.g., community settings, public place, at home, recreation facility, hospital, camp setting) or in a clinical population; and (3) involved participants receiving a PA intervention as part of a treatment regimen for a specific critical illness or comorbidity.

3.2.3. Study Selection

All search results were exported into the RefWorks library, and duplicates were removed. Title and abstract of retrieved articles were screened independently by two authors (SN and JB), using the inclusion/exclusion criteria as described above. When

full texts were not readily available, the lead author was contacted and requested to provide the full text for further assessment on eligibility. If no response was received, these studies were excluded as they could not be fully assessed for eligibility. If a study was mentioned multiple times, only the most recent publication was included in the analysis. Reference lists of the included studies and related systematic reviews were examined to identify any additional studies. Two authors (SN and JB) then independently reviewed the full text of the remaining articles to determine final inclusion. When uncertainties arose with regard to the study inclusion, consensus was achieved through discussion with a third author (AG). The third author was consulted for five articles.

3.2.4. Data Extraction Process

Data extraction was conducted in the selected studies by the first author (SN), and a second reviewer (AC) double-checked the data extraction of all the included studies. Study characteristics, intervention characteristics, description of the intervention using the Template for Intervention Description and Replication (TIDieR checklist) (Hoffmann *et al.* 2014) and effectiveness of the interventions were all extracted. The characteristics of interventions were extracted from both the main papers and where relevant from the published intervention protocol including: sample size, age of participants, study design, number of schools participating in the study, description of intervention, intervention type, timing and frequency of activities, providers, setting, resources and equipment used, underlying behavioural theory, training, the timeframe in which follow-up measurements were made, drop-out rates, characteristics of the participants, outcome measures and details of the control group. Information was extracted on whether the single-component interventions targeted a change in PA, SB or nutrition behaviour. Interventions covering multiple components that targeted a change in two or more obesity-related behaviours were also extracted. The TIDieR checklist was included in data extraction following recent guidance for improving systematic reviews (Hoffmann *et al.* 2017).

3.2.5. Evaluation of the Quality of the Studies

Two authors (SN and AG) independently assessed the risk of bias of all included trials using the Cochrane risk of bias tool (Higgins *et al.* 2011). Studies were assessed based on selection bias (i.e., random sequence generation, allocation concealment), detection

bias (i.e., blinding of study personnel), attrition bias (high is less than 70% at follow-up) and the validity of the outcome measure included in the intervention (i.e., device-based versus self-reported measures). A judgement of ‘low risk’, ‘high risk’, or ‘unclear risk’ of bias was selected for each of the domains. Disagreements were resolved through discussion until consensus was reached. If no consensus was reached, a third author independently assessed the risk of bias for that domain.

3.2.6. *Meta-Analysis*

The effect sizes were determined (mean differences) reporting 95% CI for the difference between arms (intervention vs. control) for each of the three behavioural outcomes and for BMI, as implemented into Review Manager (RevMan) (*Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014*). Data were pooled to compare the post intervention mean differences between intervention vs control for each of the outcomes. For data presented in the form of odds ratios or counts, a meta-analysis was conducted using the generic inverse variance method as implemented by RevMan. The difference between the intervention groups and control/comparison group in the mean change from baseline to post-intervention and the comparison at follow-up were used as a measure of effect size. Where study authors reported both device-measured and self-reported measurements for PA and/or SB, only the device-based measurement data were used in the statistical analysis. We quantified the extent of the variability observed that could be accounted for by true between-study differences rather than chance using the heterogeneity I^2 statistic (Higgins 2002). Results with $p < 0.05$ were reported as significant.

Pre-planned subgroup analyses were explored on possible moderators of the average intervention effect, and these were: PA and SB measurement method (device-based vs. self-report), intervention duration (<6 months vs. >6 months) and presence of underpinning theory (yes vs. no). Additional pre-planned subgroup analyses explored treatment-subgroup interactions with the type of intervention (multiple components or single component). Subgroup analyses, although planned, were exploratory; adjustments for multiple comparisons were applied.

Sensitivity analyses were performed for random-effects meta-analyses by strategically removing studies one by one if they had a small sample size, high risk of bias,

sedentary time or PA measures that were parent-reported compared to device measured to assess the robustness of the summary estimates. This would also indicate whether an individual study accounted for a large proportion of the heterogeneity. I^2 is represented as a percentage with a value of 0% indicating no dispersion and larger values indicating gradual increases in heterogeneity (i.e., 25% = low, 50% = moderate, 75% = high level of heterogeneity) (Higgins 2002). To identify any potential outliers, a set of leave-one-out analysis was performed to identify potential significant studies that resulted in a large change in the pooled estimates after they were left out one at a time from all studies.

Publication bias was assessed by examining asymmetry of funnel plots (effect size vs. standard error) where asymmetry is indicative of publication bias. We recognised that asymmetry of funnel plots can be due to either publication bias or a genuine relationship between effect size and trial size. To assess the possibility of publication bias, a minimum of 10 studies for a given outcome was required for the meaningful interpretation of funnel plots (Sterne *et al.* 2006; Ahmed *et al.* 2012).

3.3. Results

3.3.1. Database Searches

A PRISMA flowchart in Figure 3.1. illustrates the identification, screening, eligibility and inclusion of studies within the systematic review. The database search yielded 44,815 articles, while 21 additional articles were retrieved after reviewing the reference lists of the included studies. A total of 48 articles met the inclusion criteria for the narrative synthesis. Thirty-seven studies were eligible for inclusion in a meta-analysis.

3.3.2. Description of the Included Studies

The characteristics of the included studies are described in the Table 3.1. Most of the studies were cRCTs ($n = 35$, 73%) using the school or class as the unit of randomisation. The remaining studies were RCTs ($n = 13$, 27%). The 48 articles within this review involved a total of 46,235 children at baseline. The number of children participating in the study at baseline ranged from 51 (Lynch *et al.* 2016) to 3135 (Marcus *et al.* 2009). The average age of participants in each study ranged from 6.0 years (Llargues *et al.* 2011) to 10.9 years (Howe *et al.* 2011; Amini *et al.* 2016). Whilst

the participant groups were quite similar in terms of age across studies, the interventions were heterogeneous regarding study duration, intensity, type of the interventions and outcome measures. The duration of the interventions ranged from 12 weeks (Drummy *et al.* 2016) to four years (Telford *et al.* 2016), 19% of interventions ($n = 9$) had a duration of less than six months and 81% of the interventions were over six months in duration ($n = 39$). The number of schools participating in the studies ranged from one school (Lynch *et al.* 2016) to 154 schools (Kobel *et al.* 2014; Kobel *et al.* 2016). In this review, interventions were conducted within twenty different countries, including ten European countries ($n = 25$, 52%), within the USA ($n = 8$, 17%), Asia ($n = 7$, 15%) and in two Oceania countries ($n = 4$, 8%), and the remaining four studies were conducted in Argentina, Canada, Chile and Mexico (Table 3.1).

Of the 48 articles included in the qualitative synthesis, 43 (90%) articles targeted a change in PA, 29 (64%) articles targeted a decrease in SB, and 30 (63%) articles targeted change in nutrition behaviour (Table 3.2). Seven different methods were used to measure PA and SB. Both PA and SB were objectively measured via accelerometer in 13 studies (Barcardi-Gascon *et al.* 2012; Engelen *et al.* 2013; Fairclough *et al.* 2013; Martínez-Vizcaino *et al.* 2014; Madsen *et al.* 2015; Anderson *et al.* 2016; Drummy *et al.* 2016; Resaland *et al.* 2016; Farmer *et al.* 2017; Adab *et al.* 2018; Li *et al.* 2019; Seljebotn *et al.* 2019; Nathan *et al.* 2020) and subjectively measured through self-report questionnaires in 12 studies (Llargues *et al.* 2011; Williamson *et al.* 2012; Sacchetti *et al.* 2013; Kobel *et al.* 2014; Tarro *et al.* 2014; Wells *et al.* 2014; Amini *et al.* 2016; Kobel *et al.* 2016; Li *et al.* 2019; Liu *et al.* 2019; Habib-Mourad *et al.* 2020; Santana *et al.* 2021). One study used a combination of self-report and accelerometers to measure PA and SB (Bacardi-Gascon *et al.* 2012), and three studies used questionnaires to measure both PA and SB (Kobel *et al.* 2014; Kobel *et al.* 2016; Efstathiou *et al.* 2016). Two studies used three different methodologies to measure PA and SB including direct observation and device-based measurements (Wells *et al.* 2014; Telford *et al.* 2016). Seven studies measured PA using an accelerometer (Donnelly *et al.* 2009; Marcus *et al.* 2009; Ford *et al.* 2013; Drummy *et al.* 2016; Lau *et al.* 2016; Farmer *et al.* 2017; O'Leary *et al.* 2018), and four studies measured PA subjectively via questionnaires (Angelopoulos *et al.* 2009; Bacardi-Gascon *et al.* 2012; Rosario *et al.* 2017; Viggiano *et al.* 2018). To measure PA, one study combined self-

report and accelerometers (Kocken *et al.* 2016), another study combined pedometers and self-report measurements (Lynch *et al.* 2016), one used pedometer (Kain *et al.* 2014), and one used a 7-day PA recall (Howe *et al.* 2011).

A variety of dietary assessments were employed throughout the 30 articles. Food frequency questionnaires were the most commonly used (Marcus *et al.* 2009, Llargues *et al.* 2011; Rausch Hersovici *et al.* 2013; Bere *et al.* 2014; Xu *et al.* 2015; Anderson *et al.* 2016; Scherr *et al.* 2017; Adab *et al.* 2018; Li *et al.* 2019). One study used the digital photography method on three consecutive days to measure food selections and food intake (Williamson *et al.* 2012). Viggiano *et al.* (2018), used a graphical form of a food diary with a list of items to evaluate the quantity and quality of food consumption during of 7-day period. Two studies used a 24-h recall food intake questionnaire (Angelopoulos *et al.* 2009; Fairclough *et al.* 2013) two studies used a 3-day dietary recall sheet, on two weekdays and one day on the weekend, to estimate dietary intake (Ford *et al.* 2012; Amini *et al.* 2016), and one study used the 24-h food recall method among a subset of participants on a day that was convenient for the participants (n = 135) (Khan *et al.* 2014). Two studies measured children's nutrition behaviours via a parental questionnaire (Brandstetter *et al.* 2012; Kobel *et al.* 2014; Kobel *et al.* 2016). The mode of nutritional intervention delivery varied; however, the most used intervention strategy was health education classes and nutrition education programmes. One study used the board game 'Kaledo' as a strategy to improve nutrition knowledge to modify nutrition behaviour (Viggiano *et al.* 2018).

There were 35 (71%) multi-component interventions, while others adopted single component and 21 (48%) multi-component interventions targeted a change in PA, SB and nutrition behaviour. Eight (17%) interventions targeted a change in PA and SB, and five (9%) interventions targeted a change in PA and nutrition behaviour. Intervention strategies included school environment adaptations, interactive drama activities, modified PE lessons, extra- curricular PA sessions, gardening, cooking workshops, educational sessions, counselling sessions and provision of further opportunities to be physically active (e.g., active home- work, lunch and break time, PA clubs). Fourteen (30%) studies reported single-component interventions. Eight of these were targeting a change in PA by facilitating active academic lessons, activity breaks in the classroom, introducing additional brisk walking during school time,

school environment adaptations and educational sessions. Six single-component interventions targeted a change in nutrition through workshops and modifications to the school canteen (Khan *et al.* 2014), allocating free fruit (Bere *et al.* 2014) and educational sessions (Khan *et al.* 2014; Rosário *et al.* 2016; Scherr *et al.* 2017; Nickel *et al.* 2021). One study used several intervention activities including: classroom lessons, 19 take-home activities, cooking demonstrations, school gardens, family newsletters, health fairs, salad bars, procurement of regional produce and school-site wellness committees (Scherr *et al.* 2017). Four interventions did not measure BMI at any time point (Wells *et al.* 2014; Efstathiou *et al.* 2016; Habib-Mourad *et al.* 2020; Nathan *et al.* 2020). One study used a self-reported measurement for height and weight (Llauradó *et al.* 2014); the remainder of the interventions measured the participants' body weight and height objectively by a member of the research team.

Twenty-one (44%) studies explicitly reported that the interventions incorporated one or more behaviour change theories (Table 3.2). These included Social Cognitive Theory (Brandstetter *et al.* 2012; Fairclough *et al.* 2013; Kobel *et al.* 2014; Kobel *et al.* 2016; Anderson *et al.* 2016; Rosario *et al.* 2017; Scherr *et al.* 2017; Lloyd *et al.* 2018; Habib-Mourad *et al.* 2020), Social Identity Theory (Santina *et al.* 2021), the Theory of Planned Behaviour (Angelopoulos *et al.* 2009; Kochen *et al.* 2016), Socio-Ecological Model (Martínez-Vizcaíno *et al.* 2014; Scherr *et al.* 2017), RE-AIM (Reach, Efficacy, Adoption, Implementation, Maintenance) Theoretical Framework (O'Leary *et al.* 2019; Nathan *et al.* 2020), the Theory of Triadic Influence and the Comprehensive School Health Program Model (Williamson *et al.* 2012), Bronfenbrenner's Ecological Model (Bacardi-Gascon *et al.* 2012; Kobel *et al.* 2014; Kobel *et al.* 2016) and the analysis grid for environments linked to obesity (ANGELO) (Liu *et al.* 2019); two studies used a theoretical pathway that was informed by a previous mixed-method study (Llargues *et al.* 2011; Telford *et al.* 2016; Adab *et al.* 2018; Li *et al.* 2019). The remaining studies (n = 27, 56%) did not specify the use of a behaviour change model or theory.

3.3.3. *Quality of Included Studies*

Assessment of risk of bias is summarised in Figure 3.2. All the studies in this review had a low risk of bias for selective reporting (n = 48, 100%). Approximately half of the studies were assessed as having an unclear risk of bias due to insufficient

descriptions in terms of random sequence generation ($n = 21$, 44%). Most of the interventions were judged as having a low risk of bias in terms of selection bias ($n = 38$, 79%), performance bias ($n = 37$, 77%), detection bias ($n = 34$, 71%) and attrition bias ($n = 39$, 81%). The studies that were judged as having the highest risk of bias were for incomplete outcome data, blinding of outcome assessment and performance bias.

3.3.4. Meta-Analysis

Of the 48 studies included in the qualitative synthesis, 37 studies provided sufficient data for inclusion in the meta-analysis. Studies were excluded for the following reasons: not reporting sample size, missing data, inappropriate data type (i.e., studies providing different measures of variation, e.g., range, reference ranges and studies stating ‘not significant’ or ‘ $p < 0.05$ ’) and not reporting variance of data.

3.3.4.1. Effects of Interventions on Changing Moderate-to-Vigorous Physical Activity

Of the 37 studies included in the meta-analysis, 18 studies provided data for MVPA. For studies in which two measures of MVPA were obtained, data were extracted for the device-based measurement only. Assessment of the effect of interventions on MVPA comprised of 9263 participants indicating a small but statistically significant increase in MVPA in favour of the control group (2.14; 95% CI = 0.77, 3.50) with moderate inconsistency across trials ($I^2 = 66\%$). Subgroup analyses were performed as planned to explore whether the identified subgroups moderated the average intervention effect. We found several significant treatment subgroup interactions that could explain this inconsistency (Table 3.3).

3.3.4.2. Effects of Interventions on Changing Sedentary Behaviour

Of the 37 studies included in the meta-analysis, 16 studies provided sufficient data for SB. Twelve studies provided adequate data for objectively assessed sedentary time (mins/day) for which the pooled ES estimates were -0.91 (95% CI = -2.30 , 0.48). This estimate did not reach statistical significance, with low precision, as indicated by the CIs from a negative large effect to a positive large effect. Several significant treatment subgroup interactions were noted in Table 3.2. There were greater treatment effects when treatment duration was more than six months and when the measurement was device- based. Anderson *et al.* (2016) measuring screen time (mins/day) (10.17;

95% CI = -1.58, 21.92), Santina *et al.* (2021) (13.80; 95% CI = -0.96, 28.56) and an alternative study by Amini *et al.* (2016) measuring TV viewing (mins/day) (-3.00; 95% CI = -4.44, -1.56) found no significant effect, and all had very low precision.

3.3.4.3. *Effects of Interventions on Changing Nutrition Behaviour*

Eleven studies that aimed to enhance healthy dietary behaviour were included in the meta-analysis. Four RCTs including 1576 participants showed a non-significant increase in energy intake (kcal/day) (5.23; 95% CI = -77.83, 88.28). A separate meta-analysis was conducted in five studies (n = 4741) to investigate intervention effects on portions of fruit and vegetables consumed per day (0.05; 95% CI = -0.08, 0.17), and two studies examined fruit and vegetable intake (g/day) (10.45; 95% CI = -17.53, 38.43); all showed a non-significant increase in fruit and vegetable consumption. Although heterogeneity from the pooled analysis was low ($I^2 = 0\%$), the individual effects from the included studies were extremely inconsistent. All other planned subgroup analyses were non-contributory.

3.3.4.4. *Effect of Interventions on Changing BMI and BMI z-Score*

The overall effect size in 20 studies for BMI kg/m^2 is summarised in Figure 3.3, and the overall effect size in 16 studies for BMI z-score is summarised in Figure 3.4. The quantitative synthesis of the interventions showed a non-significant reduction in BMI (-0.04 kg/m^2 ; 95% CI = -0.13, 0.05) kg/m^2 in BMI and a small significant reduction in BMI z-score (-0.04; 95% CI = -0.07, -0.01) compared with the control group. Sensitivity analysis was conducted in studies measuring change from baseline rather than follow-up data in BMI (kg/m^2), removal of Ford *et al.* (2013) = (-0.04; 95% CI = -0.13, 0.05).

3.3.5. *Assessment of Publication Bias*

A subjective evaluation of the funnel plot showed a slightly asymmetric scatter consistent with publication bias (Figure 3.5).

3.4. Discussion

This review and meta-analysis synthesised the evidence of the efficacy of school-based interventions at changing obesity-related behaviours among primary-school children. Meta-analysis results indicate that school-based interventions had a small significant effect in BMI z-score compared with controls, but no significant effect on

sedentary time, energy intake, fruit and vegetable intake and BMI (kg / m^2). Subgroup analyses found studies lasting more than six months targeting a change in MVPA were more effective than studies that were of a shorter duration. In addition, we found significant interaction between theory-based interventions and interventions lasting more than six months and the effectiveness of changing BMI.

Previous reviews of interventions that target childhood obesity (Luttikhuis *et al.* 2009; Mead *et al.* 2017) of BMI/BMI z-score and weight reductions were in favour of the intervention group, however, the sustainability of any reduction detected in BMI/BMI z-score is an important factor, and there is a need for a long-term follow-up (Zolotarjova *et al.* 2018). Comparison of review findings must be examined with caution due to the varying eligibility criteria such as age of participants, study design and setting. Moreover, BMI as an outcome of these interventions may be relatively insensitive to change (Kolotourou *et al.* 2013), and additional outcomes, such as the proportion of children who were in the control or intervention group who became overweight at the end of the study period, which may have been more applicable to judge the downstream efficacy of the behavioural interventions, were not always available.

The observed small effect of MVPA in favour of the control group suggests that interventions promoting MVPA may not be effective, and this supports previous research that also highlighted the varying effectiveness of school-based interventions at improving MVPA (Dobbins *et al.* 2009; Metcalf *et al.* 2012). Many of the interventions included in the current review were multi-component interventions and targeted a change in PA. Previous reviews have also attempted to establish what components in obesity interventions work (Katz *et al.* 2008; Luttikhuis *et al.* 2009; Feng *et al.* 2017); however, only general findings were revealed, and the reviews were not solely focused on primary-school children. Within the literature we reviewed, there were no associations found between intervention components and effectiveness in the multi-component interventions, and it was not possible to determine which were the most effective components within these interventions. In line with the findings by a recent review (Liu *et al.* 2019), it is possible that effective multi-component interventions were influenced by a combination of intervention components. Thus, the effect of

combining components on intervention effectiveness ought to be the topic of further research.

Multi-component interventions that incorporate diet, PA and SB-change components were not as effective as the single-component interventions at changing obesity-related behaviours in primary-school children. This is in contrast to the findings of a systematic review (Katz *et al.* 2008) that found that multi-component interventions (nutrition and PA), a single nutrition intervention and TV reduction were equally effective at achieving weight reduction in children and adolescents. However, in the Katz *et al.* (2008) review, only a few studies ($n = 8$) were presented to adequately evaluate these strategies, and the robustness of these findings is limited due to the high degree of heterogeneity. More recently, a systematic review investigating interventions for the prevention of childhood obesity found low-certainty evidence that a combination of a diet and PA intervention reduced BMI z-score compared to the control group (Brown *et al.* 2019). In contrast to the present review, Brown *et al.* (2019) had a broader scope of included interventions, including those from the home and community, as well as the school setting. The efficiency of combined diet and PA school-based interventions to prevent obesity remains equivocal. For the current body of evidence, interventions based only on dietary improvement components were not associated with any increased efficacy in relation to nutrition behaviour, and this was consistent with other reviews (Brown *et al.* 2019; Liu *et al.* 2019). The lack of effect observed for nutritional interventions may be construed by poor adherence to dietary interventions or the intricate interplay of intervention components.

No previous research has explored whether obesity-related outcomes were altered by theoretically driven school-based interventions solely in primary-school children. Over half of the included studies in this review did not specify the use of a behaviour change model or theory, and subgroup analyses inferred a significant effect on BMI z-score for interventions that were underpinned by behaviour change theory; however, the effect size was small but statistically significant. In most of the included studies that included a behaviour change model or theory, often a theoretical framework was only stated, rather than something that was used specifically in the intervention formulation which is highlighted in previous research (Panter *et al.* 2018). Our review found no clear trend regarding a theory-based approach being more effective than

interventions that were not based on a specific theory framework. In line with the current review, a previous review also found an insufficient amount of evidence that interventions underpinned by theory were more effective than those with no specified theory in after-school PA interventions (Mears *et al.* 2016).

The lack of a clear link between using a behaviour change model or theory and intervention effectiveness could be in part due to differences in the implementation of the underpinning theory within the interventions. Schools confront many challenges in converting evidence-based interventions into routine practice, for example: funding, school climate, resources, teacher self-belief, curriculum demands and implementation support (Kearns *et al.* 2019). Many theories, frameworks and models have been implemented in the trials included in this review. However, few interventions stated theoretical fidelity, which prevents direct inferences being made between intervention effectiveness and the underpinning theory (Pérez *et al.* 2015). For example, a recent systematic review reported that several barriers exist in the adoption, application and the integration of new PA interventions in schools (Cassar *et al.* 2019). In order to face this challenge, future interventions need to establish the exact links from theory to implementation as poor application of the theory may well be the reason of the lack of success in some interventions (Naylor *et al.* 2015). Understanding the implementation of interventions is essential, as interventions need to be planned, designed and delivered for use in real-world settings to have a population wide impact (Hailemariam *et al.* 2019).

These findings reinforce that despite diversity of school-based interventions, the overall effect is promising in preventing weight gain among otherwise healthy children. Although difficult to compare outcomes between the studies included in this review due to the differing nature of the study design, target population and selected primary outcomes, the outcome of the analysis demonstrates the potential for school-based obesity prevention interventions. Nevertheless, it is challenging that so few studies were successful in increasing PA along with improving nutrition and/or reducing SB. Findings of the review should be interpreted in the context as the details of intervention characteristics varied considerably between interventions. Due to the considerable heterogeneity across paediatric obesity prevention interventions, with regards to certain interventions used (e.g., number, type and length), behavioural

targets of the interventions and the measurement of outcomes, it is vital for authors to adopt an appropriate research design. Authors should provide adequate detail about their treatment strategies, theoretical basis and components and intensity of the interventions, as well as any implementation and assessment of programme fidelity, as this may be a promising approach for future intervention attempts. Though school-based interventions have been proposed as being the most promising setting to tackle childhood obesity (Kriemler *et al.* 2011), the observed small effect exemplifies the difficulties and challenges positively impacting children's obesity-related behaviours through the school setting. More research is required in the field on the impact of these interventions for long-term (e.g., more than one academic school year) obesity-related behaviour change. Few studies provided sufficient information for meta-analysis, and in some cases, it was necessary to rely on authors' reporting of significant or non-significant effects on the interventions. Thus, these future studies should consider assessing a range of behaviours using validated objective measures and use standardised reporting of key outcomes (e.g., nutrition, sedentary and PA changes). Further research is required of school-based interventions in lower-income countries. From currently available evidence, it appears that long-term impact (e.g., more than one academic school year) of primary school-based interventions on maintenance of obesity-related behaviours needs further examination along with methodological rigor in the description and measurement of the target behaviours. Collectively, the findings from this review provide a comprehensive evaluation of the literature on the impact of interventions on lifestyle behaviours deemed essential in the prevention of childhood obesity.

3.4.1. Strengths and Limitations

This review contributes to the existing evidence base, as it is the first systematic review to assess the effectiveness of school-based interventions targeting obesity-related behaviours in primary-school children. The findings should be interpreted with caution considering the following limitations. First, the high level of heterogeneity detected across the included studies, which is a common finding amongst multi-component obesity interventions, limits the robustness of these findings. Pooled results indicate high levels of inconsistency across the included RCTs, and the majority of the analyses remained largely unexplained despite a large set of planned subgroup analyses. Therefore, the inconsistency is likely the result of variability in participants, settings,

intervention components, outcomes and trial design. Heterogeneity of outcome measures is combined by heterogeneity of intervention methods, which consequently meant that extracting the data and findings was quite challenging.

Studies included in this review were restricted to English full-text publications, and it is therefore possible some relevant non-English studies were overlooked. Researchers had to rely on limited descriptions of interventions to classify the studies, and precisely assessing the contents of some interventions was difficult due to inconsistent reporting. The review did not investigate whether studies were powered using behavioural outcomes, and future systematic reviews should consider whether interventions were powered for the behavioural outcome. Although the overall systematic review identified 48 studies, when sub-group analyses were undertaken, included studies were limited (i.e., based on 1–15 studies), and as a result, it was not possible to examine whether the findings of potentially effective intervention components were influenced by device-based or self-reported measurements. Since the present review only included RCTs and cRCTs, these will, as a result, not address any complex interplay between behaviours and real-world settings. Nevertheless, the results of RCT study designs are valuable and are considered the gold standard (Victora *et al.* 2004). Lastly, while the review attempted to separate out the most effective components, several studies comprised numerous complementary components that were not assessed individually. This review is one of the first to use meta-analyses and subgroup analyses to systematically review several studies and analyse the potentially effective components of school-based interventions for preventing obesity in primary-school children.

3.5. Conclusions

Small significant intervention effects were found between groups in BMI z-scores; nevertheless, the findings were inconsistent, and the heterogeneity observed across all outcomes was not explained by subgrouping. Furthermore, the meta-analyses of the included interventions to prevent childhood obesity showed inconclusive results were found regarding MVPA, SB, nutrition behaviour and for BMI kg/m² compared with the control condition. This review highlights the need to better understand how implementation of multi-component interventions deals with various intervention targets—perhaps it is just too much for schools to take on. It is important that future

research investigates whether consecutive rather than concurrent sequencing of delivery is better. To conclude, the chance of success may be greater in a single-component intervention that only targets one obesity-related behaviour. It is important policy makers continue to recognise the school setting as a vehicle for tackling childhood obesity.

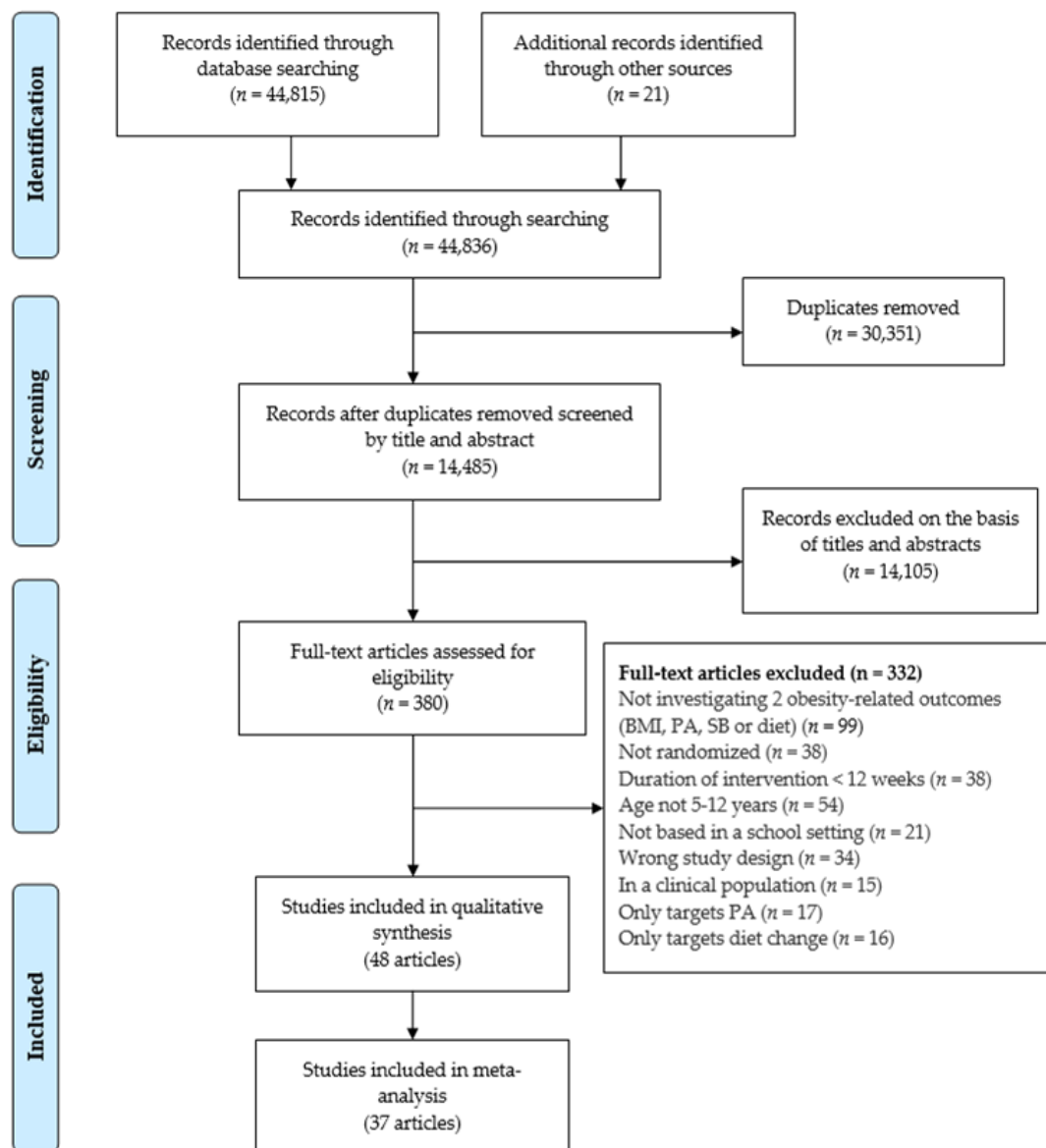


Figure 3.1. Flowchart of study selection.

Table 3.1. Description of the included trials (n = 48)

Author, year	Study design, Country	Aim/objective	Baseline characteristics	Intervention Description	Intervention outcomes			
					BMI	PA	SB	NB
Adab <i>et al.</i> (2018)	Cluster RCT, UK	To assess the effectiveness of a school and family based healthy lifestyle programme in preventing childhood obesity.	n = 1392 (54 schools) Age: 6.3 ± 0.3 yrs; Female (%) : 48.9; Attrition rate: 1 school (1.9%), 143 students (10.3%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV, 3 months Post-IV, 18 Post-IV	Underlying theory: not mentioned; Intervention setting: school and home; Content and frequency: (1) 30 mins additional MVPA on each school day (2) Termly cooking workshops (3) A six-week programme to encourage healthy eating and increase PA (4) Information sheets signposting children and their families on ways to be active and PA opportunities in their local area; CON: usual practice	BMI z-score	PA EE (kJ/kg BW/day)	Sedentary time (min/day)	Energy intake (kJ/day)
					Outcome Measure: UK 1990 BMI reference curves for children)	MVPA (min/day)	Outcome Measure: Actiheart	Total fat (g/day) Total sugar (g/day) Total fibre (g/day) Fruit and vegetable intake (g/day and portions) Outcome Measure: Child and Diet Evaluation Tool (CADET)
Amini <i>et al.</i> (2016)	Cluster RCT, Iran	To evaluate the effect of an intervention for reducing excess weight gain in primary school-age children.	n = 334 (12 schools) Age: 8-12 yrs; Female (%) : 49; Attrition rate: N/A; Length of intervention: 4.5 mons; Assessment: Baseline, Post-IV	Underlying theory: not mentioned; Intervention setting: school and home; Content and frequency: (1) nutrition education for pupils, (2) lifestyle education for parents, (3) PA education for pupils (4) improvement of schools' canteens. CON: no intervention	BMI z-score	METs	TV viewing/day (hr/day)	Energy intake (kcal/day)
					Outcome Measure: AnthroPlus	Outcome Measure : PA questionnaire	Working with computer/day (hr/day) Outcome Measure: questionnaire	Total fat (g/day) Total protein (g/day) Total carbohydrates (g/day) Daily energy from fat (%) Daily energy from carbohydrates (%) Outcome Measure: 24-hr dietary recall

Anderson <i>et al.</i> (2016)	Cluster RCT, UK	To investigate the long-term effectiveness of a school-based intervention to improve physical activity and diet in children.	n = 2221 (60 schools) Age: 8–9 yrs; Female (%): 50; Attrition rate: 54 (10%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV, 12 mons Post-IV	Underlying theory: SCT; Intervention setting: school and home; Content and frequency: (1) Training for teachers, (2) 16 lesson-plans and teaching materials (3) 10 parental-child interaction homework activities (4) Information in the school newsletters about the importance of increasing PA, reducing SB & improving diet (5) information for parents on how to encourage their children to eat healthily and be active; CON: usual practice	BMI z-score Outcome Measure: weight and height measured in classrooms (kg/m ² ; treated in all analyses as an SD z-score)	MVPA (min/day) Outcome Measure: ActiGraph GT3X+	Sedentary time (min/day) Time spent screen viewing (min/day) Outcome Measure: ActiGraph GT3X+ and self-reported questionnaire	Intake of fruit, vegetable, high-fat foods, snacks and high-energy drinks (number/day) Outcome Measure: A Day in the Life self-reported questionnaire
Angelopoulos <i>et al.</i> (2009)	Cluster RCT, Greece	To evaluate the effectiveness of this school-based intervention program, on obesity indices and blood pressure in primary school children.	n = 646 (26 schools) Age: 10.3 ± 0.4 yrs; Female (%): 47.6; Attrition rate: 0; Length of intervention: 12 mons; Assessment: Baseline, Post-IV	Underlying theory: Theory of Planned Behaviour; Intervention setting: school and home; Content and frequency: (1) student workbook and a teacher's manual was created & used in class (2) 2 x 45-min PE sessions per week delivered in the playground (3) increased accessibility to playgrounds and school yards (4) meetings to support parents (5) educational dietary activities	BMI (kg/m ²) BMI z-score Outcome Measure: Centres for Disease Control (CDC) 2000 Growth Charts.	MVPA (min/day) Outcome Measure: Self-report questionnaire	Intake of fruit, vegetable, dairy, sweets and beverages, snack, grain, meat, fat and oil (portions/day) Outcome Measure: 24-h recall	

CON: no intervention							
Bacardí-Gascon <i>et al.</i> (2012)	Quasi Cluster RCT, Mexico	To assess the effect of a six-month intervention on the BMI, food consumption and PA of 2nd and 3rd grade elementary school children.	n = 532 (4 schools) Age: 8.5 ± 0.7 yrs; Female (%) : 49; Attrition rate: 54 (11%); Length of intervention: 6 mons; Assessment: Baseline, Post-IV, 3 mons Post-IV, 7 mons Post-IV, 18 mons Post-IV.	Underlying theory: Bronfenbrenner's Ecological Model; Intervention setting: school and home; Content and frequency: (1) Three 60-minute sessions to discuss healthy lifestyles with school board & teachers (2) One 30-min interactive lesson was delivered by nutrition graduate students each week for 8 weeks (3) parents received a 60-minute session delivered by nutrition professionals each month for 4 months. CON: after the initial six-month period they received the intervention.	BMI (kg/m ²) BMI z-score Outcome Measure: WHO 2007 LMS parameters	Outdoor play (h/day) Physical Education (h/week) Supervised sports or dancing (h/week) Outcome Measure: Actigraph; INTA PA questionnaire; Subgroup analysis (n = 45)	Sitting (h/day) TV watching (h/day) Computer and video games (h/day) Outcome Measure: Self-reported questionnaire Outcome Measure: Dietary registry and questionnaire on food inventory; (on a randomly selected weekday)
Bere <i>et al.</i> (2014)	Cluster RCT, Norway	To assess if increased consumption of fruits and vegetables, due to free school fruit, have an impact on future weight status.	n = 1,950 (38 schools) Age: 11.8 ± 0.7 yrs; Female (%) : 49.5; Attrition rate: 1,630 (83.6%); Length of intervention: 9 mons; Assessment: Baseline, Post-IV, 12 mons Post-IV, 36	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) Free school fruit for the school year CON: not reported	BMI (kg/m ²) Outcome Measure: Self-reported height and weight.	Intake of unhealthy snacks, fruit and vegetable (times/week) Outcome Measure: 24-H recall & FFQ	

			mons Post-IV, 18 mons Post-IV					
Brandstetter <i>et al.</i> (2012)	Cluster RCT, Germany	To examine the effects of URMEL-ICE (Ulm Research on Metabolism, Exercise, and Lifestyle Intervention in Children), on children's BMI and other measures of fat mass.	n = 1119 (32 schools) Age: 7.6 ± 0. yrs; Female (%) : 46.5; Attrition rate: not reported; Length of intervention: 1 school year; Assessment: Baseline, Post-IV.	Underlying theory: SCT; Intervention setting: school and home; Content and frequency: 29 teaching units designed to promote health-behaviour change in (1) sugar-sweetened beverages consumption (2) screen media (3) PA. CON: not reported.	BMI (kg/m ²) BMI z-score Outcome Measure: age and sex-specific BMI charts for Germany	Outdoor play (times/week) Participation in club sport and in other sport activity (times/week) Outcome Measure: Parent questionnaire KiGGS survey	TV viewing (h/day) Outcome Measure: Parent questionnaire KiGGS survey	Intake of sugar-sweetened beverages at home/school (consuming more or less) Outcome Measure: Parent questionnaire KiGGS survey
Donnelly <i>et al.</i> (2009)	Cluster RCT, USA	The aim of this study, Physical Activity Across the Curriculum (PAAC) was to promote PA and diminish increases in overweight and obesity in elementary school children.	Subsample n = 454 (24 schools), Age: 8.3 yrs; Female (%) : 46.5; Attrition rate: 37 (2.5%); Length of intervention: 36 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1)90 minutes/wk of MVPA active academic lessons delivered intermittently throughout the school day. CON: regular classroom instruction without physically active lessons.	BMI (kg/m ²) BMI z-score Outcome Measure: BMI percentiles calculated using gender & age	MVPA (min/day) Outcome Measure: ActiGraph, 7163, Pensacola, FL)		
Drummy <i>et al.</i> (2016)	Cluster RCT,	To examine the effect of a classroom-based	n = 120 (14 schools) Age: 9.5 yrs;	Underlying theory: not reported; Intervention setting:	BMI (kg/m ²)	MVPA (min/day)		

	Northern Ireland	activity break on accelerometer-determined MVPA and adiposity in primary school children.	Female (%): not specified; Attrition rate: N/A; Length of intervention: 3 mons; Assessment: Baseline, Post-IV.	School; Content and frequency: (1) 5-min classroom-based activity break 3 times per day for 12 weeks. CON: usual practice.	Outcome Measure: Height and weight	Outcome Measure: Actigraph GT1M	
Efstathiou <i>et al.</i> (2016)	RCT, Greece	To measure classroom psychological climate & investigate its relationship to students' PA & sedentary life habits following an innovative education programme on nutrition and PA.	n = 1119 (32 schools) Age: 7.6 ± 0. yrs; Female (%): not specified; Attrition rate: N/A; Length of intervention: 7 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) <i>Intensive Intervention Group:</i> curriculum focused on theatrical with the participation of specialised personnel (nutritionists and life scientists) for 20 weekly class sessions (2) <i>Intervention Group:</i> nutrition education programme delivered over 20 weekly class sessions. CON: did not participate in the nutrition education programme.	Outdoor PA (times/week) Outcome Measure: Self-reported questionnaire	Screen time on weekdays (times/week) Outcome Measure: Self-reported questionnaire	Not reported. Outcome Measure: Self-reported questionnaire
Engelen <i>et al.</i> (2013)	Cluster RCT, Australia.	To explore the effects of an innovative school-based intervention for increasing PA.	n = 226 (12 schools) Age: 6.0 ± 0.6. yrs; Female (%): 46.2; Attrition rate: N/A; Length of	Underlying theory: not reported; Intervention setting: School playground; Content and frequency:	BMI (kg/m ²) Outcome Measure:	Total accelerometer counts MVPA (min/day)	Sedentary time (min/24 hrs)

			intervention: 13 weeks; Assessment: Baseline, Post-IV.	(1) altering the school playground by introducing loose materials and (2) a teacher–parent intervention exploring perceptions of risk associated with children's free play; CON: participated in standard break time.	Height and weight	Outcome Measure: ActiGraph GT3X+	Outcome Measure: ActiGraph GT3X+	
Fairclough <i>et al.</i> (2013)	Cluster RCT, UK.	This evaluation investigated the effectiveness of the Children’s Health, Activity and Nutrition: Get Educated! (CHANGE!) Project, an intervention to promote healthy weight using an educational focus on PA and healthy eating.	n = 318 (12 schools) Age: 10.6 ± 0.3 yrs; Female (%) : not specified; Attrition rate: 112 (35.2%); Length of intervention: 20 weeks; Assessment: Baseline, Post-IV, 10 weeks Post-IV.	Underlying theory: SCT; Intervention setting: School and home; Content and frequency: (1) teacher-led curriculum (20 weekly lessons, 60 min each), (2) learning resources, (3) homework tasks; CON: received normal instruction.	BMI (kg/m ²) BMI z-score Outcome Measure: BMI percentiles calculated using gender & age	LPA, MPA, VPA (min/day) Outcome Measure: ActiGraph GT1M	Sedentary time (min/24 hrs) Outcome Measure: ActiGraph GT1M	Consumption of breakfast cereals, breads, meats, dairy products (times/day) Outcome Measure: 24-hour recall food intake questionnaire
Farmer <i>et al.</i> (2017)	Cluster RCT, New Zealand.	The aim of the PLAY study was to determine whether providing greater opportunities for risk and challenge in primary schools	n = 840 (16 schools) Age: 8.0 ± 1.1 yrs; Female (%) : 51; Attrition rate: 210 (25%); Length of intervention: 12 mons;	Underlying theory: not reported; Intervention setting: School; Content and frequency: redesigned play environment (1) promoting greater challenges, 2) adding more dynamic equipment, 3) relaxing the rules.	BMI (kg/m ²) BMI z-score Outcome Measure: BMI percentiles calculated	Estimate of overall PA (counts/min) MVPA (min/day) Outcome Measure: ActiGraph GT3X		

		increased PA and reduced relative body weight over the long term.	Assessment: Baseline, Post-IV, 12 mons Post-IV.	CON: schools were asked to not change anything in their school play spaces.	using gender & age		
Ford <i>et al.</i> (2013)	RCT, UK.	To establish whether an accumulated brisk walking programme, performed during the school day, is effective in changing body composition	n = 174 (2 schools) subsample n = 121 Age: 5-11 yrs; Female (%) : 50.1; Attrition rate: 22 (12.7%); Length of intervention: 15 weeks; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) brisk walk around the school grounds for 15 min in the morning and afternoon, at least three times a week, for a total of 90 min per week; CON: usual practice.	BMI (kg/m ²) Outcome Measure: BMI percentiles calculated using gender & age	Total accelerometer counts Outcome Measure: MTI Accelerometer s	Energy intake (kcal/day) Outcome Measure: Parental 3-day dietary recall
Habib-Mourad <i>et al.</i> (2020)	RCT, Lebanon.	To describe the effectiveness of a school-based intervention when delivered by a non-nutrition specialist (trained schoolteachers) as compared to an expert in nutrition.	n = 2276 (52 schools) Age: 9-11 yrs; Female (%) : not given; Attrition rate: 128 (5.6%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	Underlying theory: SCT; Intervention setting: School and home; Content and frequency: (1) 12 classroom sessions incorporated into the school curriculum, 2) family module consisting of information, 3) relaxing the rules. CON: usual curriculum		Sessions of PE (times/week) Outdoor play (times/week) After school PA (times/week) Outcome Measure: Self-reported questionnaire	Daily breakfast intake Snack intake (times/day) Eating in front of the TV (times/week) Outcome Measure: Self-reported questionnaire
Howe <i>et al.</i> (2011)	RCT, USA.	To determine if a 10-month after-school PA	n = 106 (5 schools) Age: 8-12 yrs;	Underlying theory: not reported; Intervention setting: School;	BMI (kg/m ²)	MVPA, LPA, MPA, VPA (min/day)	

		intervention could prevent deleterious changes in body composition and cardiovascular fitness in young black boys.	Female (%): 0; Attrition rate: 22 (12.7%); Length of intervention: 10 mons; Assessment: Baseline, Post-IV.	Content and frequency: set afterschool and included (1)30 minutes of homework time during which the boys were provided with a healthy snack (2) followed by 80 minutes of PA; CON: no intervention and were not allowed to stay for the after-school intervention.	Outcome Measure: Height and weight Outcome Measure: seven-day PA recall
Kain <i>et al.</i> (2014)	Cluster RCT, Chile.	To evaluate the effectiveness of a 12-month multicomponent obesity prevention intervention.	n = 1949 (9 schools) Age: 6.6 ± 1.1 yrs; Female (%): 46.6; Attrition rate: 475 (24.4%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: school; Content and frequency: (1) classroom education on nutrition, 2) improve the quality of PE classes; CON: usual practice.	BMI (kg/m ²) BMI z-score Outcome Measure: WHO reference MVA in PE classes (min/day) Outcome Measure: pedometers (New Lifestyle 1000)
Khan <i>et al.</i> (2014)	RCT, USA.	To investigate the effect of a 9-month PA intervention on cardiorespiratory fitness and adiposity among prepubertal children.	n = 220 (7 schools) dietary subsample n = 135 Age: 8.8 ± 0.6 yrs; Female (%): 46.8; Attrition rate: 27 (12.3%); Length of intervention: 9 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: school; Content and frequency: 2-hour intervention (5 days/week for 9 mons), (1) each session began with 20-25 mins PA station, (2) healthy snack provided during the 15-minute educational component;	BMI (kg/m ²) BMI z-score Outcome Measure: Height and weight Total energy intake (kcal/day) Total fat, protein, carbohydrate intake (%/kcal). Outcome Measure: 24-hour food recall;

CON: regular after-school routine.								
Kobel <i>et al.</i> (2014)	Cluster RCT, Germany	To evaluate children's behaviours in respect of increased PA, a decrease in screen media use (SMU), more regular breakfast, and a reduction of the consumption of soft drinks.	n = 1943 (154 schools) Age: 7.1 ± 0.6 yrs; Female (%) : 48.8; Attrition rate: 207 (10.7%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	Underlying theory: SCT and Bronfenbrenner's social ecological model; Intervention setting: School and home; Content and frequency: based on teaching materials (1) offering action alternatives for recreational activities (without screen media), (2) PA, and a healthy diet (focusing on breakfast and soft drinks) which are integrated into the primary school curriculum CON: usual practice.	BMI (kg/m ²)			
				Outcome Measure: calculated as weight divided by height squared and converted to BMI percentiles (BMIPCT) using German reference data to define their weight status.	MVPA (min/day)	Screen time (min/day)	Intake of soft drink consumption (serving/day)	
Kobel <i>et al.</i> 2017	Cluster RCT, Germany	To evaluate children's behaviours from a migration background in respect of increased PA, a	n = 525 (154 schools) Age: 7.1 ± 0.7 yrs; Female (%) : 51.4; Attrition rate: N/A; Length of intervention: 12 mons;	Underlying theory: SCT and Bronfenbrenner's social ecological model; Intervention setting: School and home; Content and frequency:	BMI (kg/m ²)	MVPA (min/day)	Screen time (min/day)	Intake of soft drink consumption (serving/day)
				Outcome Measure: calculated as	Outcome Measure: parental questionnaire	Outcome Measure: parental questionnaire	Outcome Measure: parental questionnaire	

		decrease in screen media use (SMU), more regular breakfast, and a reduction of the consumption of soft drinks.	Assessment: Baseline, Post-IV.	based on teaching materials (1) offering action alternatives for recreational activities (without screen media), (2) PA, and a healthy diet (focusing on breakfast and soft drinks) which are integrated into the primary school curriculum CON: usual practice.	weight divided by height squared and converted to BMI percentiles using German reference data to define their weight status.				
Kocken <i>et al.</i> (2016)	RCT, Netherlands	To evaluate the effectiveness of the “Extra Fit!” education program in promoting healthy diet and PA to prevent and reduce overweightness among primary school children.	n = 1112 (45 schools) Age: 7.1 yrs; Female (%): 51.7; Attrition rate: N/A; Length of intervention: 2 school yrs; Assessment: Baseline, 7-mons Post baseline, Post-IV, 6 mons Post-IV.	Underlying theory: The Theory of Planned Behaviour; Intervention setting: School and home; Content and frequency: based on classroom and physical education activities, including practical assignments, group discussions and lessons to change (1) dietary intake, (2) PA and (3) SB. CON: usual practice.	BMI z-score Outcome Measure: Weight and height	MVPA (min/day) Outcome Measure: Actigraph and questionnaire for children	Sedentary and screen time (min/day) Outcome Measure: questionnaire for children	Energy intake (kcal/day), fat, protein, sugar sweetened beverages, other beverages, carbohydrates, fruit and vegetable (g/day) Outcome Measure: 24-h recall.	
Lau <i>et al.</i> (2016)	RCT, China	To determine the effect of a school based AVG intervention on Chinese	n = 80 (1 school) Age: 9.2 ± 0.5 yrs; Female (%): 31.3; Attrition rate: 0;	Underlying theory: not reported; Intervention setting: School; Content and frequency:	BMI (kg/m ²) Outcome Measure:	MVPA (min/day) Outcome Measure:			

		children's aerobic fitness, PA level, and PA-related psychological correlates.	Length of intervention: 12 weeks; Assessment: Baseline, Post-IV.	(1) played active videogames, Xbox 360, twice per week during after-school hours, each for 60 minutes; CON: usual practice.	Weight and height	ActiGraph GT3X+		
Li <i>et al.</i> (2019)	Cluster RCT, China	To evaluate the clinical- and cost-effectiveness of the Chinese Primary School Children Physical Activity and Dietary Behaviour Changes Intervention developed using the UK Medical Research Council complex intervention framework to prevent obesity in Chinese primary-school-aged children.	n = 1641 (40 schools) Age: 9.2 ± 0.5yrs; Female (%) : 54.5; Attrition rate: 55 (3.4%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	Underlying theory: A theoretical pathway informed by a mixed-methods study; Intervention setting: School and home; Content and frequency: Targeting PA and NB (1) Interactive education workshops for carers with summarising leaflet, (2) adjustments to school lunches, (3) taster session to teach fun & active PA games and PA homework assignment. CON: usual practice.	BMI z-score Outcome Measure: Weight and height	(1) MVPA (min/day) (2) Parental reported MVPA (min/day) (3) Proportion of children achieving ≥60 minutes MVPA/day Outcome Measure: (1) GENEActiv Original, Activinsights Ltd, (2) Adapted Godin Leisure-Time Exercise Questionnaire (3) questionnaire	(1) Sedentary time (min/day) (2) Parent reported sedentary behaviours (mins/24 hours) (3) Screen time (h/day) Outcome Measure: (1) GENEActiv Original, Activinsights Ltd, (2) Adapted Godin Leisure-Time Exercise Questionnaire (3) questionnaire	Weekly average servings of unhealthy snacks and sugar added drinks Proportion of children consuming ≥5 portions of fruit and vegetables daily Daily average portions of fruit and vegetables Outcome Measure: food frequency questionnaire;

Liu <i>et al.</i> (2019)	Cluster RCT, China	A comprehensive approach involving both environmental and individual strategies offers opportunities to strengthen school-based interventions for childhood obesity.	n = 1641 (12 schools) Age: 7-11 yrs; Female (%) :48.3; Attrition rate: 50 (2.6%); Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	Underlying theory: the analysis grid for environments linked to obesity (ANGELO); Intervention setting: School and home; Content and frequency: (1) school policies: certain food and beverages and electronic devices not permitted in the school, (2) health education activities, (3) 3 x 45-minute PE classes per week; CON: usual practice.	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	PA (min/day) Outcome Measure: Self-administered 7-day PA questionnaire .	Screen time (h/day) Outcome Measure: Self-administered questionnaire .	Intake of meat, sugar-sweetened beverages, fruit and vegetable (portion/day) Outcome Measure: Self-administered questionnaire based on the validated Block Kids Food Screener
Llargues <i>et al.</i> (2011)	Cluster RCT, Spain	To evaluate the effect of an intervention that modified food and PA habits on the progression of BMI in a population of school children using Research, Vision, Action and Change (IVAC) methodology.	n = 598 (16 schools) Age: 6.0 ± 0.3 yrs; Female (%) :46; Attrition rate: 89 (14.9%) for anthropometric data; Length of intervention: 24 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School and home; Content and frequency: (1) activities about healthy food habits and PA in classroom 3hr/week; (2) hand out healthy recipes for the families; (3) give out materials on healthy foods and about promoting healthy PA; (4) provide equipment for games; CON: usual practice.	BMI (kg/m ²) Outcome Measure: Weight and height	PA at weekends Walking before/during/after school Outcome Measure: Kreece Plus test .	TV video or DVD (h/day) Outcome Measure: Kreece Plus test .	Foods consumed at breakfast. Daily intake of fruit or juice, dairy, raw or cooked vegetables, fish, fast food, legumes, sweets and olive oil Outcome Measure: Kreece Plus test
Llaurado <i>et al.</i> (2014)	RCT, Spain	To assess the reproducibility of an educational intervention	n = 916 (16 schools) Age: 8.04 ± 0.6; Female (%) :47.7; Attrition rate:	Underlying theory: not reported; Intervention setting: School and home;	BMI (kg/m ²) BMI z-score	PA at weekends	TV video or DVD (h/day)	Foods consumed at breakfast. Daily intake of fruit or juice, dairy, raw or

		EdAI-2 (Educació en Alimentació) programme in 'Terres de l'Ebre' over 22 months, to improve lifestyles, including diet and PA.	411 (17.5%); Length of intervention: 22 mons; Assessment: Baseline, Post-IV.	Content and frequency: (1) eight lifestyle topics incorporated within 12 activities which were disseminated over 12 sessions (1 h/activity/session), and prepared, standardised and implemented as four activities per school academic year in the classroom; CON: usual practice.	Outcome Measure: Weight and height	Walking before/during/after school Outcome Measure: Kreece Plus test (parental questionnaire)	Outcome Measure: Kreece Plus test (parental questionnaire)	cooked vegetables, fish, fast food, legumes, sweets and olive oil; Outcome Measure: Kreece Plus test (parental questionnaire)
Lloyd <i>et al.</i> (2018)	Cluster RCT, UK	To establish whether a school-based intervention for children aged 9–10 years would prevent excessive weight gain after 24 months.	n = 1371 (32 schools) Age: 9.8 ± 0.3yrs; Female (%): 51.5; Attrition rate: 32 (2%) of children opted out by their parents or carers; Length of intervention: 9 mons; Assessment: Baseline, 9 mons Post-IV, 15 mons Post-IV.	Underlying theory: SCT; Intervention setting: School and home; Content and frequency: (1) creating a supportive context: professional sports people and dancers run practical workshops, (2) intensive healthy lifestyle week, (3) 10 mins personal goal setting discussion, (4) reinforce all the messages through an assembly and lesson; CON: usual practice.	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	MVPA, LPA, MPA, VPA (min/day) Outcome Measure: GENEActiv	Sedentary(min/day) Outcome Measure: GENEActiv	Energy-dense snack intake and healthy snack intake (portions/day) Outcome Measure: Food Intake Questionnaire
Lynch <i>et al.</i> (2016)	Cluster RCT, USA	To evaluate the impact of the Let's Go! 5-2-1-0 paediatric obesity intervention	n = 51 (1 schools) Age: 8.0 yrs; Female (%): 54.9; Attrition rate: 20 (39.2%);	Underlying theory: not reported; Intervention setting: School; Content and frequency:	BMI (kg/m ²)	Step count (step/day) Improved PA (score out of 10)	Screen time (h/day) Outcome Measure:	Beverage intake (portion/day) Improved eating behaviour (score out of 10)

		program in an elementary school setting.	Length of intervention: 4 mons; Assessment: Baseline, Post-IV	(1) 8 sessions anchored around the 5-2-1-0 curriculum (key daily messages of the program are for children to eat at least 5 servings of fruits and vegetables, limit recreational screen time to 2 or fewer hours, participate in at least 1 hour of PA, and to ingest 0 sugar-containing drinks) CON: usual practice.	Outcome Measure: Weight and height	Outcome Measure: Omron HJ-321 pedometer and caregiver survey	Caregiver survey	Outcome Measure: Caregiver survey
Madsen <i>et al.</i> (2015)	Cluster RCT, USA	To assess the impact of Energy Balance for Kids with Play, a school-based intervention developed by the Academy of Nutrition and Dietetics Foundation and Playworks, on students' PA, dietary habits and knowledge, and weight status.	n = 879 (6 schools) Age: 9.8 ± 0.3yrs; Female (%) :53; Attrition rate: 212 (24%); Length of intervention: 24 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) 12-week nutrition and energy balance education curriculum, (2) implement classroom wellness policies, (3) Packaging equipment for the school kitchen, (4) PA sessions and 4 afterschool sports leagues each year; CON: usual practice.	BMI (kg/m ²) Outcome Measure: Weight and height	MVPA (min/day) Outcome Measure: Actigraph GT1M or GT3X	School day sedentary(min/day) Outcome Measure: Actigraph GT1M or GT3X	Fruit and vegetable consumption (cups) Outcome Measure: Digital images and survey questions adapted from the School PA and Nutrition Questionnaire and the Child Food Consumption Questionnaire
Marcus <i>et al.</i> (2009)	Cluster RCT, Sweden	To assess whether a school-based prevention programme focused on	n = 3135 (10 schools) Age: 9.5 ± 0.7yrs; Female (%) :49; Attrition rate: 69 (14.1%);	Underlying theory: not reported; Intervention setting: School and home; Content and frequency:	BMI (kg/m ²)	Daily PA (min/day) Outcome Measure:		Intake of meat, sweet drinks, bread, dairy products, fruit and vegetable (portion/day)

		reduced unhealthy eating and increased PA during school time over a 4-year period could reduce the prevalence of overweight and obesity among 6 to 10-year-old children.	Length of intervention: 4 years; Assessment: Baseline, Post-IV.	change the school environment by (1) increase amount of PA by 30 min per child per day, (2) increased number of vegetables served at school lunch, (3) sweets, sweet buns and ice cream were eliminated at festivities; CON: usual practice.	Outcome Measure: Weight and height	Actiwatch	Outcome Measure: Parental questionnaire
Martinez-Vizcaino <i>et al.</i> (2014)	Cluster RCT, Spain	To assess the impact of a standardized physical activity program on adiposity and cardiometabolic risk factors in schoolchildren.	n = 1070 (20 schools) Age: 9.5 ± 0.7yrs; Female (%) : 49; Attrition rate: 69 (14.1%); Length of intervention: 9 mons; Assessment: Baseline, Post-IV.	Underlying theory: Socio-ecological model; Intervention setting: School and home; Content and frequency: (1) play-based and non-competitive activities and is conducted for two 90-minute sessions on weekdays and one 150-minute session on Saturday mornings; CON: usual practice. The standard physical education curriculum (2 h per week of PA at low-to-moderate intensity) continued to be taught in both the control and intervention schools.	BMI (kg/m ²) Outcome Measure: Weight and height	Daily PA (min/day) Outcome Measure: ActiGraph MTI/CSA	Sedentary (min/day) Outcome Measure: ActiGraph MTI/CS
Nathan <i>et al.</i> (2020)	Cluster RCT, Australia	To assess the impact of a multi strategy intervention	n = 2148 (12 schools) Age: 9.5 ± 2.0 yrs; Female (%) : 49; Attrition rate: 646	Underlying theory: theoretical domains framework; Intervention setting:	.	Total MVPA (min/day)	Sedentary (min/day)

		designed to improve teachers' implementation of a school PA policy on student PA levels.	(30%); Length of intervention: 9 mons; Assessment: Baseline, Post-IV.	School; Content and frequency: (1) 5 face-to-face workshop delivered by support officers, (2) various printed and electronic instructional materials to assist scheduling and implementation of PA, (3) support officers; CON: usual PA practice.	Outcome Measure: ActiGraph GT3X+ accelerometer	Outcome Measure: ActiGraph GT3X+ accelerometer
Nickel <i>et al.</i> (2020)	Cluster RCT, Canada	To determine whether improvements documented in the Healthy Buddies intervention were experienced by all children taking part in the intervention and across several different social determinants.	n = 687 (20 schools) Age: 6-12 yrs; Female (%) : 48; Attrition rate: 104 (15%); Length of intervention: 9 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) 21 healthy living lessons taught weekly in the classroom, (2) two 30-min structured PA sessions per week; CON: usual practice.	BMI z-score Outcome Measure: Centres for Disease Control and Prevention growth charts	Knowledge and attitudes to healthy eating (3-point scale for frequency) Outcome Measure: Self-administered questionnaire
O'Leary <i>et al.</i> (2019)	RCT, Ireland	To assess the impact of Project Spraoi: a school-based PA and nutrition intervention that reached 473 primary school	n = 473 (4 schools) Age: 6 yrs and 10 yrs Female (%) : not reported; Attrition rate N/A; Length of intervention: 2 yrs;	Underlying theory: RE-AIM (Reach, Efficacy, Adoption, Implementation, Maintenance) theoretical framework; Intervention setting: School and home; Content and frequency:	BMI (kg/m ²) Outcome Measure: Weight and height	MVPA (min/day) Outcome Measure: ActiGraph GT3X and wGT3X+ Knowledge and attitudes to healthy eating Outcome Measure: nutritional knowledge and

		children and 43 school staff in Cork (Ireland).	Assessment: Baseline, Post-IV.	(1) promotion of 20 min 'huff and puff' (MVPA) each day, (2) improvement of nutritional habits and knowledge through targeted class-based activities, (3) promotion of increased habitual PA, (4) reduced sedentary time; CON: usual practice.			attitudes questionnaires
Rausch Herscovici <i>et al.</i> (2013)	RCT, Argentina	To evaluate the impact of a school-based obesity prevention program that seeks to change food intake among students at schools in Rosario, Argentina.	n = 387 (6 schools) Age: 9.5 ± 0.7 yrs; Female (%) :48; Attrition rate: 18 (5%); Length of intervention: 6 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School and home; Content and frequency: (1) four workshops (healthy eating, body in motion, healthy body & for parent/caregiver), plus modifications to the school cafeteria menu; CON: usual practice.	BMI (kg/m ²) BMI z-score		Intake of fruit and vegetable, skimmed milk, cereal, juice, sweet and chocolate and sweetened beverage Outcome Measure: Weekly Food Frequency Questionnaire
Resaland <i>et al.</i> (2016)	Cluster RCT, Norway	To investigate the effect of a seven-month, school-based cluster-randomized controlled trial on academic performance in 10-year-old children.	n = 1129 (57 schools) Age: 10.2 ± 0.3 yrs; Female (%) :48; Attrition rate: 40 (4%); Length of intervention: 7 mons; Assessment: Baseline, Post-IV.	Underlying theory: Socio-ecological framework - socio-ecological model, Harter's Competence Motivation Theory, Achievement goal theory and Ryan & Deci's self-determination theory; Intervention setting: School and home; Content and frequency: (1) physically active lessons, (2) PA breaks (5 min/day)	BMI (kg/m ²) Outcome Measure: Weight and height	Total PA, LPA, MVPA (min/day) Outcome Measure: ActiGraph GT3X+	Sedentary (min/day) Outcome Measure: ActiGraph GT3X+

				implemented in the classroom during academic lessons; and (3) PA homework (10 min/day; CON: usual practice, including usual amounts of PA/PE, being approximately 135 min/week.			
Rosario <i>et al.</i> (2017)	RCT, Portugal	To evaluate the impact of an intervention program, taught by trained teachers, on foods and nutrients components of the Diet Quality Index–International among children in Grades 1 to 4.	n = 464 (7 schools) Age: 8.3 ± 1.2 yrs; Female (%): 51.5; Attrition rate: 170 (36.6); Length of intervention: 4 mons; Assessment: Baseline, Post-IV.	Underlying theory: Health promotion model and SCT; Intervention setting: School; Content and frequency: (1) Teachers had 12 sessions of 3 hours each with the study researchers CON: usual practice.	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	PA index (%/day) Outcome Measure: Questionnaire (4-point scale)	Diet Quality Index–International Outcome Measure: 24-h dietary recall
Sacchetti <i>et al.</i> (2013)	RCT, Italy	To assess whether a school-based physical education intervention was effective in improving physical abilities and influencing daily PA habits in primary school children.	n = 497 (26 schools) Age: 8-9 yrs; Female (%): 51.5; Attrition rate: 69 (13.9%); Length of intervention: 2 yrs; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) daily 45 min of MVPA in multi-environments (schoolyard, classroom, gym); CON: usual physical education programme.	BMI (kg/m ²) Outcome Measure: Weight and height	Daily PA (%/day) Outcome Measure: Physical Activity Questionnaire for children	Sedentary (%/day) Outcome Measure: Physical Activity Questionnaire for children

Santina <i>et al.</i> (2021)	Cluster RCT, Lebano n	To evaluate the efficacy of a theory- and evidence-based intervention for promoting PA among children by changing PA-related psychosocial variables and reducing obesity and screen time outside school hours.	n = 384 (2 schools) Age: 10.6 ± 0.6 yrs; Female (%): 45.7; Attrition rate: 10 (3%); Length of intervention: 14 weeks; Assessment: Baseline, Post-IV.	Underlying theory: Social identity theory; Intervention setting: School; Content and frequency: (1) 10-min daily structured MVPA, (2) 20-min daily structured and unstructured MVPA during recess, (3) letters to parents to increase their knowledge about PA, (4) 4-day training of educational staff, (5) daily monitoring of children's participation in PA, (6) additional PA equipment, (7) school events promoting PA, (8) earning activities of PA delivered in classroom; CON: received the standard school curriculum.	BMI (kg/m ²) Outcome Measure: Weight and height	PAQ-C score Outcome Measure: Physical Activity Questionnaire for Older Children (PAQ-C)	Screen time (h/day) Outcome Measure: Physical Activity Questionnaire for children
Scherr <i>et al.</i> (2017)	Cluster RCT, USA.	To investigate the effectiveness of a multicomponent, school-based nutrition intervention, the Shaping Healthy Choices Program (SHCP), to improve children's dietary behaviours and	n = 443 (4 schools) Age: 9.6 yrs; Female (%): 49.7; Attrition rate: not given; Length of intervention: 9 mons; Assessment: Baseline, Post-IV.	Underlying theory: SCT, Social Ecological Model; Intervention setting: School; Content and frequency: (1) nutrition education and promotion (15 classroom lessons & 19 take-home activities), (2) family and community partnership, (3) supporting regional agriculture, (4) foods	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height		Nutrition knowledge score Fruit and vegetable intake (servings/day) Outcome Measure: Food frequency questionnaire

		prevent childhood obesity		available on the school campus, (5) school wellness and policies; CON: The nutrition educator spent time in the control classrooms to match the number of hours spent in the intervention classrooms content was unrelated to nutrition, health, and science.		.	
Seljebotn <i>et al.</i> (2019)	Cluster RCT, Norway	To report effects of the Active School program on objectively measured PA level and aerobic fitness. In addition, the PA level during the 45-minute physically active lessons was compared to ordinary classroom lessons and physical education lessons.	n = 447 (4 schools) Age: 9.6 yrs; Female (%): 49; Attrition rate: not given; Length of intervention: 10 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School and home; Content and frequency: (1) PA increase by 190min/week, (2) PA homework and (3) physically active lessons; CON: usual practice.	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	MVPA, LPA, MPA, VPA (min/day) Outcome Measure: ActiGraph GT1M/GT3X/GT3X+	Sedentary (min/day) Outcome Measure: ActiGraph GT1M/GT3X/GT3X+
Siegrist <i>et al.</i> (2013)	RCT, Germany	To evaluate a simple and ubiquitously applicable school-based educational program to	n = 724 (8 schools) Age: 8.4 ± 0.7 yrs; Female (%): Attrition rate: 102 (14%);	Underlying theory: not reported; Intervention setting: School and home; Content and frequency:	BMI (kg/m ²) Outcome Measure:	Active days/week (≥60 min) Outcome Measure:	

		increase PA, fitness, and lifestyle awareness and to improve health obesity measures.	Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	(1) JuvenTUM intervention monthly lessons lasting 45 min with three parts: a warm-up of 10 min with running, playing running games at high intensity, 30 min exercises to improve body awareness and self-esteem with conversation in class about health-related topics, and 5 min relaxation exercises; CON: usual practice.	Weight and height	Questionnaire		
Tarro <i>et al.</i> (2014)	Cluster RCT, Spain	To implement a program by university students acting as “health promoting agents” and to evaluate the effects on obesity prevalence of the primary-school-based program that promotes healthy lifestyle.	n = 2350 (38 schools) Age: 8.4 ± 0.6 yrs; Female (%): 49.9; Attrition rate: 411 (17.5%); Length of intervention: 28 mons; Assessment: Baseline, Post-IV.	Underlying theory: not reported; Intervention setting: School and home; Content and frequency: (1) eight lifestyle topics incorporated within 12 activities which were disseminated over 12 sessions (1 h/activity/ session), and prepared, standardised and implemented as four activities per school academic year in the classroom; CON: usual practice.	BMI (kg/m²) BMI z-score Outcome Measure: Weight and height .	PA at weekends Walking before/during/ after school Outcome Measure: Kreece Plus test (parental questionnaire) .	TV video or DVD (h/day) Outcome Measure: Kreece Plus test (parental questionnaire) .	Breakfast consumption, has a dairy product for breakfast, eats cereals or derivative for breakfast, manufactured pastries for breakfast Intake of fruit or juice daily, dairy product, raw or cooked vegetables a day, fish consumption, fast food, legumes, sweets and olive oil; Outcome Measure: Kreece Plus test (parental questionnaire)

Telford <i>et al.</i> (2016)	Cluster RCT, Australia	To investigate the effect of a 4-year specialist-taught Physical Education program on PA among primary school children.	n = 853 (29 schools) Age: 8.1 ± 0.4; Female (%): 49%; Attrition rate: 313 (37%); Length of intervention: 4 yrs; Assessment: Baseline, 1 yr, 2 yrs, 3 yrs ,Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) 2 × 45 min PE lessons per week from specialist-trained PE teachers; CON: usual practice.	BMI (kg/m ²) Outcome Measure: Weight and height	1. PA during PE classes 2. Total PA (steps/day) 3. MVPA (min/day) Outcome Measure: 1. System for Observing Fitness Instruction Time 2. Pedometers 3. Actigraph GT1M	Sedentary time (min/day) Outcome Measure: Pedometer .
Viggiano <i>et al.</i> (2018)	Cluster RCT, Italy	To investigate whether the board game Kaledo improves nutritional knowledge and helps to promote a healthy lifestyle in children.	n = 1313 (10 schools) Age: 7-11 yrs; Female (%): not reported; Attrition rate: 857 (65.3%); Length of intervention: 20 weeks; Assessment: Baseline, 8 mons, 10 mons Post-IV.	Underlying theory: not reported; Intervention setting: School; Content and frequency: (1) participated in one play session (15–30 min) with the board game Kaledo, every week; CON: did not play with Kaledo.	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	PA frequency and duration (min/day) Outcome Measure: WHO Health Behaviour in School-aged Children (HBSC) PA questionnaire	Intake of healthy and junk food (portions/day). Outcome Measure: 7-day food diary .
Wells <i>et al.</i> (2014)	Cluster RCT, USA	The study examines effects of a school garden intervention on	n = 264 (12 schools) Age: 10.2 ± 0.5 yrs; Female (%): 47.7; Attrition rate: 30 (11%);	Underlying theory: not reported; Intervention setting: School garden; Content and frequency:		MVPA, MPA, LPA, VPA (min/day) PA activity	Sedentary time (min/day) Outcome Measure:

	elementary school children's PA	Length of intervention: 12 mons; Assessment: Baseline, Post-IV.	(1) garden bed raised, (2) 2 lessons, (3) resources for the school, (4) garden implementation guide; CON: received gardens at the end of the study.		Outcome Measure: (1) GEMS Activity Questionnaire (2) Actigraph GT3X+/GT1 M (3) PA Research & Assessment tool for Garden Observation (PARAGON)	(1) GEMS Activity Questionnaire (2) Actigraph GT3X+/GT1 M (3) PA Research & Assessment tool for Garden Observation (PARAGON)	
Williamson <i>et al.</i> (2012)	Cluster RCT, USA	The study was designed to test the efficacy of a Primary Prevention program (PP) and a combination of PP and a Secondary Prevention (SP) program in comparison to a Control group for prevention of weight/fat gain in the entire sample and overweight children	Underlying theory: The Theory of Triadic Influence, the Comprehensive School Health Program Model; Intervention setting: School and home; Content and frequency: three prevention arms: (1) Primary Prevention an environmental modification program, (2) Primary + Secondary Prevention, the environmental program with an added classroom and internet education component; CON: has none of the prevention components that are hypothesized to yield	BMI (kg/m ²) BMI z-score Outcome Measure: Weight and height	Total PA (min/day) Outcome Measure: Self-Administered Physical Activity Checklist (SAPAC)	Sedentary time (min/day) Outcome Measure: Self-Administered Physical Activity Checklist (SAPAC)	Total energy intake, total fat, protein, carbohydrate intake (kcal/day). Outcome Measure: (Sony DCR-TRV22) digital video camera to measure food selection and food intake

				weight gain prevention. This control arm can be viewed as a nonspecific control condition.				
Xu <i>et al.</i> (2015)	Cluster RCT, China	To assess the effectiveness of a school-based multi-component lifestyle childhood obesity prevention program	n = 1108 (8 schools) Age: 10.2 ± 0.5 yrs; Female (%): 47.7; Attrition rate: 74 (6.3%); Length of intervention: 8 mons; Assessment: Baseline, Post-IV.	Underlying theory: The Theory of Triadic Influence, the Comprehensive School Health Program Model; Intervention setting: School and home; Content and frequency: classroom curriculum (1) 30-min lesson/mon, (2) school environment support, (3) family involvement, (4) fun programs/events; CON: usual health and physical education curriculum.	BMI (kg/m²) Outcome Measure: Weight and height	PA patterns Commuting mode Outcome Measure: validated Chinese version of the International Physical Activity Questionnaire (CHN-IPAQ)	Patterns of TV viewing Outcome Measure: validated Chinese version of the International Physical Activity Questionnaire (CHN-IPAQ)	Consumption of breakfast cereals, snack, fast food, soft drink, meats, dairy products (times/day) Outcome Measure: FFQ

RCT: randomized controlled trial; UK: United Kingdom; CON: control group; yrs: years; mons: months; BMI: body mass index; PA: physical activity; SB: sedentary behaviour; EE: energy expenditure; NB: nutrition behaviour; PE: physical education; wk.: week; d: day; hr: hour; min: minute; MVPA: moderate-to-vigorous physical activity; LPA: low-intensity physical activity; MPA: moderate-intensity physical activity; VPA: vigorous physical activity; Post-IV: post-intervention; kcal: calories; SCT: social cognitive theory; FFQ: food frequency questionnaire.

Table 3.2. Characteristics of included interventions targeting a change in obesity-related behaviours and/or body mass index ($n = 48$).

Study, Year	Outcomes				PA		SB		Theory Based	Duration (>6 Months)
	PA	SB	NB	BMI	Device-Based	Self-Report	Device-Based	Self-Report		
Adab <i>et al.</i> (2018)	✓	✓	✓	✓	✓		✓			✓
Amini <i>et al.</i> (2016)	✓	✓	✓	✓		✓		✓		
Anderson <i>et al.</i> (2016)	✓	✓	✓	✓	✓		✓		✓	✓
Angelopoulos <i>et al.</i> (2009)	✓		✓	✓		✓			✓	
Bacardi-Gascon <i>et al.</i> (2012)	✓	✓	✓	✓	✓			✓	✓	
Bere <i>et al.</i> (2014)			✓	✓						✓
Brandstetter <i>et al.</i> (2012)	✓	✓	✓	✓		✓		✓	✓	✓
Donnelly <i>et al.</i> (2009)	✓			✓	✓					✓
Drummy <i>et al.</i> (2016)	✓			✓	✓					
Efstathiou <i>et al.</i> (2016)	✓	✓	✓			✓		✓		✓
Engelen <i>et al.</i> (2013)	✓	✓		✓	✓		✓			
Fairclough <i>et al.</i> (2013)	✓	✓	✓	✓	✓		✓		✓	
Farmer <i>et al.</i> (2017)	✓			✓	✓					✓
Ford <i>et al.</i> (2013)	✓		✓	✓	✓					
Habib-Mourad <i>et al.</i> (2020)	✓		✓			✓			✓	✓
Howe <i>et al.</i> (2011)	✓			✓	✓					✓
Kain <i>et al.</i> (2014)	✓			✓	✓					✓
Khan <i>et al.</i> (2014)			✓	✓						✓
Kobel <i>et al.</i> (2014)	✓	✓	✓	✓		✓		✓	✓	✓
Kobel <i>et al.</i> 2017	✓	✓	✓	✓		✓		✓	✓	✓
Kocken <i>et al.</i> (2016)	✓	✓	✓	✓	✓			✓	✓	✓
Lau <i>et al.</i> (2016)	✓			✓	✓					
Li <i>et al.</i> (2019)	✓	✓	✓	✓	✓		✓		✓	✓
Liu <i>et al.</i> (2019)	✓	✓	✓	✓		✓		✓	✓	✓
Llargues <i>et al.</i> (2011)	✓	✓	✓	✓		✓		✓		✓
Llaurado <i>et al.</i> (2014)	✓	✓	✓	✓		✓		✓		✓
Lloyd <i>et al.</i> (2018)	✓	✓	✓	✓	✓		✓		✓	✓
Lynch <i>et al.</i> (2016)	✓	✓	✓	✓	✓			✓		
Madsen <i>et al.</i> (2015)	✓	✓	✓	✓	✓		✓			✓
Marcus <i>et al.</i> (2009)	✓		✓	✓	✓					✓

Martinez-Vizcaino <i>et al.</i> (2014)	✓	✓		✓	✓		✓			✓
Nathan <i>et al.</i> (2020)	✓	✓			✓		✓			✓
Nickel <i>et al.</i> (2020)			✓	✓						✓
O’Leary <i>et al.</i> (2019)	✓			✓	✓					✓
Rausch Herscovici <i>et al.</i> (2013)			✓	✓						✓
Resaland <i>et al.</i> (2016)	✓	✓		✓	✓		✓		✓	
Rosario <i>et al.</i> (2017)	✓			✓		✓			✓	
Sacchetti <i>et al.</i> (2013)	✓	✓		✓		✓		✓		✓
Santina <i>et al.</i> (2021)	✓	✓		✓		✓		✓	✓	
Scherr <i>et al.</i> (2017)			✓	✓					✓	✓
Seljebotn <i>et al.</i> (2019)	✓	✓		✓	✓		✓			✓
Siegrist <i>et al.</i> (2013)	✓			✓		✓				✓
Tarro <i>et al.</i> (2014)	✓	✓	✓	✓		✓		✓		✓
Telford <i>et al.</i> (2016)	✓	✓		✓	✓		✓			✓
Viggiano <i>et al.</i> (2018)	✓		✓	✓		✓				
Wells <i>et al.</i> (2014)	✓	✓			✓		✓			
Williamson <i>et al.</i> (2012)	✓	✓	✓	✓		✓		✓	✓	✓
Xu <i>et al.</i> (2015)	✓		✓	✓		✓		✓	✓	✓

PA = physical activity, SB = sedentary behaviour, NB = nutrition behaviour.

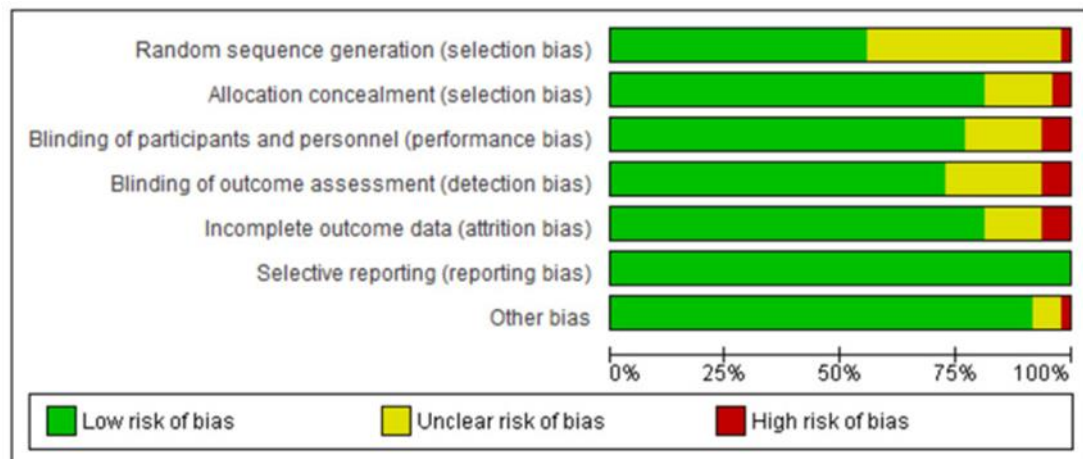


Figure 3.2. Summary of assessment of risk of bias ($n = 48$).

Table 3.3. Effectiveness of interventions at changing obesity-related behaviours and BMI/BMI z-score.

Outcome 1: MVPA (mins/day)	Studies (n=)	INT (n=)	C (n=)	I²	MD (95% CI)
Device-measured	16	4523	3921	41%	1.53 (0.49, 2.57)
Self-reported	2	372	361	0%	12.37 (8.51, 16.22)
MVPA min/day (≤ 6 months)	4	280	285	0%	4.84 (0.81, 8.88)
MVPA min/day (> 6 months)	14	4546	3997	74%	1.89 (0.09, 3.40)
Theory-based	9	3481	3102	74%	2.19 (0.04, 4.34)
No theory	9	1414	1266	49%	2.15 (-0.53, 4.82)
Outcome 2: SB (mins/day)	Studies (n=)	INT (n=)	C (n=)	I²	MD (95% CI)
Device-measured	11	3966	3456	55%	-0.91 (-2.30, 0.48)
Self-reported	1	40	52	N/A	1.40 (-25.95, 28.75)
ST min/day (≤ 6 months)	2	186	192	0%	1.29 (-5.67, 8.24)
ST min/day (> 6 months)	10	3820	3316	59%	-1.00 (-2.42, 0.42)
Theory-based	6	3091	2691	20%	-0.46 (-1.93, 1.02)
No theory	5	915	817	65%	-4.51 (-8.68, -0.34)
Outcome 3: BMI z-score	Studies (n=)	INT (n=)	C (n=)	I²	MD (95% CI)
Only targeting one outcome	5	1465	1565	68%	-0.05 (-0.10, 0.01)
Targeting > 1 outcome	11	5935	5386	57%	-0.04 (-0.08, 0.00)
≤ 6 months	2	293	314	52%	-0.02 (-0.15, 0.10)
> 6 months	14	7107	6637	61%	-0.04 (-0.08, -0.01)
Theory-based	6	3253	3287	68%	-0.08 (-0.13, -0.02)
No theory	10	4147	3664	47%	-0.02 (-0.06, 0.02)
Outcome 4: BMI (kg/m²)	Studies (n=)	INT (n=)	C (n=)	I²	MD (95% CI)
Only targeting one outcome	8	2451	2469	12%	-0.04 (-0.23, 0.16)
Targeting > 1 outcome	12	4700	4174	67%	-0.04 (-0.14, 0.06)
≤ 6 months	5	491	502	42%	-0.07 (-0.35, 0.22)
> 6 months	15	6660	6141	59%	-0.03 (-0.13, 0.06)
Theory-based	6	2596	2596	75%	-0.10 (-0.22, 0.02)
No theory	14	4555	4047	30%	0.04 (-0.09, 0.18)

INT = intervention, C = control, MVPA = moderate-to-vigorous physical activity, SB = sedentary behaviour, ST = sedentary time, MD = mean difference, BMI = body mass index.

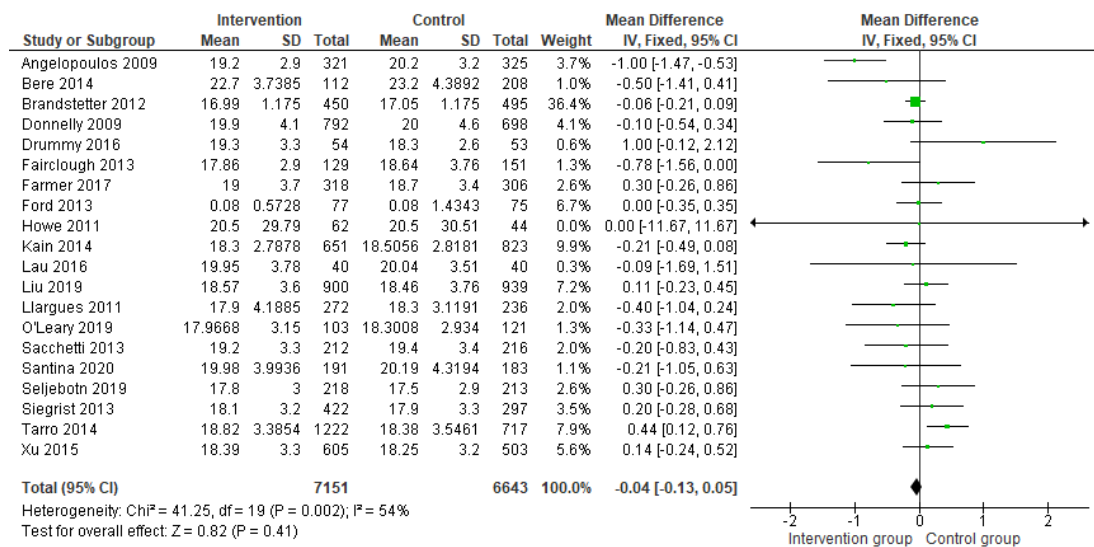


Figure 3.3. Difference between intervention and control groups of school-based interventions in primary school children at follow-up in BMI (kg/m^2).

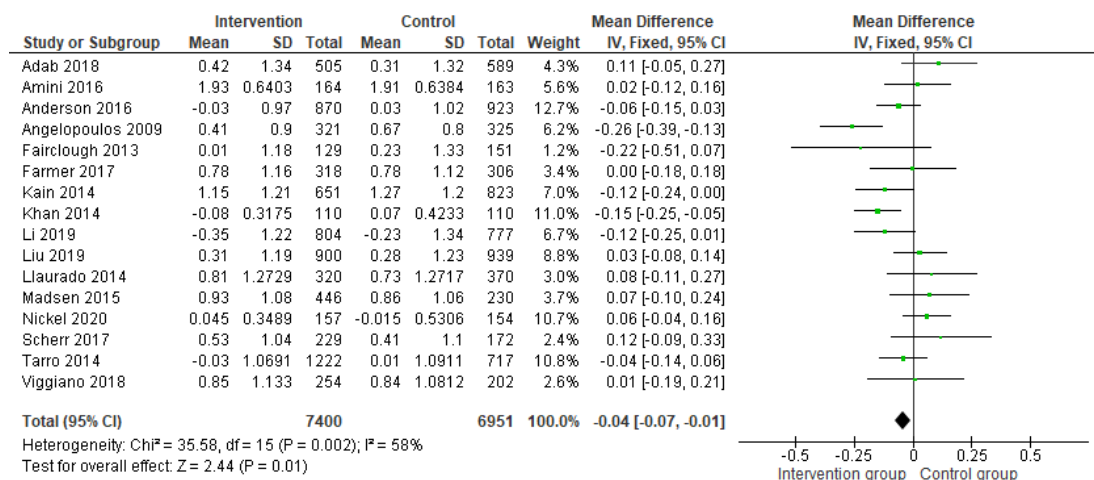


Figure 3.4. Difference between intervention and control groups of school-based interventions in primary school children in BMI z-score.

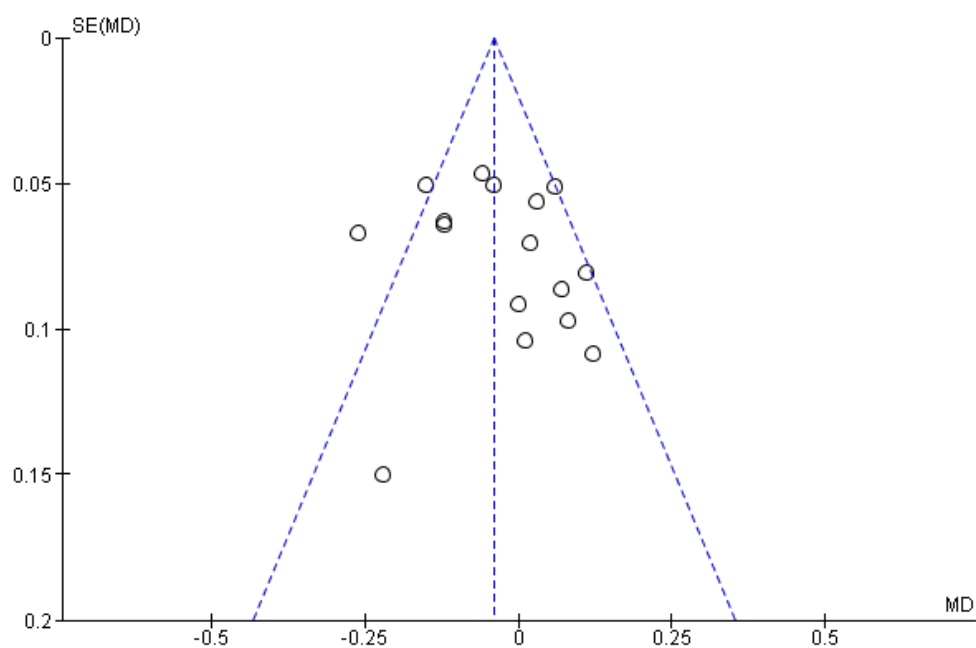


Figure 3.5. Assessment of publication bias: funnel plot (BMI z score).

Chapter 4: “When You Move You Have Fun”: Perceived barriers, and facilitators of physical activity from a child’s perspective.

Abstract

Background

In Northern Ireland (NI), many children do not meet the recommended levels of physical activity (PA). To reduce the prevalence of physical inactivity and associated health conditions, it is important to understand the influences on children's PA, which in turn has the potential to inform future intervention design. The purpose of this formative study was to examine the current views, barriers, facilitators, experiences, and perceptions of children in relation to PA in the classroom, school, and home environments, and to assess the acceptability of components for a school-based intervention.

Methods

Write and draw tasks and semi-structured focus groups ($n = 10$) were conducted with 50 children aged 7-9 years (22 boys, 28 girls) from six primary schools. Focus groups were recorded, transcribed, and analysed thematically. Pen profiles were constructed from the transcripts in a deductive manner and represent key emergent themes.

Results

Results indicated that children's perception and knowledge of PA was mainly structured and sport-based, while some referred to fun, play and health. Fun, social support and outdoor activity were identified as key facilitators. Barriers included parental restrictions, lack of time and space in the different environments. The acceptability of intervention components was examined, children recognized the potential benefits of additional movement in the classroom, but opinions differed on the sit-to-stand desks.

Conclusions

Findings contribute to a more detailed understanding of children's perceptions of context specific PA, the barriers they face, in addition to factors that support them to lead a physically active lifestyle, which may inform future PA promotion strategies.

4.1. Introduction

Developing effective health promotion strategies targeting primary school-aged children is necessary to reduce the future burden of preventable non-communicable diseases (Janssen and LeBlanc, 2010). Regular physical activity (PA) provides children with broad-ranging physical and psychological health benefits (Poitras *et al.* 2016), including improved cardiometabolic health, academic performance (Rasberry *et al.* 2011), cognitive function, and prosocial behaviour (Donnelly *et al.* 2016; Sampasa-Kanyinga *et al.* 2020). According to the World Health Organization (WHO), a major public health concern is the increasing number of children who fail to meet the current PA guidelines of an average of 60 min/day of moderate- to –vigorous-intensity aerobic PA across the week (Guthold *et al.* 2020; WHO 2020). This issue is particularly prevalent among primary-school children in Northern Ireland (NI), who are least likely to meet the recommended levels of PA, when compared with other countries in the United Kingdom (UK) (Griffiths *et al.* 2013) and in Europe (Verloigne *et al.* 2016). The Children’s Participation and Physical Activity Study found that only 20% of primary school children in NI meet PA guidelines (Woods *et al.* 2019). Research suggests that moderate-to-vigorous physical activity (MVPA) decline begins in early to mid-childhood (Farooq *et al.* 2020). There are also concerns about coexisting sedentary behaviour (SB) in children, specifically screen-based activities like television viewing, which has unfavourable effects on various health indicators, independent of PA (Tremblay *et al.* 2011).

Schools have been identified as an important setting to promote PA (Neil-Sztramko *et al.* 2021) and reduce SB (Hegarty *et al.* 2016), with the WHO specifying that the principle of a whole-of-school approach should be applied (WHO 2019; Milton *et al.* 2021). Children spend a significant amount of their waking time at school (Nickel *et al.* 2021) and many schools have the facilities, equipment, and large amount of contact time to deliver PA interventions. Timing of PA program implementation is important (Milat *et al.* 2015), teaching staff must not feel over-burdened, and children should not lose out on class time (Day *et al.* 2019). Several systematic reviews examine efficacy trials provide evidence of a slight increase of time spent in PA for children exposed to school-based interventions (Kriemler *et al.* 2011; Dobbins *et al.* 2013; Nally *et al.* 2021). Neil-Sztramko and colleagues found school-based PA interventions do not result in meaningful changes in MVPA, however, these findings should be

interrupted with caution as there was a high degree of heterogeneity across all studies (Neil-Sztramko *et al.* 2021). The out-of-school period offers additional opportunities for family-based PA. Parents can serve as role models through their parenting practices (Maric *et al.* 2020), sources of support, and gatekeepers through their control over children's opportunities for PA (Lindsay *et al.* 2006; Mitchell *et al.* 2012). Xu *et al.* (2015) found that there was a positive association between parental encouragement and support with children's PA. Additionally, parents also govern the home environment and can impact PA behaviour through the provision of opportunities to be physically active (e.g., accessibility of play and sports equipment) (Maitland *et al.* 2013).

Despite large-scale quantitative research being able to assess the direction and strengths of the trends of children's participation in PA, they are unable to explain the reasons why children maintain or cease PA. Despite years of such intervention research, increases in PA remain both modest and short term (Mitchell *et al.* 2012; Craike *et al.* 2018). There is now widespread recognition that health behaviours are difficult to change (Sheeran *et al.* 2016). As such, PA interventions have shifted focus to include the factors that influence these behaviours beyond individual choice alone. The socioecological model recognises that efforts to change health behaviours are more likely to be successful when multiple levels of influence including individual, social, environmental and policy levels are addressed at the same time. To be successful, future intervention development needs to address these multiple influences on behaviour, including the family and home setting (Sallis 2001). The evidence base is not as extensive, as research to date designed to increase PA in children and inform intervention design has largely underrepresented children's perceptions (Noonan *et al.* 2016) and has been limited to singular qualitative methods that omit children's verbal ability and interaction preference (Morgan *et al.* 2002). There is a paucity of data analysing PA barriers and facilitators in the school setting, particularly from the perspective of children aged 7-9 years. Previous literature in this age group examines children's perceptions of obesity prevention (Clarke *et al.* 2015; Hesketh *et al.* 2017), not PA.

Transform-Us! was designed in response to the aforementioned low levels of PA and high levels of SB. It is a multi-component school- and family-based intervention

which was developed through a series of extensive iterative work in Australia (Salmon *et al.* 2011). *Transform-Us!* aims to increase children's PA and decrease SB across the school day incorporating a mixture of educational, pedagogical, behavioural, and environmental approaches to integrate movement into everyday class lessons and recess/lunchtime (refer to Chapter 2, Section 2.9). Family-based components comprise of newsletters and homework assignments containing family-based activities for parents to complete with their children. The study is based on elements from the social cognitive theory (Bandura 1986), theory of planned behaviour (Rachlin 1989) and behavioural choice theory (Bronfenbrenner 1986). Although the *Transform-Us!* intervention has proved very promising as a multi-component program (Yildirim *et al.* 2014, Carson *et al.* 2013) and is in the final stages of longer-term evaluation in Australia (Salmon *et al.* 2023), we do not have similar multi-component programs which have been subjected to rigorous evaluation within NI. Several local contextual differences between the Australia and NI, in particular the educational system, social and environmental influences on PA and policy level differences mean that whole scale replication would be inappropriate. Formative research is important in the development and implementation of the intervention, as it identifies specific behaviours, the determinants of these behaviours and collects as much information as possible to assist in forming the intervention aims and objectives (Bleijenberg *et al.* 2018).

A more detailed understanding of NI children's perceptions of context specific PA, the participation barriers they face, in addition to factors that support them to lead a physically active lifestyle may inform future PA promotion strategies. This exploratory study used a formative assessment to inform the adaptation of a pre-existing PA and SB intervention *Transform-Us!* This study aimed to use a combination of qualitative techniques to explore children's current views, experiences and perceptions of classroom, school, and family-based PA. It was envisaged that the contextual information gathered from this study will provide valuable insights into the connotations children ascribe towards PA and inform the subsequent intervention design of future PA promotion and SB reduction strategies targeting primary-school aged children.

4.2. Materials and methods

The current research was conducted from a pragmatic philosophical position. Pragmatics “*recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities*” (Saunders *et al.* 2012). When conducting research from a pragmatic philosophical position, the emphasis is placed on the research question, whereby the researcher adopts methods available to address the question (Creswell and Creswell, 2018). Pragmatism insists on researching not just *what* researchers do but *why* they do things the ways they do (Morgan 2014). Within the present study and in line with a pragmatic approach, the research questions were employed to guide the research design. Reporting of this study was guided by the consolidated criteria for reporting qualitative research (COREQ, Tong *et al.* 2007). Ethical approval was granted by the University Ethics Committee (REC/20/0033), and informed written consent and assent was obtained from parents and participants prior to participation. Data collection took place between November 2020 and April 2021, during the second wave of the COVID-19 pandemic. Schools in NI had been closed during the period of March to August 2020 due to a period of ‘lockdown’ through public health legislation.

4.2.1. Recruitment

Participants were recruited from a convenience sample of primary schools spanning a range of socio-economic areas and from both rural and urban areas of NI. Ten primary schools were invited to take part in the study via e-mail/telephone. Eight primary schools agreed to participate in the study. Following school principal consent, information packs containing child and parent information sheets and consent forms were sent to parents/guardians of pupils in Primary 4 (7-8 years old) and/or Primary 5 (8-9 years old). The pupils who returned written assent forms and consent forms from parents/guardians were eligible to participate. The participants did not receive an incentive or compensation for taking part in the study. Prior to the visit, all the pupils were informed about the purpose and procedure of the study. Participants were told that they could withdraw from the study anytime.

4.2.2. Data collection

There were two complimentary qualitative methods used in the formative study: a

write and draw activity and focus groups exploring children's perceptions of PA and experiences in greater depth. Previous studies have shown that a write and draw activity can provide children with greater control over their expression and the drawings themselves are visual drawings that directly represent children's perspectives and/or experiences (Knowles *et al.* 2013; Noonan *et al.* 2016). The drawing task is also appropriate for younger children as it can demonstrate thinking at their own levels of cognitive development (Knowles *et al.* 2013). Likewise, focus groups are an effective method to explore the ideas and perspectives of children (Gibson 2007). Merriam and Tisdell (2016) strategies to promote validity and reliability were used to enhance trustworthiness. The study's conceptualisation and the methods employed for data collection, analysis, interpretation, and presentation of findings were carefully considered. With regards to trustworthiness, using a combination of qualitative research techniques, including sustained interest, enabled the data-generation process to be fun and engaging for participants, prevented bias arising from the overreliance of one method, and served to triangulate and cross-check data (Punch 2002). Other than participant age, there were no specific inclusion criteria employed. Data collection was facilitated by the first author, in the school's assembly hall or in an outdoor classroom where participants and researcher alike could be overlooked but not overheard. By interviewing children in a group setting at school, we aimed to create a friendly and safe space which would encourage children to share their ideas and thoughts (Adler *et al.* 2019).

4.2.3. Write and Draw Activity

The write and draw activity was completed prior to the focus groups and prior to break time (i.e., morning recess) to reduce the influence recent experiences may have on participants' thoughts and perceptions. The write and draw activity was double sided and contained five sections (**Appendix 3A**). For the purpose of this study, children were asked to express their perceptions of PA visually, and independently, (i.e., not completed in conjunction with peers) during class time in each school. To minimize distraction from the task, no written instructions were provided (Knowles *et al.* 2013). The first author (SN) facilitated the activity and separately engaged with the children in informal conversations to answer any questions. The first author refrained from providing any feedback.

4.2.4. Focus groups

To further triangulate the data and ensure the credibility and dependability of the findings, participants were invited to express their perceptions of PA through discussions via focus groups (Merriam and Tisdell, 2016). A semi-structured topic guide standardized discussions between subjects and allowed for participants to respond freely whilst also ensuring key topics were covered in detail to allow a degree of comparability across the transcripts (Punch and Graham, 2016). The topic guide was derived from reviewing the existing literature in relation to PA and were designed to be exploratory. The questions focused on the current views, barriers, facilitators, experiences, and perceptions of children in relation to PA in the classroom, school, and home environments, and aimed to evaluate and assess the acceptability of components used in *Transform-Us!* for a school-based intervention (topic guide available in **Appendix 3B**). The topic guide was pilot tested with a group of four primary-school children, from a school that was not included in this study, to ensure that questions were deemed appropriate for this age group. Based on informal feedback from the primary-school children, minor amendments were made to the topic guide following completion of pilot focus groups. Probing questions were used throughout the focus group to facilitate discussion (Elo *et al.* 2014).

The first author (female Ph.D. candidate holding an MRes, trained in running focus groups) facilitated separate semi-structured focus groups that included 4-6 children (10 focus groups, $n = 50$). To reduce the potential power imbalance that may arise when an adult facilitates a children's focus group, it was made clear that the moderator was not a teacher, there were no right or wrong answers, and the children were free to express their own opinions (Heary and Hennessy, 2002; Morgan *et al.* 2002). First names were used to moderate the hierarchical adult-child relationship. Following an explanation of the procedure, verbal assent was obtained from all participants. At the beginning of the focus group, participants were informed that the definition of 'physical activity' was any movement of the body that uses energy, and this included all forms of sport, physical education (PE), indoor and outdoor play, adventurous activities, active travel, and normal activities such as using the stairs, doing housework and gardening. The questions asked during the focus groups and the PA definition used were purposely kept broad to capture what types of PA and settings were meaningful from the perspective of the participants. A short icebreaker was used at

the beginning of the focus group to help children feel comfortable and relaxed. Photographs presenting a range of active and inactive activities were used to encourage discussion amongst children, having previously been shown to be an effective method (Hesketh *et al.* 2005). Examples of the activities included children skipping outside, watching television, and a child brushing the floor. Participants were asked several questions regarding the activities (**Appendix 3B**). Moreover, a photograph of a sit-to-stand desk was used to elicit conversation, ensuring the topic was covered in detail and allowed a degree of comparability across the transcripts (Ereaut 2002). Open-ended questions starting with ‘what’, ‘why’ and ‘how’ were posed to participants to stimulate conversation. To maintain the interest and enthusiasm of participants and accommodate short attention spans (Colucci 2007), each focus group discussion lasted between 16 and 30 (mean 20.11) minutes. With the participants’ permission, the interviews were audio recorded using a Homder digital voice recorder.

4.2.5. Data management and analysis

To examine the collected data, a mixed analysis procedure was used using pen profiles and the use of verbatim quotations (see Ridgers *et al.* 2012). The separate data sources were pooled together for complimentary purposes in order to expand, enhance and clarify findings from each of the separate data sources. Text responses for the write tasks were extracted verbatim, while drawings were used to identify additional key themes (e.g., playing sport, social interaction, fun). The following procedure and terminology were used to analyse the questions. Drawings had to be legible. Children’s responses to the questions were categorized as a ‘mark’. A ‘mark’ within a child’s drawing referred to an item which could be identifiable as theme. It was possible for one mark to identify more than one theme. For example, the identification of how many ‘times’ a theme was identified (e.g., a child drawing a football game and writing ‘playing football’) would be counted as two times. Ten write and draw sheets were independently reviewed by a second author (N.R.) and a discussion was had about the findings until a consensus of the themes were reached. Subsequently, the data were then analysed using pen profiles analysis.

The focus group discussions were audio recorded and transcribed verbatim. The analysis consisted of all together 102 pages of double-spaced transcription. All data were managed in NVivo12 (Version 12.6.0; QSR International Pty Ltd, Victoria,

Australia) and analysed independently by SN. To ensure children were unhindered by researchers' previous views about PA in children, in our study we chose a deductive followed by an inductive approach. Braun and Clarke's phases of thematic analysis were used to inform the coding process once S.N had become familiar with the transcripts (Braun and Clarke, 2019). Transcripts were systematically coded, responses were transcribed anonymously, and key themes were developed. The socio-ecological model was used as an initial framework to initially examine the data. The inductive approach allowed different themes within the broader socioecological model constructs to emerge. Quotes that were considered to represent a similar meaning or pattern were clustered together into potential themes and subthemes. During this process, themes were identified and were broadly reflective of the socio-ecological model (Elder *et al.* 2007) which has been used in previous research to demonstrate the influence various factors have on children's participation in PA, i.e., intrapersonal, interpersonal, and organizational factors (Hesketh *et al.* 2017; Martínez-Andrés *et al.* 2020). Quotations from the transcripts were extracted to further contextualize key findings from the discussions. The second author acted as a "critical friend" by independently reviewing a subsample of transcripts and offering alternative interpretations of the data, encouraging reflection, and challenging the initial thematic structure. The research group critically discussed all steps and outcomes in each phase of the data analysis process until they reached consensus. In case of disagreements and uncertainties, another member was consulted. Furthermore, Merriam and Tisdell (2016) strategies to promote validity and reliability were used to enhance trustworthiness. With regards to rigour, the inclusion of the participants voice help researchers conduct rigorous analysis when adopting thematic analysis (Merriam and Tisdell, 2016).

The pen profile approach has been utilized in studies examining youth PA (Mackintosh *et al.* 2011; Ridgers *et al.* 2012; Noonan *et al.* 2016; Taylor *et al.* 2018) and presents findings from content analysis via a diagram of composite key emerging themes. For these reasons it is an appropriate and effective method of presenting data to researchers that have an affinity with both quantitative and qualitative approaches (Ridgers *et al.* 2012; Noonan *et al.* 2016). Pen profiles are a visual approach for presenting key themes identified during data analysis through combining verbatim quotes taken directly from the transcripts and write and draw to provide further context

and insight to the discussions. These profiles provide key themes from the data deduced via an efficient process which offers examples of verbatim data as opposed to more comprehensive (in number) and truncated (due to space) offerings within content analysis Raw Data themes. These extracted quotes by the children, were self-definable in the expression of a single recognisable aspect of the children's experience. The authors critically questioned the analysis and interrogated the data, tracking the process in reverse from the pen profiles to the write and data sheets and/or the transcripts, until a consensus had been reached. Merriam and Tisdell (2016) strategies to promote validity and reliability were used to enhance trustworthiness, as triangulation of the analysis occurred through presentation of the pen profiles together with associated verbatim/illustrative material by the research team. Thus, methodological rigor, credibility and transferability was reached via verbatim transcription of data and triangular consensus procedure (Mackintosh *et al.* 2011; Ridgers *et al.* 2012). In some cases, visual illustrations were added to add further context to the data.

4.3. Results

Data are presented in five pen profiles, and focus on children's perspectives on PA, PA knowledge, PA barriers and facilitators and intervention approaches.

4.3.1. Write and Draw

Fifty primary-school aged children (22 boys, 28 girls) completed the write and draw activity. Blank spaces and answers were due to children not having sufficient time to complete the activity or not providing an answer. A total of 49 participants completed the 'what does physical activity mean to you?' section, with all the responses legible. PA was mostly associated with sport-based activity e.g., football (n = 10), dancing (n = 7) and structured activity e.g., PE (n = 8), with participants also defining PA as 'sport' (n = 17). Furthermore, participants refer to fun (n = 6), health (n = 6) and play-based activities (n = 3). Several reported '*movement*' as their definition of PA. For example, one child wrote that: '*any movement that keeps your health up*' (ID37) and another child wrote: '*it means to me it is sports and help your body. Any sort of movement*' (ID39). Drawings linked to the write and draw activity are presented in Figure 4.1.

Forty-nine participants completed the ‘what I like about physical activity’ section, and 215 marks on specific themes with two unidentifiable responses were noted within the data analysis. Forty-seven participants completed the ‘what I dislike about physical activity’ section, and 108 marks on specific themes were noted within the data analysis and there were no unidentifiable responses. Table 4.1. illustrates completion by write or draw section. Figure 4.2. demonstrates the combined pen profiles of children’s likes and dislikes regarding PA. A range of physical activities participated in by the children were described, with the most common being organized sports ($n = 20$) (i.e., football, hockey) cycling, swimming, tennis, and walking. Though the activities undertaken varied across the cohort, a consistent reason for PA participation was for fun ($n = 9$) and for peer interaction ($n = 19$). Many pupils suggested that there was nothing that they disliked ($n = 15$) about PA. Physical exertion ($n = 11$) and going on walks ($n = 10$) were also commonly reported as dislikes.

Figure 4.3. illustrates the composite pen profile which denotes the key themes from the following two questions from the write and draw activity: ‘if you could change your classroom, what would you change?’ and ‘where are you most likely to take part in physical activity?’. Blank returns were due to insufficient time to complete the task. Fifty participants completed the ‘if you could change your classroom, what would you change?’ section. All the written responses were identifiable and there were 125 marks on specific themes within the data analysis. Physical changes to the classroom were the most requested classroom changes by the children. The ‘Where are you most likely to take part in physical activity?’ section was completed by all the participants ($n = 50$). A total of 138 marks on specific themes within the data analysis were found and data revealed that outdoor ($n = 30$) and sports facilities ($n = 19$) were the commonly reported themes. Forty-eight participants completed the ‘Over the past week what sort of physical activities did you do outside of school?’ section. A total of 172 marks on specific themes within the data analysis were noted, structured sport-based activities ($n = 28$), outdoor play ($n = 26$) and social interaction ($n = 19$) were identified as the highest frequency themes.

4.3.2. Facilitators of Physical Activity

Overall, children reported a diverse range of PA facilitators within the school and family environments (Figure 4.4.). One of the primary motivations reported by children was the sense of fun experienced through the social aspect of PA. Children in

all focus groups highlighted the importance of social support from their friends, but family members were also noted. Being able to go outside, and enjoyment of PA were also commonly reported facilitators.

Some children expressed a strong desire to exercise, with PA allowing them an outlet from daily routines and the ability to share enjoyment with friends. The competitive and vigorous nature of organized physical activities appeared particularly appealing and enjoyable for many children as they perceived them to be more engaging and beneficial to physical health. Peers also played an important role in influencing participants to be active, with some having a positive experience with their classmates (Figure 4.4.). At school, children noted unstructured and structured PA opportunities as facilitators. Boys tended to mention organized sports, especially football, whereas girls commonly referred to creative play, drawing and art. PE seen as an opportunity practice PA and was described as a structured PA opportunity. At school, children were enthusiastic about the competitive element and challenges occasionally posed amongst peers in PE class or during breaktime. Children specified that family and school play a role in promoting and raising PA awareness. Parental co-participation in the children's activities were also deemed to facilitate activity (Figure 4.4.).

4.3.3. Barriers of Physical Activity

A range of barriers were reported by the children in relation to PA participation both at home and within school environment (Figure 4.5.). In the home environment, parents restricting PA and being able to freely access and watch TV were key barriers. Using other electronic devices was less commonly reported by these children. Parental restrictions were due to parental time restraints, safety concerns, time, and costs. Children were not allowed go to the park or play near their houses without adult supervision. In contrast, few children spoke about siblings and peers limiting engagement in PA. Children expressed the negative impact weather has on the ability to do PA outdoors.

Regarding the physical environment, children noted that a lack of space, both at school and home, as well as limited/no access to equipment/facilities were barriers. The size of indoor and outdoor space available for play, movement in the classroom and for PE was identified as a challenge in every focus group. The unavailability and the inaccessibility of spaces were also identified as key barriers to children's PA. Due to

the lack of space noted inside the sports hall, children favoured the outdoor environment for PE at school.

Furthermore, many children stated that they wanted to participate in PA, however, due to lack of discretionary time they were not able to do so. Children also indicated that they do not get time to be active, sometimes owing to external commitments such as homework. Each focus group raised issues of physical ability and explained that these insecurities often prevented them from taking part in PA. Concerns regarding physical ability included tiredness, being unfit, and having an illness or injury. Many children explained that they did not like to participate in PA after school as they were tired. Teachers who limit movement in the classroom were also identified as barriers to maintaining PA.

Children stated that the COVID-19 pandemic was a key barrier to PA participation. Similar to many countries, NI imposed restrictions requiring physical distancing (two meters), and limited community and social gatherings and interactions, sport, and playground and park use. All organized after-school activities were cancelled. Thus, most children had to comply with physical distancing, activity constraints and behaviour restrictions (Fegert *et al.* 2020).

4.3.4. Intervention approaches

Children discussed a number of intervention components, including active homework, sit-to-stand desks, and active breaks (Figure 4.6.). In each focus group, children stated that they enjoyed the opportunity to be active during the school day. The flexibility and adaptability of active homework appealed to children. The idea of incorporating movement and active breaks into the classroom were perceived as fun. Children were enthusiastic about the additional movement in the classroom component and suggested that it may help them with their academic performance and health.

Children had a mixed response to the sit-to-stand desks. Children were apprehensive regarding the mechanical and logistical side of the sit-to-stand desks. Furthermore, children voiced their concerns regarding the flexibility and adaptability of the desks in the classroom. Additional barriers to the implementation of sit-to-stand desks included time within an intense curriculum, space, and tiredness after prolonged standing. Children noted that they wanted to change the seating and table arrangements to make different patterns to create more space.

4.4. Discussion

The aim of this research was to examine the influences on children's PA current views, experiences, and perceptions of PA in the classroom, school, and home environment and to examine the perceived benefits and barriers of participation. Although previous qualitative research has examined barriers and facilitators to primary-school children being physically active (Brunton *et al.* 2003; Hesketh *et al.* 2017), most studies were based in the USA, making their generalizability to the UK setting uncertain. This exploratory study has identified factors that facilitate and inhibit children's participation in PA from the child's perspective and has provided important considerations for adapting *Transform-Us!* to the NI context. Findings from the current study suggest parental restrictions, being able to access and watch TV and lack of discretionary time are barriers to PA participation at home for children aged 7-9 years. Children identified access to, and high levels of, screen time negatively impacted on PA. Other important school-based barriers included a lack of space, in addition to limited or no access to equipment and facilities. The ability to have fun, play, go outside and enjoy PA were important facilitators of PA. These identified issues should be areas of focus for program developers as well as school staff to ensure that strategies are available to mitigate these factors when they serve as barriers, to support program implementation. Based on the data from the present study, many children recognized the physical health benefits of PA. However, data revealed a lack of knowledge and identified lack of PA recognition, which is comparable to previous formative research (Mackintosh *et al.* 2011) where some children demonstrated a limited understanding of what constitutes PA. When describing the likes and dislikes, children were more inclined to focus on their favourite activity. Participants 'likes' were predominantly structured and sport-based activities were more common than play activities and feelings. Consistent with other studies (Timperio *et al.* 2013; Watson *et al.* 2015) children generally conflated PA with sport, which was confirmed within the write and draw data, with children expressing a greater recollection of structured physical activities, games (i.e., football) (refer to Fig. 4.1a and 4.1b). In contrast, during the focus groups children ascribed PA with fun and tended to participate in PA if they perceived themselves to be physically capable; that is, they had the necessary skills and it felt it was worthwhile. Educators could teach children the meaning of PA and emphasize that it does not have to equate to sport. Providing

opportunities to try different activities at school, beyond PE and organized sport, may help to redefine children's perceptions of PA to include a range of activities that they may enjoy.

Interestingly, many of the themes identified were reported to act as both facilitators and barriers across the different schools (e.g., role of parents, school environment, peer influence and interrelationships). Similar to findings from other qualitative studies, parents were perceived as both significant barriers and enablers to children's PA participation, indicating that parents have a great influence over their children's involvement in PA with the ability to both facilitate and impede participation (Brockman *et al.* 2009; Stenhammar *et al.* 2012; Noonan *et al.* 2016). In this study, some children specifically identified their father as a role model for PA participation (Figure 4.4). The findings are in line with previous research by Lijuan *et al.* (2017), who found that 23.3% of the variance in MVPA for boys (aged 7–11) was explained by the MVPA engagement of fathers. Sigmundová *et al.* (2018), found that mother's and father's levels of PA are associated with children's weekly PA. Furthermore, research suggests that active parents, who could act as role models for children, facilitate children's activity (Rodrigues *et al.* 2018). Consequently, targeting parents to increase their own PA levels, particularly through the participation in organized PA, may be an effective way to increase the activity levels of their children while providing health benefits for the whole family.

Within the home and family environment, our findings found that being able to go outside appeared fundamentally important to children's PA within drawings (refer to Figs. 4.1a, 4.1b, 4.1c and 4.1d), so much so that many children reported travelling with parents to parks farther afield that are larger in size and have 'better' provision. PA participation through family walks were discussed by participants alongside dog ownership. Dog ownership is associated with a number of health benefits and research indicates that children from dog-owning families accumulate more PA (Westgarth *et al.* 2019). Data also revealed siblings were perceived as a barrier and as a facilitator. Participants indicated that siblings may increase activity through co-participation and social support but can also persuade each other to co-participate in sedentary pursuits, including television viewing or electronic device use. Participants identified siblings' preferences for sedentary activities as a deterrent to being active, stating that the

sibling was not at the same developmental level as they were in sport, in most cases mentioning that the younger sibling was not at the same level. However, participants also emphasized the positive influence siblings have on sports participation and play. Other studies looking at sibling influence on sports participation have reported similar findings (Hohepa *et al.* 2007; Silva *et al.* 2016). Kracht and Sisson (2018) reviewed siblings influence on children's objectively measured PA and found that children with siblings have a healthier PA pattern with more PA and potentially less SB. Thus, the involvement of parents, pet and/or family members appear to be fundamental to children's PA levels and it is therefore important that the key components of the intervention are structured around both parents and schools.

Whilst parents clearly have a significant role in shaping young children's health behaviours, our findings revealed that children see peer interaction as reasons to be physically active and the role of friendship groups was key in helping to promote and influence the participation of PA at home and within the school environment. Play, fun and social support were reported as key facilitators for PA participation in children aged 7-9 years. Present results are in line with previous findings that participants reported that enjoyment of PA and spending time with friends were the key influences on maintaining participation in PA (Knowles *et al.* 2013; Hesketh *et al.* 2017). Some of the enablers support previous qualitative research, including a UK qualitative study with 10–11-year-olds, which found that children engaged in PA for multiple reasons including socializing, preventing boredom and a sense of freedom (Brockman *et al.* 2011). Findings also support previous research which indicates that friends' social support is known to be valuable for after school activities, although parental support may be less important (Jago *et al.* 2009). In line with our findings, recess literature shows that playtime is a critical time to play with peers and is one of the last free-play opportunities that they have with peers (Ridgers *et al.* 2012; Parrish *et al.* 2020). Thus, providing PA opportunities that enable children to socialize with their friends was identified from focus group discussions as a key component within future intervention. Given that play (Ridgers *et al.* 2012), appreciation of outdoor activity (Knowles *et al.* 2013) and opportunities to socialize with peers (Salmon *et al.* 2003) are strongly associated with PA participation in children, these factors should be highlighted when planning strategies for future PA interventions. Furthermore, interventions that focus on providing social opportunities for activity may be effective activity promotion

methods to control the intrinsic enjoyment of PA that was expressed by these primary-school children.

Previous systematic reviews of PA interventions in schools found favourable effects of classroom movement breaks on increasing PA (Norris *et al.* 2015; Martin and Murtagh, 2017; Watson *et al.* 2017). In this qualitative study, the majority of children found the idea of active breaks and/or incorporating movement in the classroom to be desirable. Participants perceived the additional movement as being ‘*very good for your body*’ and suggested that the addition of activity in the classroom may have possible health benefits. However, some children noted that having to engage in active breaks or perform activities within the confined space of their classroom served as a limitation. This finding is in line with previous process evaluations exploring children’s perceptions of active breaks, where some participants did not like taking part in active breaks due to lack of space (Howie *et al.* 2014; Machell *et al.* 2019). Overall, this finding suggests that researchers should consider the classroom space when adapting the *Transform-Us!*

Standing workstations have the potential to be integrated in the primary-school classroom environment (Blake *et al.* 2012; Hinckson *et al.* 2013). In this study, contradictory opinions in relation to the sit-to-stand desks were apparent, with participants voicing concern over the possibility of class disruption, the practicalities and stability of the desks. Several participants mentioned potential benefits of using the sit-to-stand desks, such as improved academic performance and increased alertness. A pilot study conducted in primary schools in Australia and England, found that irrespective of implementation, integrating sit-to-stand desks into classrooms may be an effective method of reducing classroom sitting (Clemes *et al.* 2016). However, the acceptability and feasibility of implementing sit-to-stand desks within NI primary schools is unknown, such information is essential for determining full-scale randomized controlled trials where intervention effectiveness can be evaluated.

Data from this study reveals that several limits were placed on where and how children could play and highlights those children had little access to organized sport. In line with our results, a research study found that COVID-19 restrictions were both a barrier and a facilitator for PA in Irish adolescents (Ng *et al.* 2020). COVID-19 and lockdown

presented opportunities with more time as a facilitator to take part in activities not done previously, like PA. Children had been working on finding new and innovative ways to remain physically active. During the period of the study, children were forced to adapt to a new 'normal' due to COVID-19 restrictions, which may have caused a substantial decrease in excursions outside of the home. Recent studies highlight the decline in PA participation, with only 2.6% of children meeting the Canadian 24-Hour Movement Behaviours Guidelines, compared to rates between 12% and 17% before lockdown (Moore *et al.* 2020) and a three-fold reduction in PA was observed in Chinese adolescents (Xiang *et al.* 2020). A study conducted in Western Australia found no change in overall PA among children during the COVID-19 pandemic, and an increase in children's unstructured PA and outdoor play was observed (Nathan *et al.* 2021). However, as a result of the context-specific nature of the pandemic contextual factors should be taken into consideration and the imposed restrictions within and between countries, thus this finding may not be generalizable to other countries.

The weather was reported as a barrier to PA. In line with our findings, several studies have found relationships between various weather conditions and children's PA. Rainfall has been associated with decreased activity (Harrison *et al.* 2011; Goodman *et al.* 2012). Internationally, research indicates that children in Northern Europe and Melbourne, Australia were active given the weather conditions they experienced (Harrison *et al.* 2017). Contrary to previous research that winter weather (e.g., snow) is a barrier to outdoor playtime (Burdette *et al.* 2004), this research found that it was rain that hindered children. Nevertheless, it is important to note that contextual differences between North America and in the UK are apparent, and snowfall is quite infrequent and short-lived. Thus, there is a need to provide seasonal and meteorological data, when developing interventions to increase children's outdoor PA. Seasonal variation in young children's PA is apparent (Carson and Spence, 2010; McKee *et al.* 2012). Overcoming weather issues can be a challenge. Thus, learning to adapt to weather conditions that may provide fun opportunities for PA (i.e., wet weather) or providing parents with feasible contingency opportunities in locations where weather extremes are common, may be beneficial and may lead to consistently higher levels of PA in primary-school age children (Hesketh *et al.* 2017). The data also suggests that lack of time for activities is a factor that appeared to constrain family

and school-based activity. Lack of time has previously been reported by youth as a significant barrier to PA (Brockman *et al.* 2009).

4.4.1. Strengths and Limitations

This study utilized a write and draw methodology alongside focus groups, which has not been widely used in primary-school children in NI. Nevertheless, the participants in this study responded well to the combination of interactive tasks, providing important evidence for future studies to adopt a similar methodological approach. The strength of this study is the design as it includes the ability to investigate the phenomenon in natural settings and the use of a variety of research methods to obtain rich descriptions and deep insights. The drawings informed about the main environments the participants participated in PA, helped to express their opinions and experiences, and added different levels of depth to the children's responses. Triangulation of qualitative methods allowed the identification of possibly overlooked stressors, nuances in theory, and put an emphasis on the importance of context. Thus, the dual-method approach provided the participants with alternative ways to express their perceptions and experiences.

There are some limitations to this study that should be considered when interpreting the results. Due to COVID-19 protocols and curriculum restrictions, the length of the data collection was restricted, and a 45-minute data collection session was stipulated by participating schools. Thus, each group completed both the write and draw task and a focus group within a 45-minute timeframe, and this was standardized across all participating schools. Despite this time limitation, the results of this study offer novel findings into the experiences and understandings of PA in primary-school children, and 15–20-minute write and draw activity length has been used in previous research. Furthermore, we were successful in recruiting children from several geographical locations across NI during the COVID-19 pandemic. This helps in gaining a better understanding of PA determinants in children and increases the generalizability of the study findings. It must be noted that the majority of participants were of white ethnicity and no participants had physical disabilities. Thus, future work should include a more diverse sample of participants to reflect the diversity of NI cultures. Future research should consider if another setting is more appropriate to

capture children's experiences of non-school related PA, however researchers should consider the recruitment difficulties in a community setting (Brown *et al.* 2015).

4.5. Conclusions

This qualitative study is the first in NI to explore the identification of barriers and facilitators of children's PA during the COVID-19 pandemic. Peers and family were main influences on children's PA and could both facilitate and impede on PA participation. Collectively these findings highlight that elements of fun, social support, time, space and are likely to be central to the adaptation and maintenance of PA among primary-school children and that activity promotion strategies that are based around co-participation with peers and family members could be an effective means of engaging in PA. Furthermore, the study findings offer suggestions to educators regarding the school and family environment. The study emphasizes social opportunities for activity may be effective activity promotion methods to provide the intrinsic enjoyment of PA that was expressed by these primary-school children.

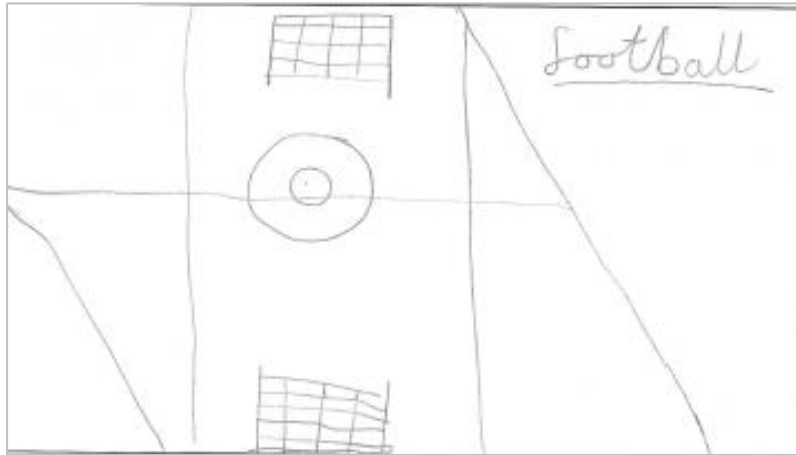


Figure 4.1a. Drawing from a boy (ID9) illustrating the football pitch as where he is most likely to engage in physical activity.

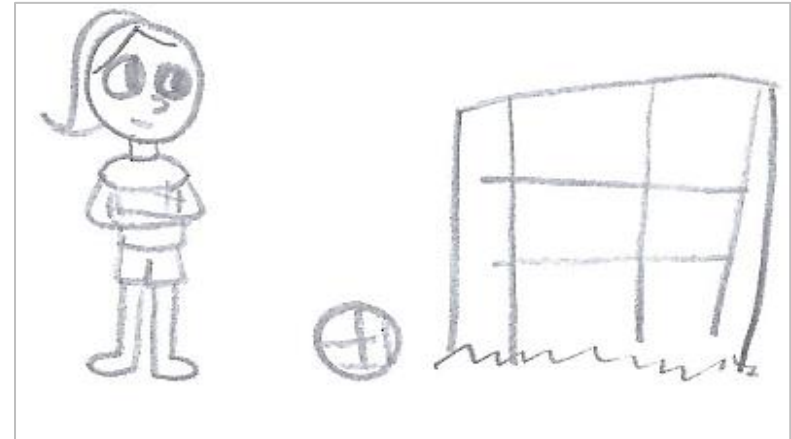


Figure 4.1b. Drawing from a girl (ID34) illustrating what she dislikes about physical activity.

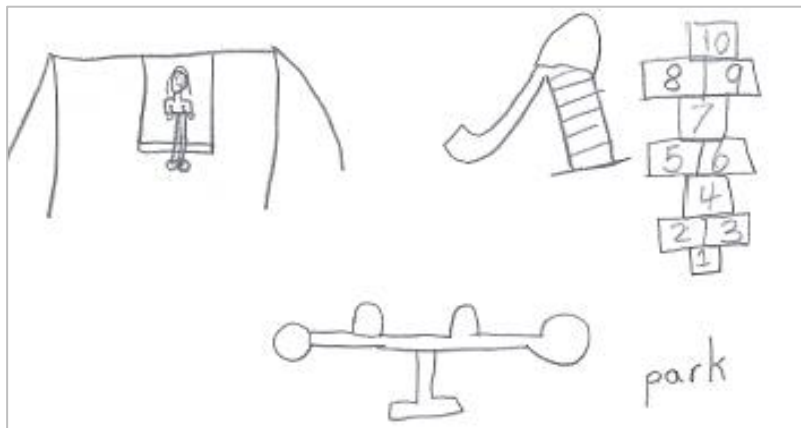


Figure 4.1c. Drawing from a boy (ID2) illustrating the places where he habitually engages in physical activity.



Figure 4.1d. Drawing from a girl (ID17) illustrating a walk with her dog and friend.

Table 4.1. Write and Draw Task Completion by Section

Section	Writing in the box		Drawing in the box	
	Provided	Legible	Provided	Legible
PA Likes	84%	92%	31%	100%
PA Dislikes	87%	100%	54%	89%
Place most likely to take part in PA	94%	100%	40%	96%
Types of PA participated outside of school	96%	100%	29%	100%
Physical activity (PA)				

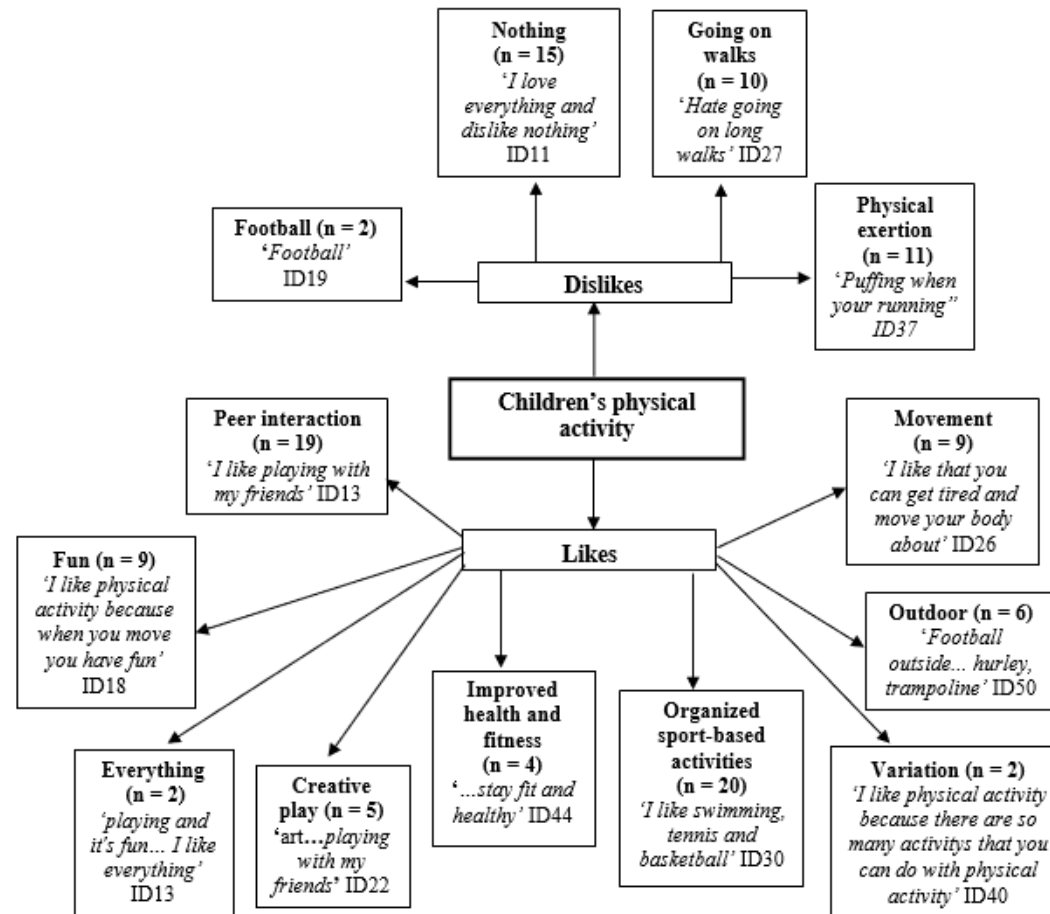


Figure 4.2. Children's likes and dislikes towards physical activity.

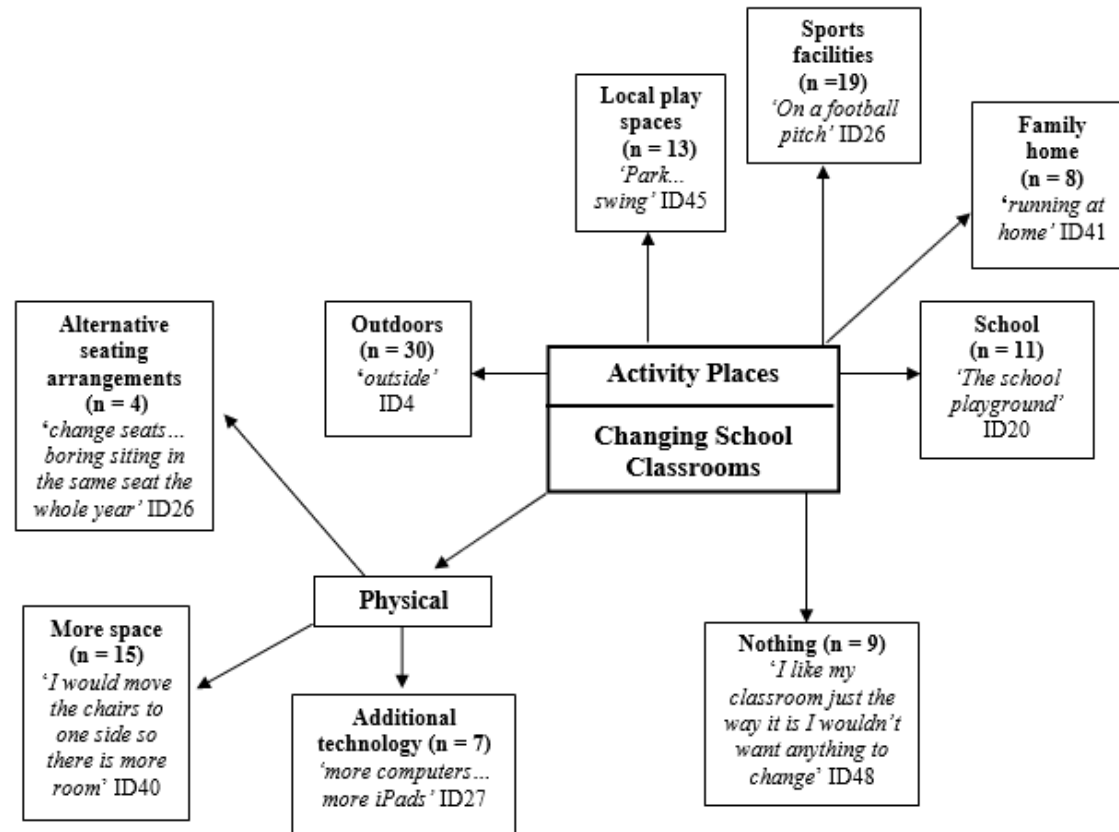


Figure 4.3. Write and draw activity.

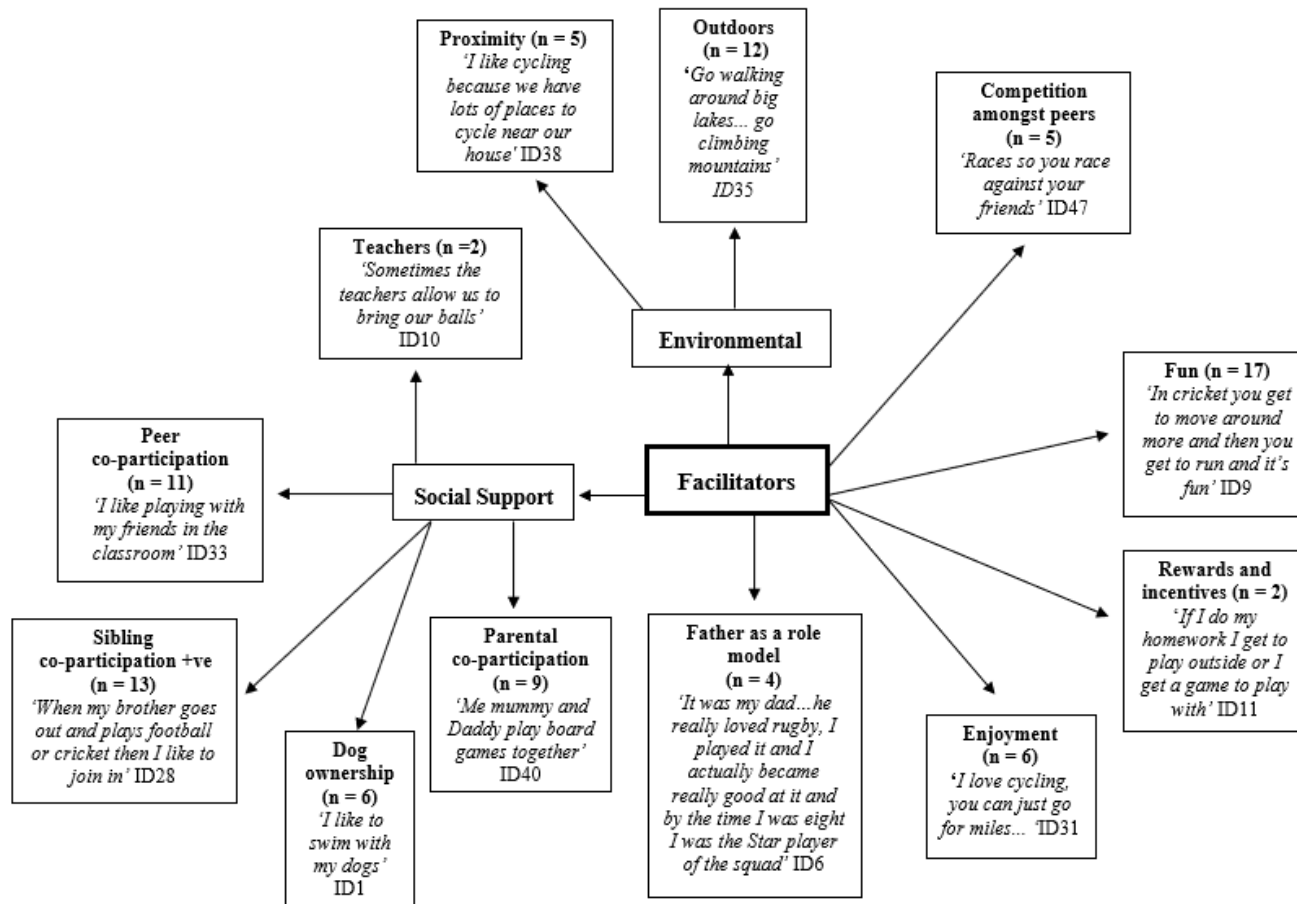


Figure 4.4. Facilitators to children's physical activity +ve = positive.

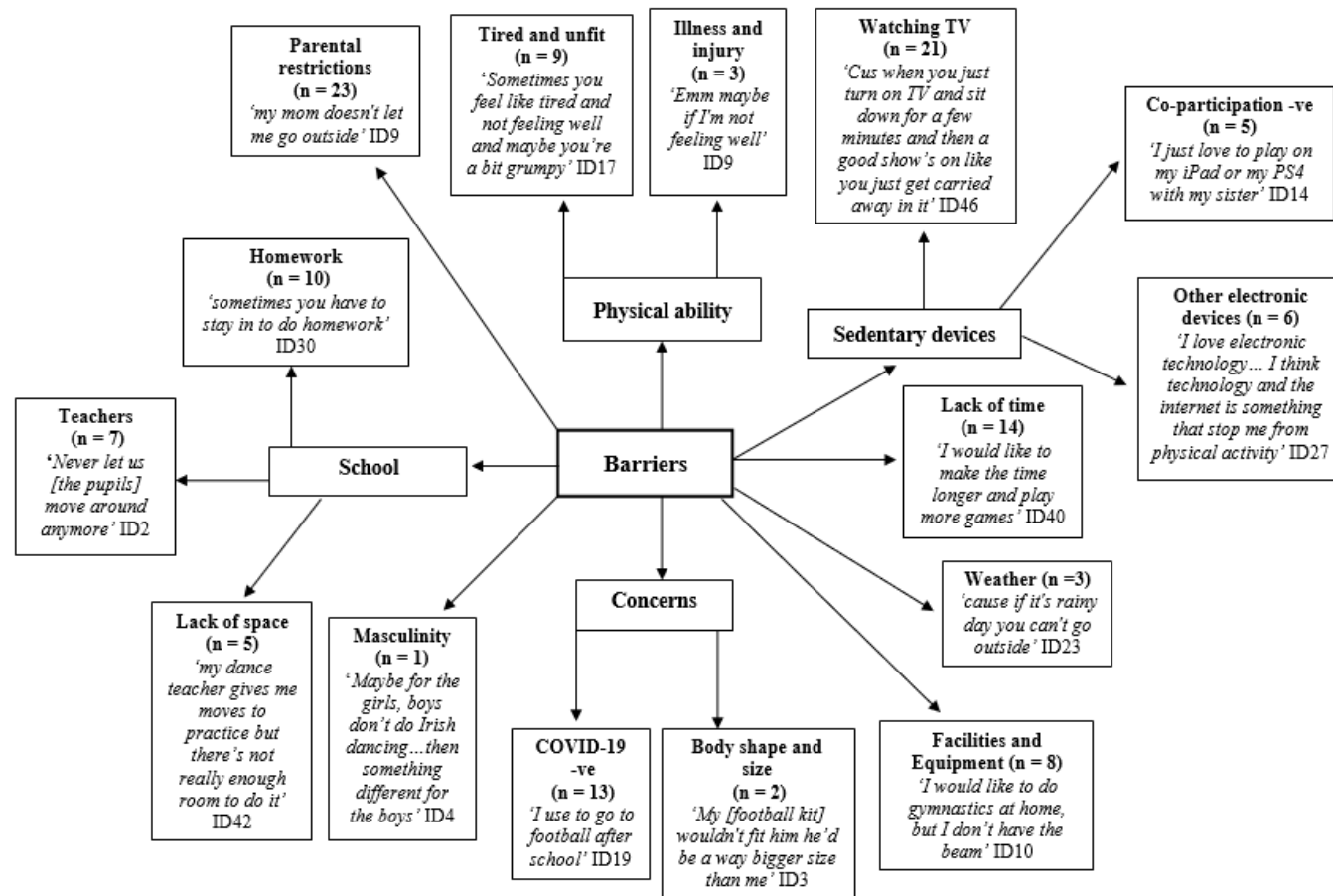


Figure 4.5. Barriers to children's physical activity -ve = negative.

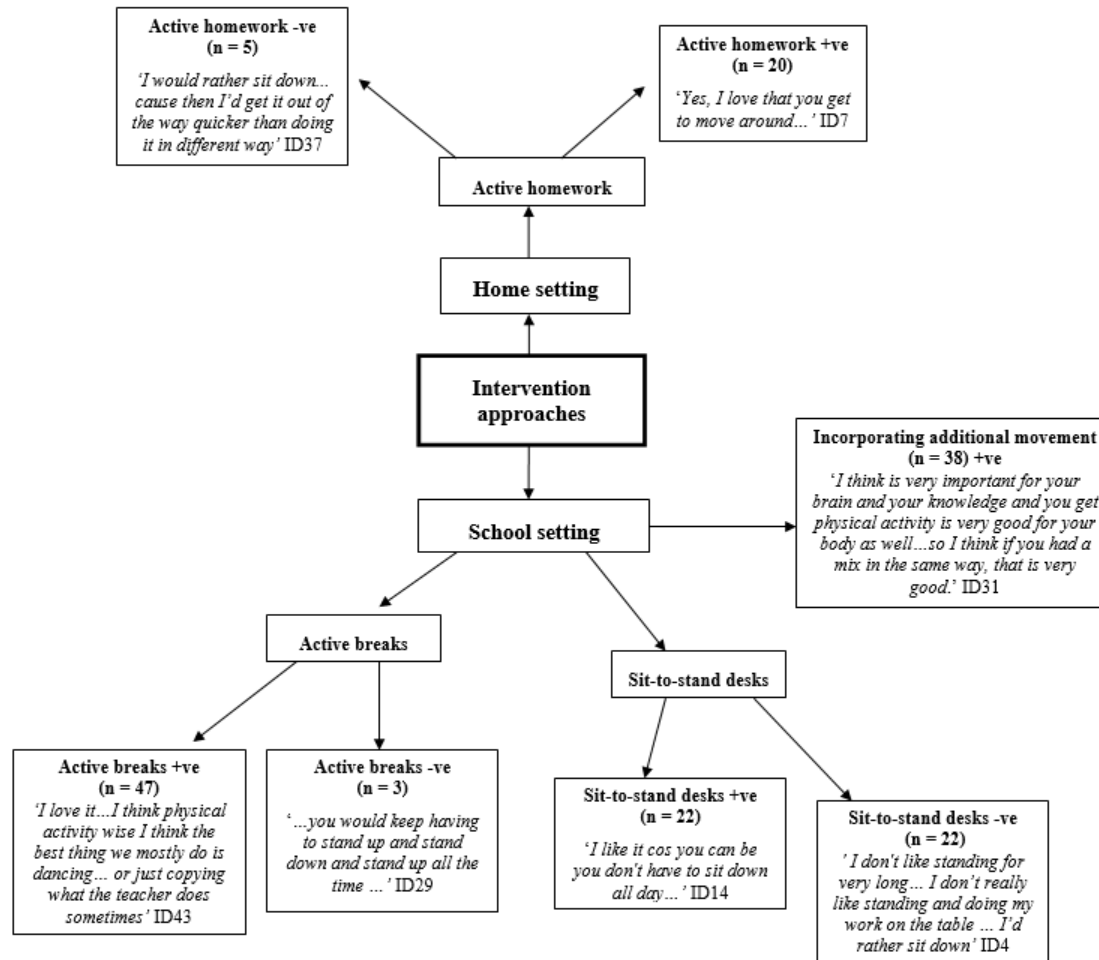


Figure 4.6. Intervention approaches to tackle children's physical inactivity +ve = positive -ve = negative.

Chapter 5: Investigating Parents' and Teachers' Perceptions of the Factors Influencing Children's School- and Home-Based Physical Activity.

Abstract

Background

Childhood physical inactivity crisis is an ongoing public health problem. The school and home setting provide a promising environment to increase children's physical activity (PA). Understanding the factors that affect PA in childhood could help develop effective strategies for overcoming barriers and increasing activity levels in this age group. Thus, the aim of this study was to explore parents' and teachers' perceptions of PA in the classroom, school, and home environment, to inform the design of a future PA intervention in Northern Ireland (NI).

Methods

In total, twelve semi-structured telephone interviews were conducted with primary schoolteachers (n = 6) and with the parents (n = 6) of primary school aged children. All data were audio-recorded, transcribed verbatim and analysed using thematic analysis.

Results

Analyses revealed an understanding of the relationship between PA and health, however the knowledge and perceptions of PA varied. Participants' felt PA was important but believed several factors impacted children's ability to be active. Three main themes emerged from the study, reflecting parents' and teachers' perspectives on promoting primary school children's PA at school and at home: (1) knowledge and perception of PA, (2) barriers and facilitators to an active lifestyle, and (3) parent and teacher acceptability and feasibility of the *Transform-Us!* intervention.

Conclusions

Findings suggest that the most significant barriers, as perceived by parents and teachers, to promoting PA among primary school children namely the lack of space, uneven distribution of PA equipment and limited access to play and sporting facilities and suggest opportunities for overcoming these barriers as a way of increasing children's PA at school. The *Transform-Us!* intervention components were considered appropriate by parents and teachers; nevertheless, lack of teacher and parental support and lack of time were highlighted as key barriers for intervention delivery. Implications for intervention development and future directions were also considered. A one-size-fits-all approach is not applicable when designing a school-based PA intervention, as some degree of flexibility is required.

5.1. Introduction

The physiological health and psychological well-being benefits associated with regular physical activity (PA) have been clearly described (Löllgen *et al.* 2009; Kelly *et al.* 2014). It is recommended that children are physically active and accumulate an average of 60 minutes of moderate-to-vigorous PA (MVPA) daily (WHO 2020). Despite this, only 51% of children aged 7-8-years in the United Kingdom (UK) meet these recommendations (Griffiths *et al.* 2013) and two thirds of European children and adolescents are not sufficiently active (Steene-Johannessen *et al.* 2020). Multiple studies have shown that MVPA declines, and sedentary time increases in an approximately linear fashion between ages 6 and 15, with girls less active than boys across all age groups (Cooper *et al.* 2015; Jago *et al.* 2017), thus early intervention to prevent the age-related decline in children's PA is required. During childhood, behaviour patterns are established which have vital implications on the short- and longer-term health and well-being of children (LioRET *et al.* 2020). Changing a behaviour requires an understanding of the influences on the behaviour in the context in which they occur (Atkins *et al.* 2013).

Primary schools are a key setting for child PA promotion. Children spend on average 180 days/year in school accruing PA through opportunities including PE lessons, extra-curricular PA, after school activities, breaktime/recess and travelling to/and from school (Domville *et al.* 2019). However, even with the provision of PA opportunities and the supporting role of PE co-ordinators, the impact of school-based PA interventions in the UK on overall PA has been questioned (Russ *et al.* 2015). Researchers have found that the addition of a family component (e.g., parent education) to school-based interventions to improve PA in children, has been effective (van Sluijs *et al.* 2008). In addition, home-based interventions have been shown to be effective at promoting PA in children (Guagliano *et al.* 2020). However, research suggests that in order to increase family-based intervention efficacy, the context within which they are delivered should be tailored and adapting programme content to reflect on cultural preferences must be considered (Brown *et al.* 2016).

Engaging school stakeholders in the development phase of an intervention aligns to the Medical Research Council (MRC) guidance (Craig *et al.* 2008; Skivington *et al.* 2021) and can identify factors that influence children's school-based PA to be targeted in subsequent interventions. In accordance with the socio-ecological model (SEM) of health behaviour (Sallis *et al.* 2008), various factors across multiple levels of influence can

promote or impede children's school-based PA, including the development of effective intervention components that overcome any barriers to increase PA (Russ *et al.* 2015) and decrease sedentary behaviour (SB). To develop effective PA promotion and SB reduction interventions in a primary school and home setting, it is important to identify the barriers and facilitators beforehand so they can be anticipated, facilitating implementation. Qualitative methods offer this in-depth insight into individuals' experiences and perceptions of the motives and barriers to participation in PA, crucial for designing successful interventions (Domville *et al.* 2019). Such approaches have effectively informed previous PA interventions (Salmon *et al.* 2011; O'Kane *et al.* 2020; Cowley *et al.* 2021). Therefore, formative research is now viewed as a critical step in the development of health behaviour change. For instance, preliminary qualitative research can optimise randomised controlled trials (RCTs) by improving recruitment rates, help in explaining trial findings and ensures that interventions meet the needs of the target users (O'Cathain *et al.* 2013).

Teachers' perceptions of using school-based PA interventions in primary school classrooms have been examined in several qualitative studies (Cothran *et al.* 2010; Howie *et al.* 2014; Norris *et al.* 2015). However, most of these studies were conducted in different countries and it is likely that there may be differences in barriers faced, due to differences in schooling systems in the UK. Additionally, there is limited evidence in relation to parent and teacher perceptions of school-based PA interventions in the Northern Ireland (NI) primary school context. Therefore, further consideration of parents' and teachers' perceptions of the behaviours is warranted. The *Children - Sit Less, Move More* (C-SLAMM) intervention aims to adopt components from the *Transform-Us!* intervention (refer to **Chapter 2, section 2.9**), through co-design (with parents and teachers) to support primary school teachers in reducing and breaking-up sitting time and increasing PA in the classroom-, school- and home-setting for future implementation in NI. Co-design is an emerging methodology used in public health research, that aims to actively engage specific groups of individuals, such as parents and teachers (e.g., the end-users), to assist in the development of products or services through knowledge sharing (Batalden *et al.* 2016; Constantin *et al.* 2022). Primary school teachers and parents from NI were recruited to take part in qualitative interviews, as part of the intervention development, to explore their current views on children's PA behaviour and to identify areas for school- and home-based PA and SB improvements and targeted interventions. The purpose of this formative study was to: (a) explore classroom teachers' and parents'

current views, barriers, facilitators, knowledge, and perceptions in relation to PA and SB of children both at school and in the home environment and (b) use this data to determine the acceptability of proposed intervention strategies, to inform the design, delivery, development, and implementation of a school- and home-based multicomponent intervention.

5.2. Methods

5.2.1. Sampling, recruitment, and participants

In-depth interviews were held with parents/guardians and primary-school teachers of children aged 7-9 years. Purposive sampling was used to select participants. Data collection took place between November 2020 and April 2021, during the second wave of the COVID-19 pandemic. Participants were recruited from a convenience sample of primary schools spanning a range of socio-economic areas from both rural and urban areas of NI. Initially ten primary schools were invited to take part in the study via e-mail/telephone. Ethical approval was granted by the University Ethics Committee (REC/20/0033), and informed written consent was obtained from parents and teachers prior to participation. All participants provided written informed consent prior to participation.

5.2.2. Interviews

Semi-structured telephone interviews were conducted with follow up questions and probes for parents (Table 5.1.) and teachers (Table 5.2.). The interviews were conducted virtually, as Ulster University regulations in response to the COVID-19 pandemic prevented in-person meetings at that time. Interviews followed a semi-structured discussion guide, which was developed using open-ended questions to facilitate the exploration of participant views. Open-ended questions enable participants to fully express their experiences and beliefs while allowing the researcher to ask probing questions (Turner 2010). The conversational nature of semi-structured interviews allowed the interviewer to modify interviews as warranted by the responses, whilst making sure that relevant topics from the interview were covered. Questions were designed to stimulate discussion about parents' and teachers' beliefs about engaging their children in PA, knowledge of guidelines and strategies to change behaviour relating to PA. Additionally, parents and teachers were asked specific questions regarding the intervention components from the *Transform-Us!* intervention (Salmon *et al.* 2011).

Interviews were held at a time of day convenient for each participant. All the interviews were conducted by a trained member of the research team (SN) with prior experience conducting interviews. Questions were structured to flow naturally from one section to another, and to maintain the participant's engagement in the interview process.

5.2.3. *Data analysis and representation*

Interviews were audio recorded using a Dictaphone and transcribed verbatim. All transcripts were imported into NVivo12 Pro Software (QSR International, Warrington, UK) qualitative analysis software and analysed thematically, using an inductive approach which involved six key phases Braun and Clarke (2019); (1) familiarisation with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Each transcript was read several times by the researcher (SN) to help with immersion in the data (Silverman 2005). All transcripts were subjected to systematic coding, whereby meaningful quotes or key examples from participants were assigned a code. The assigning of specific quotes, conversations and paragraphs were then further analysed allowing broader themes to emerge from the data to best encapsulate participants' views. These themes were then reviewed to ensure the themes were representative of the coded excerpts. This process, known as open coding, is considered desirable for enhancing the credibility of findings when using semi-structured interviews (Morse 2015). Open-coding allowed the researcher to better represent the multiple levels of influence and how the various levels can impact children's school-based PA and SB.

Within this study credibility and transferability (qualitative equivalent of internal and external validity, respectively) were demonstrated through verbatim transcription of data. As recommended by Kvale *et al.* (2015), and to ensure trustworthiness of the coding and interpretation of the data initially, findings were also discussed among co-authors and involved frequent de-briefing sessions between all authors which facilitated the discussion, debate, and re-definition of themes. Interview quotations that best described the themes were selected for presentation, while also aiming to incorporate examples from most participants. Quotations from participants were used to highlight typical responses and ideas that led to the development of the identified themes. Participants were anonymised, and letter/number combination was used for the purposes of data presentation (P=Parent, T=Teacher; M=Male, F=Female).

5.3. Results

Of the 16 parents and eight teachers who received initial invitations, four did not respond to the invitation; one did not return the consent form; seven declined to participate. Six parents (5 female, 1 male) and six female primary school teachers, who taught children aged 7-9 years, participated in the study. Of these classroom teachers, three taught Primary 4 (aged 7-8 years) and three taught Primary 5 (aged 8-9 years). All six schools from which the participants were drawn, were non-fee-paying schools which catered for children aged 4-11 years and ranged in school size. Interviews lasted between 16 and 33 min (mean = 22.5 min), generating 270.1 min of audio data. Data from parent and teacher interviews were combined throughout the results section to promote a deeper understanding and holistic representation of the factors discussed. The main themes that emerged from these discussions fall under three key themes: (1) knowledge and perception of PA, (2) barriers and facilitators to an active lifestyle, and (3) parent and teacher acceptability and feasibility of each *Transform-Us!* intervention component.

5.3.1. Knowledge and perception of physical activity

Data on parent and teacher experiences and perceptions of children's PA varied. Parents estimated that children should engage in 20-30 minutes of PA a day and could not accurately report the current UK guidelines for MVPA for children. Despite a lack of awareness about what the recommendations were, all parents and teachers agreed that PA was important for children's health and wellbeing. Participating parents' and teachers' noted a decline in children's PA with age. Parents recognised the importance of children having fun and active play; however, few spoke about the health and developmental outcomes of active play. Parents reported seeking new PA opportunities for their child and they would try to find new initiatives in their local area. Parents reported that they would like to see more health-promoting initiatives in the school and highlighted that the school could do more to improve children's health and they wanted more PA incorporated across the school day. According to parents, schools did not put as much of an emphasis on PA when the children progress to Key Stage 2 (aged 8-9 years), with more of an emphasis on movement when children are younger, and the classroom was viewed as being very '*formal*'. Parents highlighted that it would not be an easy task to implement more movement into the school day, as some teachers were '*stuck in their own routine*' and that teachers would need to '*buy into*' the intervention for it to succeed: '*You've got a lot of big hurdles to jump in terms of head teachers, teachers, changing their routine,*

you know, that's where you have to have the buy in of the teacher and it's really dependent on the teacher' (P3, M).

Due to the COVID-19 pandemic, parents experienced a period of home-schooling and commented on how they got a first-hand experience of their children's learning and work style. More than half of parents who participated in the study recognised that their child favoured standing when completing homework and stressed that they *'couldn't sit still'*. Findings suggested that all classroom teachers interviewed recognised the importance of increasing PA and were willing to find ways for pupils to be physically active during otherwise sedentary classroom activities. However, teachers' perceptions of PA in the school and classroom varied. Teachers noted that they had multiple commitments and a lack of experience teaching PA. Teachers also suggested that parents have the primary responsibility for facilitating health behaviour change and for developing healthy habits in children and that teachers: *'can only do so much at school, it's up to the parents'* (T2, F). Findings from parents and teachers highlighted that both play, and PA time was used as a behavioural reward in every school.

5.3.2. *Barriers and facilitators to an active lifestyle*

The main barriers and facilitators identified were: (a) gender difference, (b) impact of the COVID-19 pandemic, (c) parental influence, (d) resources, facilities, and space, and (e) rewards and incentives.

5.3.2.1. *Gender differences*

Findings revealed a clear gender gap regarding PA participation at school. Football was viewed as an important sport during and after school in each of the participating schools. All teachers reported that the boys played football outside during break. There was an interpretation by both parents and teachers that girls did not get the same access to PA facilities during the school day and that boys got preferential treatment: *'The boys end up on it playing football and sometimes I see if the girls sometimes want to join in, but the boys can get a wee bit competitive. I guess it discourages the girls from joining in, so I think maybe structuring those sorts of facilities for a rota during the week maybe dodgeball this day, this another day or get like you know, another set of equipment for the next day and give everyone a chance to join in on a range of sports'* (T1, F).

Both parents and teachers emphasised that it is females in particular who struggle to meet the MVPA recommendations at home and at school. Additionally, responses revealed that girls favoured art, crafts, and social activities (e.g., walking, TikTok dances) over competitive sports.

‘She’s an art and craft person.... maybe a boy would run around but [my child] will sit and read or she’ll paint or draw...’ (P6, F).

Interestingly, parents believed that there was apparent favouritism over pupils who played football and who participated in after-school clubs over pupils who did not. Teachers commented that there was an uneven distribution of equipment and access to play facilities between boys and girls.

5.3.2.2. Impact of the COVID-19 pandemic

Both parents and teachers highlighted the significant impact the COVID-19 pandemic had on PA participation as after-school clubs, team sports and that movement in the classroom discontinued and/or declined considerably during this period. Both parents and teachers noted that PA was not at the forefront of the school’s policy and had taken a backseat during the COVID-19 pandemic. Parents commented that children were unable to go on play dates, visit family and/or play team sports. Teachers noted that they were unable to deliver regular physical education (PE) lessons due to the lack of space within the school and because of the assembly hall being converted into additional classrooms.

‘..... physical activity during the COVID pandemic has been very difficult, especially for schools because they can’t do the normal PE classes and things and like they can’t do, they can’t share equipment’ (T4, F).

‘.....it’s all to do with Coronavirus. Their assembly hall is now their classroom....and now their PE is half an hour once a week where they run around the pitch which [my child] despises....’ (P2, F).

Conversely, parents revealed that they had made positive changes during the pandemic, with all of them stating that this meant spending more time together as a family; family walks, board games, playing outdoors, playing with pets were all mentioned.

Nonetheless, all parents interviewed reported a decrease in their children's PA levels due to the COVID-19 pandemic.

'....at the minute cause of coronavirus....[the children] don't have soft play....they don't have the drama club or their dance club. They're missing out at the minute' (P4, F).

Additionally, four of the teachers who participated in the study, assigned active homework tasks over lockdown. 'Jo Wicks', a health and fitness social media personality, offered live/online workouts and both parents and teachers had encouraged children to take part.

5.3.2.3. Parental influence

At home, parental influence played a key factor in both facilitating and/or impeding PA. Parental work demands, and lack of time were recognised by both parents and teachers a key barrier in the participation of PA.

'So sometimes it's just difficult to get children will say well I do want to go but Mommy's working our daddy's working, or they can't make it that night' (T3, F).

Furthermore, parents acknowledged that excess screen time and parental support were the main barrier of children's PA participation at home. Teachers stressed that some parents allowed their children to spend hours on sedentary-based devices (e.g., iPad©) and failed to push their children to engage in PA. Teachers highlighted that low parental engagement, parental attitude towards PA and lack of parental support were key barriers to children's PA participation.

'I often ask them [the children], did you go back?... None of the parents, nobody ever took them back to the swimming pool' (T1, F)

'...it's parents' attitudes as well. Parents aren't interested or involved, sometimes it's hard to make children, get involved in it [physical activity] then. Parents don't have love for ...going out for a walk or doing some physical activity and that as well' (T3, F).

5.3.2.4. Resources, facilities, and space

Parents recognised that the local environment has an important role for encouraging children's PA and cited local community facilities such as green space, the beach, playgrounds, and sporting facilities as encouraging children to be physically active.

'...we would go for a walk on the beach or to the local park...they play spiders and an awful lot of running and a lot of tag and chase those types of games... climbing frame in the garden, we would a gymnastics type of bar that's attached to the climbing frame with swings, and we've a trampoline in the yard and then we have all the footballs, and tennis rackets and hurling sticks' (P3, M).

Parents reported that their children frequently used the available facilities but expressed a need for a greater number and variety of facilities, particularly considering the decreasing size of gardens. Dog ownership facilitated play at home and family walks, particularly during the COVID-19 pandemic.

'We've three dogs... she [the daughter] would be out walking with them, especially at the minute, we could be out for maybe a couple of hours a day' (P2, F).

Teachers highlighted that variability evident within and between classrooms in schools with respect to resources, accessibility, and specific types of PA programming. Space and storage are key elements when considering PA equipment for the classroom. Lack of facilities (e.g., no playground, lack of green space at school), safety concerns and lack of space were reported by parents as the main barriers to PA at school. Furthermore, lack of PA educational resources and equipment, and lack of funding from the Department of Education (NI) were all reported as barriers within the school environment by teachers.

'Sporting equipment in particular the school would have very little...it's taken me years to get new kits for the football team...even updating the numbers of footballs and the number of cones you have; you know simple things not big money things either. Just like a set of 12 balls that would make a massive difference' (T4, F).

A barrier to allowing imaginative free play repeatedly mentioned was the potential for litigation issues and the need to follow clear health and safety and risk assessment guidelines. Accountability for injuries or accidents often meant teachers did not want to run activities where injuries were more likely to occur.

‘.... there’s so much safety restraints too and so much stuff that children aren’t allowed to do...the things that they might have been allowed to do in the past, they can’t do as much’ (T5, F).

Teachers spoke about the requirement to adhere to staffing ratios, and how difficult it can be at times to monitor children closely and to always ensure correct safeguarding for the pupils. Safety was also a barrier for active transport to and from school due to risks on local roads. Bad weather was perceived as a barrier for PA participation both at home and in the school-setting: *‘If they can’t go outside there’s not much to be done inside’ (P1, F).* For many, this prevented pupils going outside for free play, however, the magnitude of this restriction seemed to come down to teacher’s discretion regarding risk. Some teachers encouraged outdoor play in the elements, whilst others felt the health and safety risks were too great and children needed to stay inside.

5.3.2.5. Rewards and incentives

When asked what would encourage children to be physically active, all parents and teachers referred to rewards and incentives: *‘...Fergal [the father] does pay her [the child] to go running... he’ll give her two pound and then a reward actually’ (P5, F).* Parents described incentives as a useful tool to increase and/or improve children’s PA. One parent described *‘having a laugh with their friends’* as an incentive for PA. Teachers reported the use of play and games as a motivating factor for after the structured lessons.

‘....if you have a few games in your head that gets them [the children] moving, the kids love to play’ (T6, F).

Teachers stressed that children like competition, and that there must be a motivating factor or source of motivation. Rewards and incentives were used in every school within the classroom to facilitate PA.

'in my class they love our token system, so they get tokens and then at the end of the week we count them and that would be table points. So whatever table has received the most points, they get to play board games' (T2, F).

'my kids love working with certificates and they love getting stickers for things.... stickers really encourage them' (T5, F).

Football was favoured above all the other sports and play activities at school as it was considered the safest option and easy to facilitate PA during break time.

5.3.3. Acceptability and feasibility of the Transform-Us! intervention components

There were six higher order themes of each *Transform-Us!* intervention component: (1) interrupting classroom sitting time, (2) active learning, (3) standing lesson, (4) active homework, (5) newsletters for home, and (6) mode of intervention delivery and resources (refer to chapter 2, section 2.9, where more detail on each intervention component is provided).

5.3.3.1. Interrupting classroom sitting time

Typically described by teachers as '*brain break activities*' or '*movement breaks*', teachers welcomed the intervention component. In their own teaching practices, they reported regularly encouraging breaks in the classroom to increase teacher control in the classroom. Parents commented on the element of fun and how the break would help children as they would have something to look forward too and a classroom buzzer would motivate them.

'I think that would add an element of fun to it for the children. OK, they might be in the middle of a discussion about something you know, if they were discussing a poem or something and then the buzzer went off. And they all had to get up and do something for two minutes, but it would motivate them. And it would maybe then focus them again to go back to their discussion or they'd maybe come at it from a different angle. I think it would help' (P6, F).

With limited time, teachers expressed a preference for quick and easy activities that were enjoyable for pupils. Teachers reported numerous health benefits of taking a short active break in between lessons including improved coordination, and greater control whenever

the pupils returned to their seats, improved academic performance and a decrease in behavioural issues in the classroom. Additionally, each participant highlighted the *'element of fun'* to this intervention component and that the *'kids love it'*. One teacher described not having enough time for them in their classrooms and the difficulty of fitting in even a short activity break. Curriculum demands and pressure to deliver were noted as a key barrier to facilitating short breaks throughout the day: *'it's really important to cover everything and sometimes lessons are short by the time like you get all the resources handed out and you get you know everything set up like you're in and you explain it.... then you do have interruptions which means then sometimes you could only be given 20 minutes left for the activity'* (T2, F).

Teachers reported an increased likelihood of adopting active breaks if they were simple to adopt, of benefit to teachers, innovative in their educational practices and were compatible with their teaching skills and philosophies. However, some teachers expressed concern over classroom management and the challenge of returning to on task behaviour after the activity highlighting that educational achievement was very important to both parents and teachers.

5.3.3.2. Active learning

Both parents and teachers recognised that children spend too much time sitting and that more movement should be incorporated into the classroom. Parents highlighted that children nowadays spend too much time based in the classroom, stuck indoors at desks: *'Think it's [active learning] brilliant because it feels a little bit less like the trudge of sitting at a desk'* (P2, F).

Teachers favoured active lessons that would allow them to incorporate or make links to academic content. Teachers mentioned that they feel under pressure to cover all the academic teaching requirements in a short space of time throughout each teaching block. All teachers mentioned the lack of space in their classroom.

'Classrooms are very small....space is tight in the classroom especially for us here because we have 30 [pupils] usually in each class' (T5, F).

When asked about active lessons, open outdoor classrooms were mentioned by teachers, as a means of getting children walking, talking, and learning.

5.3.3.3. Standing lesson

Overall, there was a favourable response to the suggestion of sit-to-stand desks in the classroom to facilitate standing lessons. Parents noted that the classroom is quite a *'formal'* place for children when they progress to Key Stage 2 and that they *'lose a lot of that play-based fun'* and that sit-to-stand desks could enhance their academic performance. Both parents and teachers recognised that children learn in different ways. Parents noted that the sit-to-stand desks were a good idea as some children naturally want to stand anyway and it gives children the flexibility to sit or stand in class: *'I think it'd be a great idea. Perfect, you know, at the end of the day, they're seven to nine, they're not 70 to 90, so the more standing they do the better'* (P4, F).

One parent was not so keen on the idea of a sit-stand desk stating: *'I'd prefer that they were sitting down to do their work and either being active or sitting down... I wouldn't like to be standing doing the work'* (P1, F). Space constraints were repeatedly noted as the main barrier to implementing sit-to-stand desks in the classroom. Teachers specified that if the height-adjustable desks replaced the old desks and if a pilot was conducted beforehand to ensure optimal spacing between desks, then it should not be a problem. One teacher stated that the practicability of a standing lesson would depend on the lesson and classroom climate as: *'some days you can get away with doing more practical things and [the children] get the activities moving around the room. But other days it's just doesn't seem as feasible'* (T4, F).

5.3.3.4. Active homework

There was a mix of responses to active homework tasks incorporating PA and reducing sitting time. Most parents disagreed with the concept of homework in general and reported the desire to eliminate homework completely: *'I hate homework, absolutely detest it cause my kids are never in the house The idea of sitting down doing comprehension at 8 o'clock at night whenever they've done their swimming and their football on the same night, you know it's just, it's a no go'* (P6, F). Teachers liked the idea of active homework but specified that all children should be included and that their ability and needs must be catered for. One teacher stated that play equipment and resources vary considerably in every household, and this should be considered when sending home active homework, as no child should feel left out: *'I would give them a couple of options to be like, look if you don't have these resources, why don't you do this*

instead, and so they're given the options, and no one feels like you know they're being totally left out' (T2, F).

Parents and teachers recognised the health and social benefits of active homework as it can get the whole family involved in the tasks. Most parents stated that it was a good idea and that it would be more engaging and fun for children: *'add an element of fun to it for the children'* (P2, F). However, one parent did not like the idea of active learning at home: *'I probably wouldn't be that keen. You know, if they want to do [that] in school, that's fine. They do have.... as long as there's plenty of opportunities for them to be running about, I don't know that I would be that fussed on active learning at home'* (P1, F). Nonetheless, most parents and teachers favoured the active homework approach over the conventional homework methodology: *'Would welcome any kind of new way of learning and trying to take away the 'sit at the table', stagnant approach to keep them moving, we would appreciate it'* (P5, F).

5.3.3.5. Newsletters for home

One parent voiced concern regarding the possible reach of school newsletters: *'I am on the Parent Teacher Association in the school, and we look at how many people read the newsletter out via email....there's only about 40% of them ever actually opened. So, from that perspective I don't know that you would reach as many people as you would like...'*. All parents and teachers favoured physical forms of health promoting materials (e.g., PA leaflets, booklets, and PA cards) and suggested informative leaflets to provide ideas to families on how to be more active, particularly at the weekends. *'Game ideas'* were referred to so that the whole family could participate and noted that a child-friendly visual version would be the most optimal as children could take part in it: *'If it incorporated new ideas and new ways of learning physical activity'* (P3, M).

5.3.3.6. Mode of intervention delivery and resources

All teachers favoured in-person face-to-face teacher training (e.g., how to deliver active breaks and other components of the *Transform-Us!* intervention) over online teacher training. In addition, teachers expressed interest in workshops, question & answer session and short demonstrations. Online training was viewed as *'boring'* and that they were likely to *'lose concentration with it.'* Teachers commented on the value of watching a

demonstrator, ahead of using the new methods in their own teaching practices. Teachers stressed the importance of being able to discuss the new methodologies in person with other teachers and highlighted the potential benefits: *'It is so great even to be able to sit with other teachers just say look this is what I do in my class... then to learn from them'* (T6, F). All the teachers were open to teacher training within the area of PA promotion.

'Teacher training days are normally dull so if it was something new, something we actually all got to try it and got to move...it would also show you how well it works whenever you're able to get up and do it yourself' (T3, F).

Physical resources of the proposed intervention (e.g., as a booklet, print outs) were preferred over online materials. Teachers liked the idea of something *'concrete'*, where they did not have to go searching through websites or emails but rather, they could refer to the resource as and when they needed too. Furthermore, teachers wanted to be able to try and test out the resources for themselves and highlighted that a handout would not be sufficient.

'Touch and play with the resources the way the children would and just explore for ourselves' (T1, F).

5.4. Discussion

The present study sought to gather qualitative information from parents and teachers and found that whilst parents of children (aged 7-9 years) understood the importance of PA, parental work demands, lack of local facilities, bad weather, lack of time and lack of school-based PA initiatives all hindered their child's PA. In addition, although teachers in primary schools appreciated the importance of child health, implementation of health interventions were hindered by priorities of educational achievement, lack of funding, lack of facilities, lack of space, lack of time and low parental engagement. The majority of participants had positive perceptions regarding the components of *Transform-Us!* intervention (Salmon *et al.* 2011). These findings will be used to inform the development of a future intervention (The *C-SLAMM* intervention; discussed in **Chapters 6 and 7**) which is aimed at increasing children's PA participation and decreasing SB in the school- and home-based setting.

One potential explanation for the low rates of PA in primary-school children, is parents' and teachers' lack awareness of the guidelines and their lack of knowledge of recommendations in relation to dose, frequency, intensity and duration of PA. In a 2009 survey, approximately 10% of parents were knowledgeable about the amount of activity children required daily (DeBastiani *et al.* 2014). Similarly, a study led by the *Office of Disease Prevention and Health Promotion in America*, disseminated an online survey to adults who were PA contemplators (n = 2050), with the aim to understand and assess their knowledge of PA. Results revealed that only 22% of adults were aware of the current PA recommendations (at least 150 min/week) (Piercy *et al.* 2020). Notably, in the present qualitative study all parents and teachers correctly identified the known benefits of PA. However, most parents were unaware of the current PA recommendations in the UK. Enhancing family-based education on what constitutes PA, how it can be incorporated into daily family life, and more effective communication strategies to translate and disseminate PA and SB guidance is warranted in future intervention design.

In line with previous studies, the qualitative findings from this study reported parents' lack of concern regarding children's levels of PA and screen time (Hinkley *et al.* 2011; De Decker *et al.* 2012). Bentley *et al.* (2015) found that parents perceived young children to be naturally physically active. Parents in the present study believe that schools could do more to facilitate and encourage PA, and that there's more of an emphasis on PA in children in younger classes at school. Teachers reported that involving parents in school-based health interventions was challenging. This difficulty has been expressed by teachers in previous research (Christian *et al.* 2015) and no consensus has emerged in previous research regarding the best way to involve parents. In agreement with previous qualitative research (Bower *et al.* 2008; Haerens *et al.* 2010), parents and teachers highlighted the environmental influences on children's PA levels such as seasonal impact, availability and characteristics of outdoor spaces, time spent outdoors and school characteristics.

In March 2020, the WHO declared the COVID-19 outbreak as a global pandemic and resulted in an unprecedented time worldwide and forced families to support their children's education at home (WHO, 2020). As previously mentioned, this study was conducted during the COVID-19 pandemic and consistent with international findings, parents reported their children's involvement in PA had decreased (Stockwell *et al.* 2021; ten Velde *et al.* 2021). A Canadian study by Moore *et al.* (2020), found that parental engagement in PA was associated with an increase in indoor PA and outdoor play with

their children. In the present study, parents' and teachers' voiced concerns regarding the COVID-19 restrictions, accessibility, and lack of space in schools to engage in PA. Nevertheless, in the present study some teachers assigned active homework and a few of the participating parents commented on how they tried to encourage play and online fitness classes during this period.

The present study reported that parents were essential agents to cultivate and facilitate children's engagement in both formal and informal PA opportunities. This is in line with previous research, which demonstrated that family is recognised as a major influence on children's PA and their PA experience, and the extent of PA varies based on economic resources, family, income and structure, locality, parental employment and working hours, and parenting practices (Sleddens *et al.* 2012; Dagkas 2016). In the current study, parents and teachers spoke about marked differences in PA levels between boys and girls, with girls engaging in less MVPA and more sedentary time on both weekdays and weekends than boys at the same age. This suggests that efforts to tackle differences in PA should also consider such gender differences (Jago *et al.* 2020).

Some of the findings from this study suggest that curriculum pressure may be a major barrier to PA when implementing school-based health interventions and supports previous research (Huberty *et al.* 2012). Pressure to prepare pupils academically limits the amount of time schools are able to set aside to deliver health-related activities. Therefore, it has been argued that schools need to be recognised and funded for the work they do for children's health and well-being, as well as for educational achievement. For health interventions to succeed, they need to be prioritised in educational mandate at a local and national level and funding should be available to support the interventions (Buche *et al.* 2012; Clarke *et al.* 2013). To create effective and meaningful multi-component school and home based-PA programmes, parents' and teachers' voices should be at the core of their development (Clarke *et al.* 2015). The current study identified several multilevel factors that influence children's PA and suggests practical recommendations to inform the development of future PA interventions for this group, including the C-SLAMM intervention.

Interview data indicates that for the proposed intervention, acceptance into schools and consideration of how to increase teacher buy-in is important. In the present study teachers suggested that teachers who perceived the environment at the school as more supportive

of PA promotion in the classroom were more likely to have favourable perceptions of promoting PA in their classrooms. Teachers' perceptions indicate that given the appropriate support and guidance, classroom teachers are willing to incorporate suggested classroom strategies (e.g., active lesson, standing lesson) into their classrooms. Teachers should feel confident and comfortable to deliver any intervention – as it appears important to support schoolteacher's understanding of the proposed intervention and its impact on pupil outcomes, enhance delivery competence, and provide easy to implement resources that encourage sustainable delivery. The feedback from teachers is in line with previous qualitative research, as teachers reported an increased likelihood of adopting active breaks if they were simple to adopt and compatible with their teaching skills and philosophies (Watson *et al.* 2019).

Teachers in the present study offered invaluable opinions and suggestions on how to improve the intervention components and promote the likelihood of the intervention being implemented both in the home and school setting which were taken into the pilot testing of the C-SLAMM intervention (as described in chapters 6 and chapter 7). Interventions conducted in the school-setting should consider cross-curricular approaches as demonstrating a positive effect on educational outcomes may increase the likelihood of teachers adopting interventions. In fact, if schools can identify benefits to an intervention that fit with their key curricular outcomes, the separation that exists between health and education will be reduced (Mohammadi *et al.* 2010). A consideration of school ethos is also important to consider when planning interventions (West 2006). Furthermore, programmes need to be developed with longer-term investments in mind as short-term programmes often change repeatedly and lead to initiative overload. The findings of the present study highlight the need to account for variability between different school environments, teaching staff, and pupils. Similar work conducted by Jago *et al.* (2015), assessing teacher beliefs regarding PA intervention design also highlighted the need for staff buy-in. A one size fits all approach is not appropriate when designing a health promotion intervention as some degree of flexibility and choice is required (Christian *et al.* 2015). Future school- and home-based interventions with an element of adaptability was preferred over the delivery of blanket fixed interventions.

5.4.1. Strengths and Limitations

The present study was successful in recruiting parents and teachers from several different schools in NI. This is beneficial as the proposed intervention (The C-SLAMM

intervention) aims to be rolled out to all schools in NI. The formative exploration determined teachers' and parents' views on the proposed intervention strategies adapted from the *Transform-Us!* intervention. Although the current study aimed to use methodological rigor in qualitative analysis to explore classroom teachers' and parents' current views, barriers, facilitators, knowledge, and perceptions in relation to PA and SB of children, it is also important to note the limitations. The study disproportionately included females (e.g., all but one interviewee was female) creating gender bias. Virtual interviewing may exclude individuals without technological access, nonetheless, telephone interviews support greater ecological validity, removing institutional settings and reducing researcher presence (Keen *et al.* 2022). Furthermore, additional stakeholders (e.g., teaching assistance, school principals) were not included. Consequently, discussions with local and national educational authorities and additional stakeholders should be included in future research design as it is possible that their opinion will inform the incorporation of school-based interventions. Research was conducted during the COVID-19 pandemic and offers an insight into how COVID-19 affected children's PA levels both at school and at home. The main strength of the study lies in the richness of data collected, covering a broad range of recurrent themes. The study adds to the available literature by exploring in more depth the barriers and facilitator of PA for children, by including the perspectives of parents and teachers. The range and diversity of themes that emerged from the data illustrates the complexity of the issue.

5.5. Conclusions

This study has highlighted that the knowledge and perceptions of PA in parents and teachers of primary-school children (aged 7-9 years) in NI varied. Parents and teachers noted key PA facilitators, specifically the importance of parental support and engagement, using rewards and incentives, addressing gender gaps in PA participation and maximising PA facilities. Barriers towards PA participation included the lack of space, uneven distribution of PA equipment and limited access to play and sporting facilities. A one-size-fits-all approach is not applicable when designing a PA intervention as some degree of flexibility is required. Our data indicates that participating teachers, are supportive of classroom-based activity, whilst most of the teachers highlighted a desire to include more movement in the classroom and throughout the school day. The *Transform-Us!* intervention components were considered appropriate by parents and teachers; however, lack of classroom space, lack of teacher and parental support and lack of time were highlighted as key barriers for intervention delivery. These findings will

guide efforts to promote PA, reduce SB and inform strategies for future PA intervention design in primary schools in NI for example, the pilot *Children - Sit Less, Move More* (C-SLAMM) intervention.

Table 5.1. Semi-structured discussion guide for parent interviews

Parent interview topic guide
1. Which proportion of children do you think meet the current guidelines of 60 minutes of moderate-to-vigorous physical activity a day? <i>*How does this vary by gender and age?</i> 2. What prevents your child from being physically active? 3. What more could be done to encourage more healthy environments and behaviours, especially those that may address the issue of physical inactivity? 4. What rewards and incentives would appeal to this age group for participating in physical activity intervention? 5. What role (if any) do you think schools play in the promotion of physical activity? 6. What do you think about school newsletters to promote health behaviours? Do you think there are more effective ways/delivery modes to inform positive healthy habits to children? 7. If schools were asked to fit in an extra 30 minutes of activity into the school day. How would you feel about it? How do you feel about active learning? 8. What do you think about teachers asking the class to engage in an active/standing educational lesson, where children complete their lesson whilst in a standing position? 9. What do you think about teachers allocating “active homework” to your children? <i>*Some examples given – mathematics equations, spelling etc.</i>

Table 5.2. Semi-structured discussion guide for teacher interviews

Teacher interview topic guide
1. Which proportion of children do you think meet the current guidelines of 60 minutes of moderate-to-vigorous physical activity a day? <i>*How does this vary by gender and age?</i> 2. What prevents children from being physically active? 3. What role (if any) do you think schools play in the promotion of physical activity? 4. Do you think children could be more active at school? <i>*If so, how? If not, why?</i> 5. Do you implement movement into your classroom/ lessons? 6. How would you feel about introducing a 2-minute standing break every 30 minutes? 7. What do you think about signposting sheets and newsletters to promote physical activity? 8. Do you think a daily 30-minute standing lesson, where children are required to stand for the duration of the lesson, is feasible? <i>*If so, how? If not, why?</i> 9. What is your preferred method of teacher training? Online or via a face-to-face teacher training workshop? 10. Research studies conducted in other countries have included environmental changes in classrooms by incorporating height-adjustable, stand-biased standing desks/workstations. stools, chairs, exercise balls, bean bags and mats. How practical do you think these environmental changes would be in your classroom?

Chapter 6: The impact of the *Children – Sit Less, Move More* (C-SLAMM) intervention to reduce sedentary behaviour and increase physical activity in primary-school children.

Abstract

Background

Most primary-school children in Northern Ireland (NI) are insufficiently active and sit for prolonged periods of time at school. The aim of this study was to evaluate the effect of implementing a pilot cluster randomised controlled trial (cRCT) to reduce sitting time and increase physical activity (PA) both in the school- and home-setting.

Methods

A two-arm teacher-led multicomponent school- and home-based *Children- Sit Less, Move More* (C-SLAMM) intervention was conducted in eight primary schools across NI. Schools were randomised on a 1:1 basis to control or intervention. The primary outcome was time spent sitting (minutes per day), assessed using the activPAL accelerometer for 7 days at baseline and follow-up (week 8). The feasibility of the intervention (using quantitative measures) included school and participant recruitment and retention rates, outcome measure completion rates and effectiveness of the intervention on PA levels.

Results

In total, 162 children (aged 7-9 years, 53.6% boys) participated in the study. Overall, 47% (n = 76) of children met valid wear time criteria (at baseline and follow-up) and were included in the analysis. At baseline, children in both arms spent over 6 hours of their waking day (363.31 ± 73.38 minutes/day) and over half of their school day sitting (194.72 ± 42.63 minutes/day). We found no effect of the intervention on the primary outcome (overall sitting time) between the intervention and control schools between baseline and at follow-up (week 8).

Conclusions

This study demonstrates that primary-school children in NI sit for extended periods. No change was observed in sitting time and PA outcomes in the intervention group, which suggests that the study may have lacked sufficient statistical power for change. Findings revealed that the recruitment strategy and retention rates were acceptable. Due to inadequate intervention implementation, clear conclusions could not be made in relation to the impact of the intervention on children's sitting time and PA levels. In order to improve compliance in children, further research is warranted to explore attachment methods for the activPAL monitor. As this was a pilot study, a fully powered long-term cRCT is required to explore the effectiveness of this intervention.

6.1. Introduction

Sedentary behaviour (SB) is commonly defined as ‘*any waking behaviour characterized by an energy expenditure ≤ 1.5 METs while in a sitting or reclining posture*’ (Tremblay *et al.* 2017). Accumulating high levels of SB is associated with adverse cardio-metabolic health risk-markers, reduced self-esteem and academic performance in children (Carson *et al.* 2016; Chaput *et al.* 2020). SBs identified in primary school children include sitting at school, passive commuting (e.g., car and bus) (Morton *et al.* 2016), however the most frequent SB occurs during screen-based activities (e.g., watching TV, playing video games) where children sit for prolonged, uninterrupted periods of time (Hegarty *et al.* 2016; Auhuber *et al.* 2019). SB guidelines recommend that children and adolescents (aged 5-17 years) should limit the amount of SB, specifically the amount of recreational screen time per day (WHO 2020). Despite this, children spend approximately 50% of their waking day sedentary (Bauman *et al.* 2018).

Research unequivocally highlights the separate benefits of being physically active and low SB among children (Zeng *et al.* 2017; Bauman *et al.* 2018; Stanczykiewicz *et al.* 2019). It is important to note, both physical activity (PA) and SB behaviours are not largely independent of each other, as being physically active has been shown to reduce some of the health consequences associated with prolonged time spent sitting (Ekelund *et al.* 2019). Some research suggests that it would be inappropriate to examine their associations with health in isolation (McGregor *et al.* 2018; Rollo *et al.* 2020). In Northern Ireland (NI), children and adolescents (6-17 years) are recommended to accumulate at least 60 minutes per day of moderate-to-vigorous physical activity (MVPA) (UK Chief Medical Officers' Physical Activity Guidelines, 2019). Nationally representative data from NI indicates that 79% of primary schoolchildren (aged 9 to 11 years) are insufficiently active (Woods *et al.* 2022) and spend long periods sitting (Connolly *et al.* 2020). In recent years an increasing number of studies, using compositional analyses, have shown that targeting a combination of movement behaviours (e.g., PA, SB and sleep) across a 24-hour period may have important implications for children (Carson *et al.* 2016; Tremblay *et al.* 2016). As a result, the public health recommendation to “*sit less, move more*” is widespread and

there is an urgent need to develop low-cost, scalable interventions to increase daily PA and reduce SB.

Primary schools offer an invaluable opportunity to accumulate PA (Kriemler *et al.* 2011) and reduce sedentary time (Hegarty *et al.* 2016) as they can target all pupils irrespective of their socioeconomic status, providing access to those who may benefit most (Singh *et al.* 2017; Watson *et al.* 2017; Tassitano *et al.* 2020). Examples of school-based PA opportunities during particular times of the school day include; recess/lunchtime (Ridgers *et al.* 2012), physical education (PE) lessons (Lonsdale *et al.* 2013), classroom-based interventions (Watson *et al.* 2017; Calella *et al.* 2020) and after-school programmes (Mears 2016). Several existing systematic reviews have examined the effectiveness of interventions promoting PA and/or reducing SB within the school-setting (Dobbins *et al.* 2013; Kriemler *et al.* 2011; Hegarty *et al.* 2016) and found that multicomponent interventions may be an effective approach for reducing children's SB and increasing PA, although results should be interpreted with caution as the methodological quality of studies included were mixed (Dobbins *et al.* 2013; Kriemler *et al.* 2011; Hegarty *et al.* 2016).

A mixed-studies systematic review and meta-analysis, conducted by Jones *et al.* (2022), found that classroom PA breaks and physically active lessons may be the most promising intervention strategies, as 82% of studies ($n = 17$) reported a positive effect on PA in children (aged 5-11 years). The review also identified no intervention effect for MVPA levels across the whole day. It is important to note that the systematic review by Jones *et al.* (2022) is the only review that has examined the effect of school-based interventions at reducing sedentary time in children. Quantitative results retrieved from the meta-analysis found inconclusive evidence in relation to sedentary time, likely due to the high degree of heterogeneity across the included studies ($n = 11$) (Jones *et al.* 2022). Thus, the limited effectiveness of these interventions coupled with the limited number of interventions targeting a change in SB, has led to calls for more school-based approaches to be implemented for primary school children (Neil-Sztramko *et al.* 2021).

One intervention that has been successful in recent years, at reducing sitting time and increasing PA in primary school children, is the *Transform-Us!* intervention (Salmon

et al. 2011; Salmon *et al.* 2023). As previously described (see **Chapter Two; Section 2.9**), the *Transform-Us!* intervention was developed to determine the impact of strategies to promote children's PA and/or reduce SB, on behavioural and health outcomes (Salmon *et al.* 2011). Findings have highlighted that the multi-component school- and home-based *Transform-Us!* intervention had a positive effect on children's PA and reduced SB in children aged 8-9 years (Salmon *et al.* 2023). Although the *Transform-Us!* intervention has proved promising as a multi-component intervention, we do not have similar multi-component intervention which have been subjected to rigorous evaluation within NI. It is important to consider that several local contextual differences exist between Australia and NI, in particular the educational system, social and environmental influences on PA (Clemes *et al.* 2015). Consequently, the differences mean that wholesale replication would be inappropriate. Considering the positive independent effects of increasing PA and reducing SB can have for health and school related outcomes in primary school children (Carson *et al.* 2016; Donnelly *et al.* 2016), effective school-based interventions are required in NI. This pilot intervention aims to address this gap in the evidence.

Pilot interventions are considered “*mini versions*” of a full-scale intervention and often integrate feasibility and acceptability measures (van Teijlingen & Hundley, 2002). The Medical Research Council (MRC) framework recognises the importance of conducting pilot studies and recommends an evaluation to support the implementation and development of future interventions (Skivington *et al.* 2021). Thus, the purpose of this investigation was to assess the feasibility of an 8-week pilot multicomponent school- and home-based intervention at reducing SB and increasing PA levels in Primary 4 (P4) and Primary 5 (P5) school children (aged 7-9 years) in NI. As previously stated, (in **Chapters 1 to 5**), key approaches were adapted from the *Transform-Us!* intervention (Salmon *et al.* 2011) to develop a context-specific school- and home-based intervention called the *Children – Sit Less, Move More* (C-SLAMM) intervention. Furthermore, the *C-SLAMM* intervention has been informed by the formative qualitative work (**Chapters 4 and 5**), which examined the perceived barriers and facilitators of PA within the classroom, school and/or home environment (REC/20/0033).

This study aimed to (i) examine the feasibility of collecting activPAL data to examine sitting and PA levels of primary-school children (aged 7-9 years), (ii) assess the feasibility of recruiting and retaining children to the multi-component intervention, and (iii) assess the effectiveness of the intervention on sitting time

6.2. Methods

6.2.1. Study design

The *C-SLAMM* intervention was a two-armed pilot cluster randomised controlled trial (cRCT), conducted between September 2021 and May 2022. Schools were the unit of allocation (cluster), and individuals (children aged 7-9 years) were the unit of analysis. Following completion of baseline measurements, schools were randomly assigned to one of two conditions: (1) intervention condition or (2) current practice (control condition). The intervention was conducted in line with MRC guidelines developing and evaluating complex interventions (Skivington *et al.* 2021). Ethical approval for this study was obtained from Ulster University Ethics Committee (REC/21/0027). The study was registered retrospectively with clinicaltrials.gov (reference: NCT05854355).

6.2.2. Study sample, recruitment and inclusion criteria

Recruitment was conducted in September 2021. In line with recommendations for pilot studies by Beets *et al.* (2021), the recruitment target was eight primary schools to reflect the target population and target setting(s) of the larger trial. —Eight primary schools, each with at least 15 child participants (approximately half of a typically class size in NI) will be recruited giving a minimum total sample of 120. This sample matches the minimum of four clusters per arm recommended for a cluster RCT (Clemes *et al.* 2018). Consequently, the sample will be sufficiently large to provide clear estimates of recruitment and follow-up for a definitive trial (Beets *et al.* 2021). To maximise participant uptake, a convenience sample of primary schools in NI were invited to take part in the study (from three counties in NI, specifically; Antrim, Armagh, and Derry/Londonderry). Prior to participation, emails were sent to school principals inviting them to participate in the study. Following school recruitment, invitational letters were sent to parents and/or guardians of all P4 (7-8 years old) and/or P5 (8-9 years old) children. All children were provided with an information pack containing a participant information sheet and consent form. Children were required

to provide written assent prior to the baseline measurement and were excluded from the study if they had any medical condition that limited their participation in a PA intervention. Participating teachers (of P4 and P5 classes) were also given an information sheet and written consent was obtained.

6.2.3. Randomisation

To control for contamination between intervention and control schools, randomisation was carried out on a cluster level (Marion *et al.* 2012). Schools were assigned an anonymous code and randomly allocated to one of two study arms until all eight schools had been assigned a study arm (i.e., four intervention schools, four control schools). Randomisation was conducted using a computer-based random number generator after baseline data were collected (October 2021). The procedure was performed by a researcher at the University, independent of data collection. Control schools were informed via email of their selection and agreed to continue with their usual timetabled number of breaks and physical education (PE) lessons without any additional time allocated for PA participation. Given the nature of the intervention, blinding of schools, participants, and researchers were not possible following randomisation. The researcher responsible for subsequent data collection and analysis was not blinded to group allocation. Due to COVID-19 pandemic restrictions, the intervention opted for a phased approach (Phase 1 and Phase 2). Figure 6.1 provides an overview of the study timeline. Schools that were randomly allocated to Phase 2, were unaware of the assigned condition until after baseline measurements took place in January 2022.

6.2.4. Development phase

A development phase took place in May 2021, ahead of recruitment for the *C-SLAMM* intervention. The lead researcher (SN) attended two primary schools on one occasion and spoke with teachers ($n = 4$) who taught P4 and/or P5 classes. The two schools did not participate in the pilot intervention and were only involved in the development phase. The purpose of the visit was to: (1) obtain feedback from teachers regarding the proposed *C-SLAMM* intervention design (adapted from the *Transform Us!* intervention); (2) to avoid encountering any problems within the *C-SLAMM* intervention; and (3) to ensure the incorporation of active breaks, PA equipment and sit-to-stand desks were feasible within the NI classroom setting. Teachers were asked

to provide informal feedback regarding the resources and the practicalities of the intervention components within the classroom (e.g., PA equipment box, sit-to-stand desk suitability and the *Transform-Us!* teacher manual). No pupils were involved at this stage of the research as the focus at this point was solely on the classroom environment. All *C-SLAMM* intervention components were adapted from *Transform-Us!* by the research team with direct input from current primary school teachers, to ensure it was potentially suitable in a NI classroom. Such engagement with key stakeholders is crucial to the success and implementation of school-based interventions (van Sluijs & Kriemler, 2016). The formative research conducted in previous chapters (**Chapters 3, 4 and 5**) coupled with the findings from the developmental phase, facilitated the refinement of an 8-week school- and home-based intervention entitled the ‘*Children- Sit Less, Move More*’ (*C-SLAMM*) intervention (see logo; Figure 6.2).

6.2.5. The ‘*Children- Sit Less, Move More*’ Intervention

The *C-SLAMM* intervention incorporated behavioural, pedagogical, and environmental strategies within the classroom, school, and home setting to get primary school children (aged 7-9 years) from NI, moving more and sitting less. Strategies were based on the *Transform-Us!* intervention (see **Chapter 2 Section 2.9** for more information on *Transform-Us!*) and involved incorporating movement into everyday class lessons. The intervention did not involve any adaptations to the curriculum. All the materials and resources were previously tried and tested in Australian schoolchildren aged 8-9 years (Salmon *et al.* 2011; Salmon *et al.* 2023). The research team had open access to all the *Transform-Us!* intervention components and could adapt all material(s) (see **Chapter 2 Table 2.1** for more information on the *Transform-Us!* intervention strategies). Dissimilarities in the use of language were revised (e.g., states and territories in Australia, Australian animals’ ‘*koala*’, variation in seasons) and updated to include terminology used in NI.

The *C-SLAMM* intervention were based on social cognitive theory (Bandura 1986), behavioural choice theory (Freeman 1989) and ecological systems theory (Bronfenbrenner 1986). Table 6.2 demonstrates the mediators that were targeted in the *C-SLAMM* intervention. The low-cost intervention was designed to be delivered by generalist teachers i.e., teachers who did not have specific expertise in teaching

physical education. To support implementation, teachers completed a 45-minute face-to-face training workshop, and were provided with *C-SLAMM* intervention materials, lesson planning guides and a copy of the online teacher training handbook. The teacher training covered what resources were available, how to utilise the resources and how often each intervention component was to occur across the school week. Teachers had to familiarise themselves with the *C-SLAMM* intervention and plan intervention components into their future lesson plans. Resources included health lessons, active lessons, active breaks, active homework, active environments, and newsletters for parents. Examples of some of the resources that were used in the *C-SLAMM* intervention are included in **Appendix 5**. For logistical reasons, there was a one-week gap between the allocation of groups and the beginning of the intervention period to account for teacher training and the distribution of *C-SLAMM* intervention resources. Schools randomised to control were offered information on the intervention and associated materials at the end of the intervention.

The *C-SLAMM* intervention comprises of six key components (Figure 6.3) including: (i) health lessons incorporating key PA/SB messages, (ii) active lessons, (iii) breaks from sitting, (iii) promotional signage and class sets of sports/PA equipment for use during class time, lunchtime and breaktime, (iv) active homework, and (v) parent newsletters promoting PA/reducing sitting time. A brief description of each intervention component with the recommended duration and frequency (per school day or week) is presented in Table 6.2. Each week teachers were advised to incorporate elements of the intervention within the classroom and school setting. Teachers were asked to modify the delivery of at least one class lesson per week (~30 minutes) so that children completed the lesson standing up (active lesson). In addition, teachers were provided with four complete lesson plans (30 minutes in duration) to be delivered biweekly across the 8-week intervention and were encouraged to modify the materials to suit their class and teaching style (health lessons). Teachers were provided with a suite of standing lesson delivery methods that could be modified to any class topic. Furthermore, every two-hour classroom teaching block was to be interrupted every 30 minutes with a 2-minute guided light-intensity activity break (breaks from sitting). A novelty timer was given to each class so that teachers could monitor 2-minute standing breaks and every 30-minutes of sitting class time.

PA was promoted and encouraged during breaktime and lunch breaks. Schools were provided with a low-cost box of PA and sports equipment (£200 per box) to facilitate play and PA for children to use during lunch breaks, and teachers could provide encouragement and support for active games (**Appendix 5**). Moreover, each class were provided with six sit-stand desks so that children could rotate learning activities at 'standing stations'. Sit-to-stand desks were implemented instead of the standing easels (used in *Transform-Us!*) due to emerging research that suggests that irrespective of implementation, integrating sit-to-stand desks into classrooms may be an effective method of reducing classroom sitting (Clemes *et al.* 2016). The *Alpha* sit-to-stand desks (Figure 6.4.) were installed in the intervention classroom after baseline measurements and traditional classroom chairs were retained for use with the new desks. Before the intervention began, pupils and teaching staff were trained by research team members in how to position the desk to the correct height whilst sitting and standing according to the manufacturer's guidelines.

Four newsletters were sent home bi-weekly to parents providing tips on promoting their child's PA and how to decrease SB. Homework tasks were modified to incorporate PA and children were encouraged to complete these tasks with their parents (e.g., go for a walk with their parents and write about where they went and what they saw; mathematics homework using their stride as the unit of measurement). As teachers were responsible for intervention delivery, they were asked to use a logbook to track implementation of the intervention. The intervention groups received support from the lead researcher (SN) with biweekly visits during the intervention period. Within the control group, teachers continued with normal lesson delivery with no changes to the classroom environment. As an incentive, all participants that completed baseline and follow-up measurements were given a stress ball, stickers and pencils.

6.2.6. Outcome Measures

All measurements were conducted by a trained researcher (SN) following a standardised protocol. All measurements were completed at two time points during each phase: baseline and during the final week of the intervention (week 8). Physical measurements were conducted in a semi-screened area with another adult present during data collection.

6.2.6.1 Feasibility

Data related to the recruitment and retention rates were recorded. Completion rates of the outcome measures were recorded, along with the occurrence of any study-related adverse events. All intervention teachers were asked to complete a logbook for the duration of the 8-week intervention (further information regarding the methodology used for logbooks and fidelity checks has been described in **Chapter 7**).

6.2.6.2 Anthropometric measurements

Height (cm) (portable stadiometer: Seca UK, Birmingham, UK) and weight (kg) (portable electronic weighing scales: Seca model 887) were recorded to the nearest 0.1cm and 0.1kg, respectively. Height and weight were measured barefoot. Body Mass Index (BMI) was calculated from height and weight measurements.

6.2.6.3 Sitting and physical activity

Time spent in different postures (sitting, standing and stepping) during school time and across the full week were assessed using the activPAL monitor (*PAL Technologies Ltd, Glasgow, UK*). The activPAL 3 monitor (*PAL Technologies Ltd, Glasgow, UK*) is a small (25 x 45 x 5 mm), lightweight (9g), thigh-worn device that directly measures the postural aspect of SB. The use of the activPAL monitor to objectively measure sitting has increased in recent years and is regarded the most accurate method of assessing sitting behaviour in free-living settings in measuring sitting, standing, walking, and postural transitions in children (Aminian & Hinckson, 2012; Edwardson *et al.* 2017). The activPAL monitor which provides inclinometer functionality and due to its position on the thigh, has become the preferred device for sedentary assessment in children due to its ability to discern sitting from standing/stepping using proprietary algorithms (van der Berg *et al.* 2016; Barone & Kline, 2018).

Participants were asked to wear the activPAL monitor (*PAL Technologies Ltd*), continuously on the anterior aspect of the right thigh for 24 hours/day for seven consecutive days at baseline (week 0) and during the last week of the intervention (week 8). Each participant was provided with a waterproofed [using a nitrile sleeve and hypoallergenic Hypafix® (BSN medical, Hull, UK) dressing] and an activPAL monitor. Participants were provided with a verbal, written and a pre-recorded video demonstration of its use. Devices were attached at school and if a participant

experienced skin irritation, they were advised to attach the device to the opposite leg, as this allowed the participant to keep the device in the same optimal location rather than a sub-optimal position on the same leg. Additional adhesive patches and dressings (Hypafix® and Tegaderm dressings) were given to participants for them to be changed as required. Participants were advised that the device must be removed for swimming and bathing, contact sports or if any skin irritation occurred. Participants were provided with a brief diary (**Appendix 6**) an instruction sheet (**Appendix 7**) and during each monitoring period, in which they were requested to document time in bed and any periods of non-wear. Completion of the non-wear diary enabled the researcher to investigate non-wear time that could not be inferred from the monitor output alone.

6.2.6.3.1 ActivPAL data reduction and processing

All activPAL data were downloaded (PAL files) using standard manufacturer software (activPAL Professional v.7.2.29 and v.7.2.32). The PAL files were visually inspected once downloaded within the activity summary feature of the software as a basic compliance check. Events.csv files with sufficient data were produced in activPAL and analysed in Processing PAL. Following quality checks, data for the 7-day period were exported to a customised Microsoft Excel macro and categorised by activity. The outcome of interest as measured by the ActivPAL included: total sitting, standing and stepping time; total number of steps and number of sit to stand transitions. To assess the impact of the intervention on school-time activity levels, a school-time filter was applied during data analysis (09:00- 15:00). The aim of the school-time filter was to capture the time that children spent sitting, standing, and stepping during school hours.

Periods of non-wear and sleep time were excluded from the analyses using an automated algorithm (applied within the Processing PAL software) and supplemented with cross-checking against participants' diary entries. The total amount of non-wear time from each output was summed up for each day. Any measured waking day that had a non-wear time greater than 4 hours was removed from the analysis. Wear time compliance was set at $\geq 10\text{h/day}$, ≥ 2 days (Rich *et al.* 2013; Vanhelst *et al.* 2021). Thus, children were included in the main analysis if they wore the monitor for at least 10 waking hours on at least 2 days (weekday or weekend), at baseline and follow-up (week 8). An additional wear time criteria was set for the school-time analysis. A valid

school wear time was defined as having at least 4.5 hours or more (270 minutes) of wear during school time (Engelen *et al.* 2013; Ajja *et al.* 2021).

6.2.7. Data analysis

The data were analysed using SPSS for Windows (Version 26, SPSS Inc, Chicago, IL) and Microsoft Excel 2010. All data were visually inspected to identify irregularities or errors. Only participants that provided both baseline and follow up (week 8) accelerometer data were included within the analysis. Descriptive data are presented as mean and standard deviation (SD), unless stated otherwise. Wear time (days), step counts, sit-to-stand transitions, sitting/stepping and standing time were first tested for normality using the Shapiro-Wilk test. The Shapiro-Wilk tested the variables for four different distributions – 2 levels of treatment and 2 levels pre-post (within-subject factor), a p-value > 0.05 indicated a normal distribution. Changes in activPAL data between baseline and follow-up (week 8) were analysed using a mixed between-within subjects' analysis of variance with one between (group) and one within (time) subjects' factor. A p value of <0.05 was considered as statistically significant. Due to the low number of clusters, we used summary statistics rather than multi-level modelling.

6.3. Results

6.3.1. Feasibility

Of the 11 schools initially contacted to take part in the study, eight schools agreed to participate, two schools declined to participate due to logistics and staffing and one school declined due to COVID-19 concerns (Figure 6.5). Invitational letters with consent forms were sent to 194 parent/guardians across the eight schools. A total of 162 parents/guardians and participants returned signed consent and assent forms (84% response rate). At baseline testing, the sample size reduced to 153 participants (control n = 73; intervention n = 80) after nine participants were absent on the day of baseline data collection. In total, four schools were assigned to Phase 1 (n = 70 participants) and four schools took part in Phase 2 (n = 92 participants). Of the 153 participants who completed baseline measurements, 122 participants provided accelerometer data (control n = 61; intervention n = 61). Participants were excluded at baseline (n = 33) due to device malfunction (n = 16), insufficient wear time (n = 5), lost the monitor (n

= 5), adverse reaction (e.g., skin irritation) (n = 6) and refused to wear the monitor (n = 1).

At follow-up measurements the sample size reduced to 141 (control n = 67; intervention n = 74) due to participants moving school (n = 6), unavailable on the day of data collection (n = 10) and not wanting to participate in follow-up data collection (n = 5). Furthermore, 100 participants (control n = 53; intervention n = 47) provided accelerometer data at follow-up. Participants were excluded at follow-up (n = 41) due to contracting COVID-19 (n = 5), device malfunction (n = 9), insufficient wear time (n = 8), lost the monitor (n = 3), adverse reaction (e.g., skin irritation) (n = 6) and refused to wear the monitor (n = 10). Of the 162 participants recruited, 76 participants met valid wear time criteria (at baseline and follow up) and were included in the analysis.

6.3.2. Characteristics of participants

Baseline descriptive characteristics of participants in the control (n = 73) and intervention group (n = 80) can be found in (Table 6.3). At baseline, children in both arms (n = 76) spent 8 hours on average in sedentary pursuits (479.04 ± 82.69 minutes) and over 6 hours of sitting (363.31 ± 73.38 minutes) per day (Table 6.4.). Additionally, during an average school day (09:00 – 15:00) children (n = 76) spent over half of the school day sitting (194.72 ± 42.63 minutes).

6.3.3. Changes in sitting and physical activity

Table 6.4 displays the descriptive statistics for all activPAL variables throughout waking hours for the control and intervention groups at baseline and at follow-up (week 8). There were no significant differences between groups over time for minutes per day of sitting time, with those in the intervention group decreasing sitting time by 25.4 minutes compared to a decrease of 12.1 minutes per day in the control group, $F(1, 74) = 0.63$, $p = 0.431$. There were no significant differences were observed for average time spent in sitting, standing and stepping across an average day between groups (Table 6.4) and during the school day (Table 6.5). No significant differences were observed for sitting, standing and stepping time (minutes per school day) between intervention and control groups over time. The activPAL data also revealed no significant differences between groups for step-counts and sit-to-stand transitions ($p > 0.05$).

6.3.4. Anthropometric measurements

A statistically significant two-way interaction between treatment and time (baseline and follow-up) was observed for weight, $F(1,74) = 6.24$, $p < 0.05$ (Table 6.6).

6.4. Discussion

This pilot cRCT evaluated the effectiveness and feasibility of the 8-week multicomponent school- and home-based *C-SLAMM* intervention, deriving estimates of the effects of the intervention on childrens' sitting time and PA outcomes between intervention and control groups. The following discussion will review findings related to intervention effectiveness, study recruitment, intervention feasibility and outline the strengths and weaknesses of this study. It is important to note, that the following chapter in this thesis (**Chapter 7**) provides insight into intervention acceptability and findings from the *C-SLAMM* intervention process evaluation, which aimed to investigate teachers' and childrens' perceptions of the *C-SLAMM* intervention.

The *C-SLAMM* intervention is the first multicomponent school-and home-based intervention to be undertaken in primary school children (aged 7-9 years) in NI. No significant changes were observed between intervention and control groups for the primary outcome of total weekly sitting time. An important reason for this, could be that the sample size was too small to have a meaningful impact on overall sitting time. However, it is inappropriate to run a retrospective sample size calculation (Hoenig & Heisey, 2001), as it was not originally powered for the analysis. Interestingly, while it was hypothesized the addition of a multicomponent intervention would yield change, no significant improvements on total weekly step count, sit-to-stand transitions, stepping and standing time between the control and intervention group were observed. One possible reason for this could be due to the lack of data regarding the potential health benefits of substituting one behaviour (e.g., sedentary time) for another (e.g., light-intensity PA) for this study sample. Further research is required to establish whether compensation explains these results (Rowlands *et al.* 2015; Swelam *et al.* 2022). Another important explanation for the lack of intervention effect, seems to be high levels of PA in the control group, which is not uncommon in PA school-based interventions (Reasland *et al.* 2016).

Findings from the *C-SLAMM* intervention highlight that improvements to compliance with protocols for assessing proposed primary outcomes (activPAL determined sitting time) are warranted. In the *C-SLAMM* intervention, approximately 50% ($n = 76$) of primary-school children who completed baseline measurements, met the wear time criteria at baseline and at follow-up (week 8). Children indicated that they experienced skin irritation from the medical dressing(s) and subsequently removed and/or refused to wear the device. Similarly, the ‘*Stand Out In Class*’ pilot cRCT, which aimed to increase children’s PA and decrease sitting time using sit-to-stand desks, revealed that some pupils experienced skin irritation (Clemes *et al.* 2020; Chen *et al.* 2021). In contrast to the methodology used in the *C-SLAMM* intervention, the *Stand Out in Class* study used two devices to measure children’s sitting time (the activPAL and the ActiGraph) and stated that activPAL compliance rates were much lower than the compliance rate observed for the ActiGraph (63% vs 83%) (Clemes *et al.* 2020; Chen *et al.* 2021). Some research suggests that the activPAL monitor may not be a comprehensive data processing or analytical tool as there is currently no gold standard processing and analysis procedure (Xu *et al.* 2022). Thus, future work should consider the feasibility of including both activPAL and accelerometer devices, as accelerometer software can estimate time spent inactive and the activPAL software can accurately measure sitting, standing, walking and postural transitions in children (Tudor-Locke *et al.* 2015; Ridley *et al.* 2016; Edwardson *et al.* 2017).

At baseline, the findings of the current study indicate that primary school children (aged 7-9 years) in NI spend over 6 hours of their typical day sitting and around 54% of their school-day sitting. The results concur with previous research conducted in the UK, that found children ($n = 243$, aged 10-11 years) spend large portions (up to 69%) at school in sedentary time (Fairclough *et al.* 2018) and approximately 70% of their school-day sitting ($n = 30$, aged 9-10 years) (Clemes *et al.* 2015). A systematic review by Pearson *et al.* (2017) demonstrated that high volumes of sitting time may increase accelerometer-measured sedentary time by 10–20 min per day (each year) into adolescence, suggesting that an age-related increase in sedentary time may occur. Our baseline data collection took place in Autumn 2021, when lockdown restrictions had mostly been removed. The effects of the COVID-19 pandemic and subsequent restrictions on habitual PA levels, may have contributed to the high levels of sitting time observed (Runacres *et al.* 2021). The impact of the COVID-19 pandemic in

children, particularly how movement behaviours (e.g., PA and SB) have changed over time are still yet to be understood (Bates *et al.* 2020; Salway *et al.* 2022). Thus, the high level of sitting time observed in the *C-SLAMM* intervention is a serious public health concern, given the links with cardiometabolic risk, fitness and body composition in children (Carson *et al.* 2016; Nguyen *et al.* 2020).

The present study highlights the feasibility of incorporating an 8-week multicomponent school- and home-based intervention in NI primary schools, providing additional opportunities for children to sit less and move more (e.g., through the inclusion of additional breaks from sitting, low-cost box of PA equipment and active homework activities) (**Appendix 5**). Some research suggests that the addition of sit-to-stand desks or classroom-based PA equipment (e.g., bean bags to facilitate movement) may reduce sedentary time (Aminian *et al.* 2015; Hinckson *et al.* 2016). Additionally, evidence has shown that implementing PA in the classroom may give primary school children the chance to get regular exposure to activity daily (Kolimechikov *et al.* 2017). Nevertheless, the *C-SLAMM* intervention had no significant effects on sitting time and PA outcomes during school-time. Our findings are in line with results from meta-analyses, that found multi-component school-based PA interventions that used device-based measurements had little (5 minutes) to no effect on children's PA (Metcalf *et al.* 2012; Love *et al.* 2018; Neil-Sztramko *et al.* 2021). The results from the meta-analyses also identified that school-based methodologies varied significantly, specifically by lack of blinding of participants/outcome assessors and due to disparities in implementation (e.g., such as failure to deliver the intended intervention) (Love *et al.* 2018; Neil-Sztramko *et al.* 2021).

The findings of the present *C-SLAMM* intervention suggest that the teachers assigned to the intervention group may not have implemented one or more of the intervention strategies (e.g., breaks from sitting or active lessons) appropriately or the control group may have engaged in more PA during the *C-SLAMM* intervention period, as there was also no significant intervention effect on sit-to-stand transitions. The components that were implemented were potentially those considered the easiest to implement for schools (Jong *et al.* 2020). Factors affecting implementation (e.g., perceived barriers and facilitators) are often evaluated after the intervention is conducted, and the

feasibility of introducing a school- and home-based PA intervention before implementation is not always reported (Naylor *et al.* 2015). Some consideration into the factors affecting successful implementation is important in terms of understanding the success or lack of success of an intervention (Naylor *et al.* 2015; Routen *et al.* 2018). Although not included in the results section, several approaches that may possibly be used by future interventionists to support implementation were considered by teachers and children (refer to the process evaluation; **Chapter 7**). In line with findings of previous research, the successful implementation of *C-SLAMM* intervention was influenced by a variety of factors (e.g., time constraints, lack of classroom space and availability of resources) (Stylianou *et al.* 2016; Dyrstad *et al.* 2018; Routen *et al.* 2018). The qualitative synthesis (**Chapter 7**) confirmed that during the 8-week intervention period, substitute teachers were employed to each intervention school (e.g., due to teacher absence or sickness) and one school did not implement all the intervention components, thus the results could have been influenced by the lack of transferability (further information outlined in **Chapter 7**). Hence, prior to commencing a fully powered cRCT, investigators should consider incorporating future fidelity checks (e.g., observation, using accelerometer data or questionnaires) to ensure that breaks from sitting occur every 30 minutes (as per *C-SLAMM* intervention protocol) (Clemes *et al.* 2020).

Another possible explanation for the lack of intervention effectiveness, may be the inadequate length of exposure, as the pilot intervention ran for an 8-week period, which may not be a long enough duration to elicit an improvement in PA (Kriemler *et al.* 2011). A recent systematic review by Vaquero-Solís *et al.* (2022) investigating school-based PA interventions in children and adolescents (aged 6-18 years) found that intervention time was an essential variable to ensure a change in PA behaviour, concluding that shorter interventions (e.g., less than three months in duration) presented fewer intervention effects than those of a longer duration (e.g., 3 months to 1 year in duration). Furthermore, the impact of the *C-SLAMM* intervention on long-term behaviour change is unknown. Salmon *et al.* (2023) revealed that the *Transform-Us!* intervention had more positive behavioural effects at 30 months than 18 months (a reduction of 27 min in childrens' sedentary time at 18-months and 33 min at 30-months compared to usual practice), highlighting the need for longer term interventions to demonstrate programme benefits.

The study aimed to undertake a pilot cRCT to assess the feasibility of recruiting and retaining children to the multicomponent school-and home-based *C-SLAMM* intervention. Findings from this study indicated that school principals were interested in the *C-SLAMM* intervention, and the recruitment strategy was deemed successful as the response rates were high (84%). Previous school-based PA interventions have examined possible motivating factors to school-based PA intervention participation and state that effective recruitment strategies contribute to the success of PA interventions (Jong *et al.* 2020; McQuinn *et al.* 2022; Gallagher *et al.* 2023). The high recruitment rates for the *C-SLAMM* intervention could be due to friend/peer involvement or support (Edwards *et al.* 2016), due to small rewards or incentives (e.g., such as a pencil) (Jong *et al.* 2020) or children may have perceived the intervention to be fun (Jago *et al.* 2011). Overall, the recruitment and retention methodology used in the *C-SLAMM* intervention were positively received, with 87% of primary-school children (aged 7-9 years) retained at follow-up (week 8). Due to the variation of sample sizes, it is difficult to directly compare retention rates between intervention studies, however, the *C-SLAMM* intervention retention rates are higher than those from a similar study conducted by McLellan *et al.* (2022) which reported an 80% retention rate.

6.4.4. *Strengths and Limitations*

Study strengths include the intervention design which enabled schools to tailor their specific content, the pilot cRCT design and real-life setting. This study contributes to the expanding literature on pilot studies of multicomponent school- and home-based PA interventions. The *C-SLAMM* intervention was developed through formative work and a development phase, which were instrumental to the creation of the pilot intervention, as they insured the intervention components were appropriate for a NI primary school setting. Schools were recruited across different jurisdictions in NI. The intervention was low-cost and required few resources to implement within the school- and home-setting. A key strength to this study was the in-person teacher training, which was conducted ahead of the intervention. The activPAL device-based measurement has been shown to be a valid measure of SB in children (Ridley *et al.* 2016) and used to assess the effectiveness of the intervention on sitting time and PA.

The study also had a number of limitations. The poor compliance to the activPAL wear time criteria, likely had an impact on intervention findings. The present study was conducted in NI, and one should therefore be careful when generalising the results. No environmental factors were accounted for within the *C-SLAMM* intervention (e.g., changes in local PA and school sport policies and contamination by other school-based PA interventions offered). The intervention is limited due to its short intervention period (8 weeks) and the lack of long-term follow-up. This pilot study was not conducted with the intention to make statistical inferences and consequently was not adequately powered. Children had different teachers throughout the intervention, the results could have been influenced by the lack of transferability (further information outlined in **Chapter 7**).

6.5. Conclusions

This study explored the feasibility of an 8-week multicomponent school- and home-based *C-SLAMM* intervention that was adapted from the *Transform-Us!* intervention. The *C-SLAMM* intervention is the first multicomponent school- and home-based intervention to be undertaken in primary school children (aged 7-9 years) in NI. There were no changes observed across any of the SB outcomes measured. Due to inadequate intervention implementation (see **Chapter 7** for more detail), clear conclusions could not be made in relation to the impact of the intervention on children's sitting time and PA levels. As this was a pilot study, a fully powered cRCT is warranted to explore the effectiveness of this intervention.

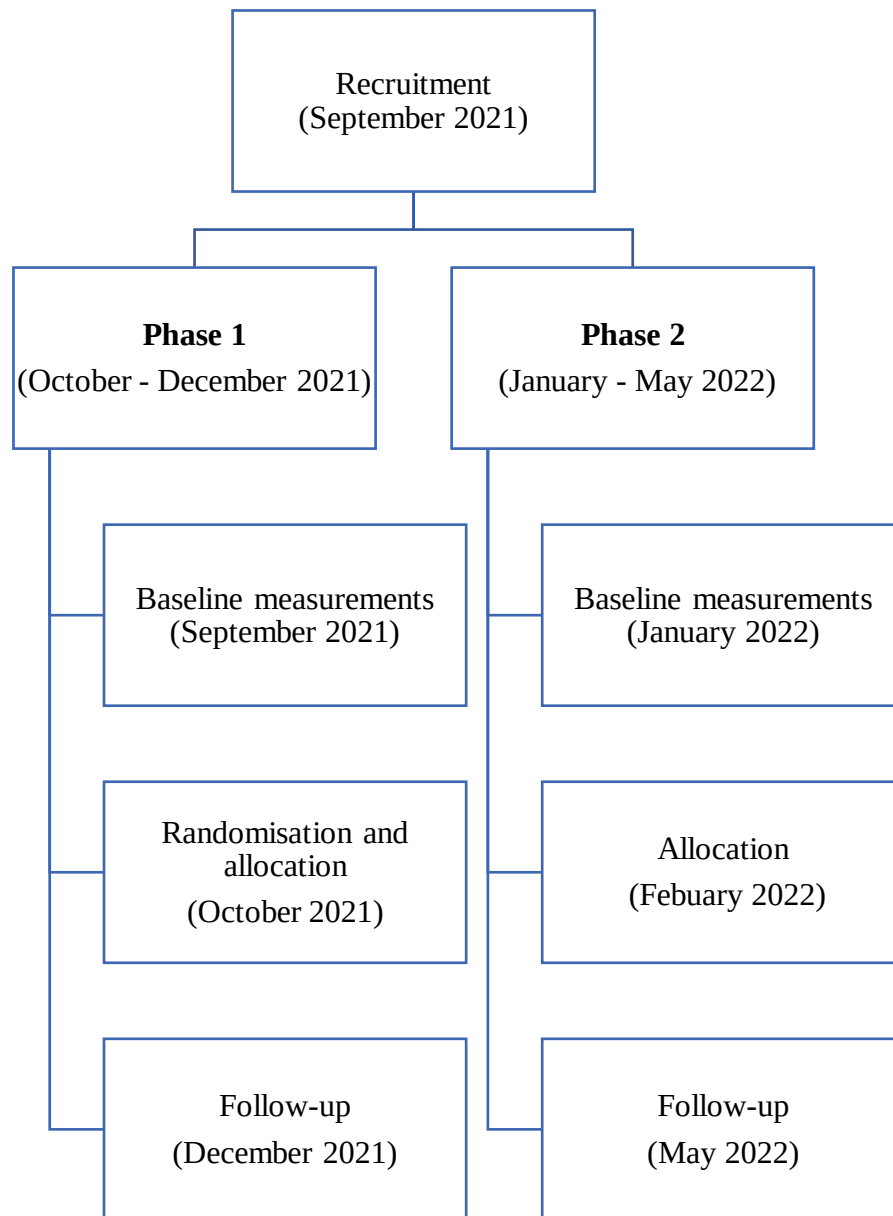


Figure 6.1. Flow diagram for the *Children- Sit Less, Move More* intervention



Figure 6.2. The *Children - Sit Less, Move More* (C-SLAMM) intervention logo.

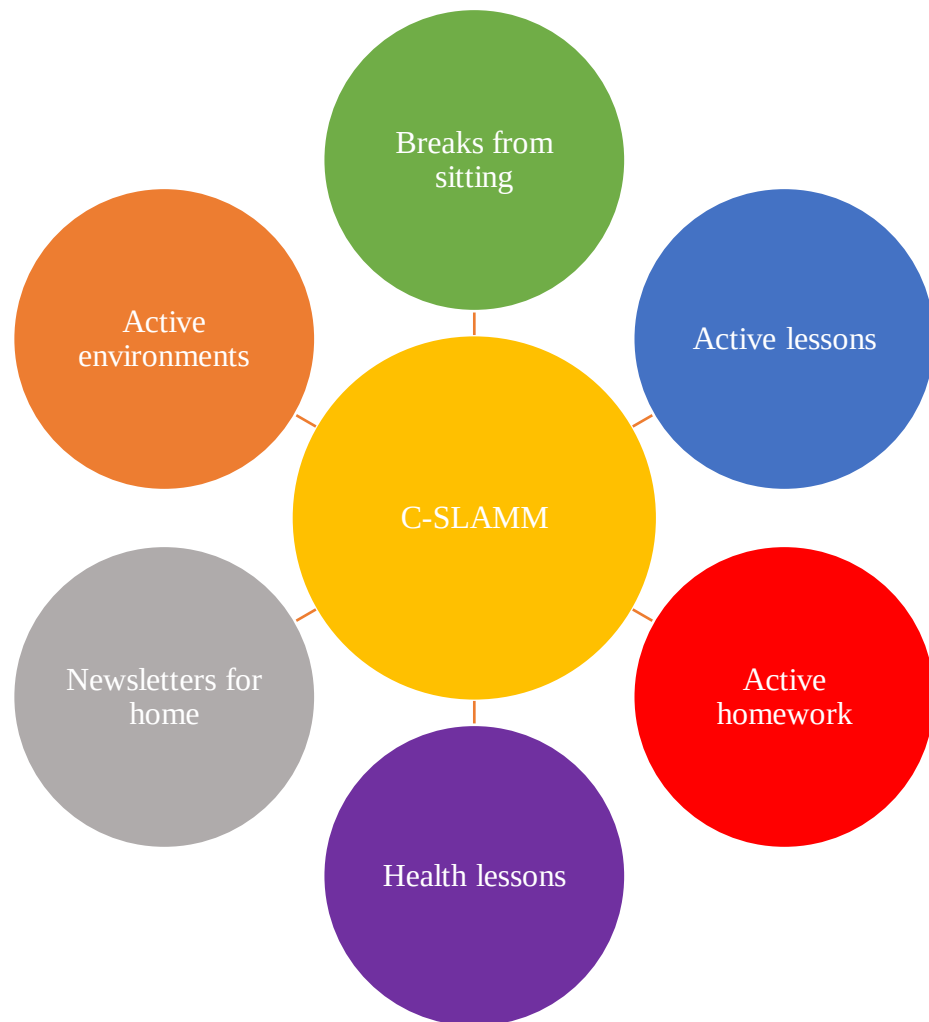


Figure 6.3. Intervention components of the *Children- Sit Less, Move More* intervention. Adapted from the *Transform-Us!* intervention (Salmon *et al.* 2011).

Table 6.1: Theoretical basis of the C-SLAMM intervention and links to programme objectives

Constructs	Mediators/determinants	The C-SLAMM intervention objectives
Intrapersonal		
Confidence	Self-efficacy	Improve confidence in ability to be active or reduce sedentary time
Preference	Enjoyment	Increase enjoyment and preference for PA
Expectations	Benefits/barriers	Increase knowledge of benefits and strategies to overcome barriers
Expectancies	Evaluation of anticipated outcome	Alter perception of pros and cons of being more active
Skills	Self-management	Self-rewards, self-instruction, TV viewing
Behavioural rehearsal	Self-monitoring and contracting	Goal setting, contracting with others, rewards
Interpersonal		
Observational learning	Modelling by parents/siblings	Encourage parents and siblings to reduce their own SB and increase PA
Social support	Modelling/social support	Encourage parents and siblings to support child to spend less time in SB and more in PA; teachers encourage/support PA during break and lunchtime
Social structure	Rules	Parents enforce rules regarding limiting screen time at home

Environmental

Imposed environment	Availability	Increase amount of PA equipment at school and home.
		Reduce availability of electronic devices at home.
Imposed environment	Access	Increase access and opportunities for PA at school and at home.
		Decrease accessibility to electronic devices at home.
		Interrupted sitting during class-time; presence of supervising teachers during break/lunch.

Adapted from Salmon *et al.* (2011) and based on social cognitive theory (Bandura, 1966), behavioural choice theory (Rachlin, 1989) and ecological systems choice theory (Bronfenbrenner, 1986). PA; physical activity

Table 6.2 Components of the *Children – Sit Less Move More* (C-SLAMM) intervention.

Intervention component	Target domain	Duration	Frequency	Description	Qualitative Findings (from development phase, Chapters 4 and 5)
Breaks from sitting	Classroom	2 minutes	x6/day	Within a 2-hour teaching block. Teachers were asked to break up sitting time. A two-minute active break were conducted after 30 minutes of class time. A novelty timer was given to each class so that teachers could monitor 2-minute standing breaks and every 30-minutes of sitting class time.	Deemed feasible and acceptable. No changes required.
Active lesson	Classroom	30 minutes	x1/day	Standing lessons. Teachers were provided with a suite of standing lesson delivery methods that could be modified to any class topic.	Deemed feasible but must account for space in the classroom. As per teachers request and due to COVID-19 social distancing polices, pupils were not permitted to share PA equipment (a class set of equipment was provided (e.g., small bean bags).
Active homework	Family	Varied	x2/week	Homework tasks incorporate PA and reductions in sitting time.	Deemed feasible and acceptable. No changes required.

Health lesson	Classroom	30-40 minutes	Every 2 weeks	Four key learning messages. Four lesson plans given (1 every 2 weeks) in the same sequence as <i>Transform-Us!</i>: • Physical activity, sitting time and health • Self-management of sitting time and physical activity for children • Decision making (Choosing to move or sit) • Active families	Deemed feasible and acceptable. Any potential variations in use of language were revised (e.g., states and territories in Australia, Australian animals' 'koala', variation in seasons).
Newsletters for home	Family	N/A	Every 2 weeks	Four newsletters on tips to reduce sitting time and promote PA at home. The newsletters link to the key learning messages from the health lesson component.	Updated to incorporate the new and existing guidelines in NI. (e.g., 60 minutes of MVPA).
Active environment	Classroom and/or School	N/A	N/A	Six adjustable sit-stand desks per classroom. Provision of sporting equipment and signage (indoor only) to promote PA. Each sit-to-stand desk accommodated two pupils. Provision of pedometers for each class.	Deemed feasible and acceptable.

N/A: not applicable, MVPA: moderate-to-vigorous-physical activity, PA: physical activity, SB: sedentary behaviour, NI; Northern Ireland.

Alpha Electric Desk Standard Education Auth Model Alpha DF32



Figure 6. 4. The *Alpha* sit-to-stand desk.

From left-to-right: the silver telescopic frame, the dual controller and the desks set-up in a classroom.

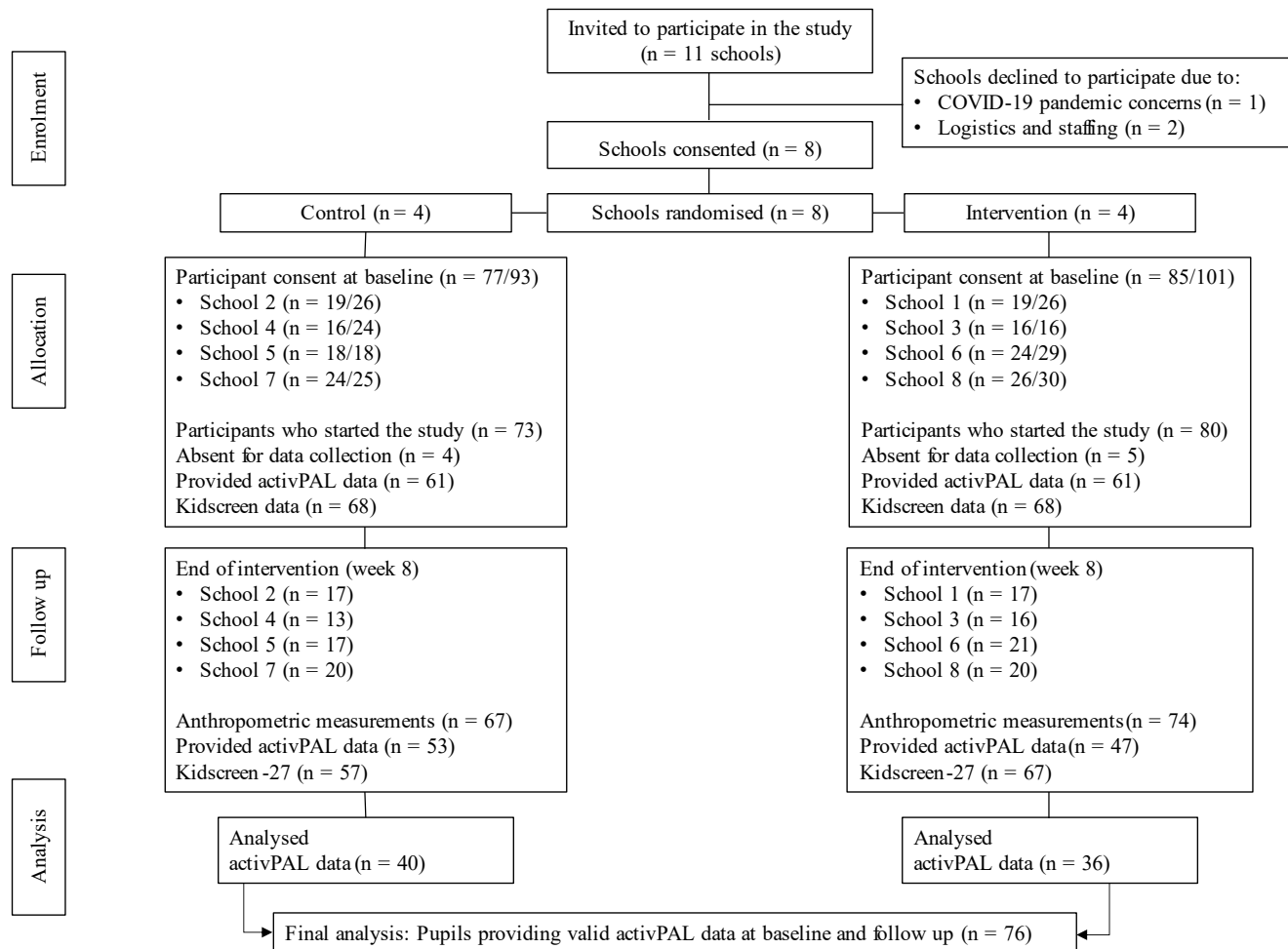


Figure 6.5. CONSORT Flow diagram

Table 6.3. Baseline characteristics of the *Children- Sit Less, Move More* intervention study participants.

Variable	Control	Intervention	All
<i>N</i>	73	80	153
Sex, M: F (M %)	37:36 (50.6)	45:35 (56.3)	82:71 (53.6)
Class; N(%)			
Primary 4 (7-8 years old)	30 (41.1)	42 (52.5)	72 (47.1)
Primary 5 (8-9 years old)	43 (58.9)	38 (47.5)	81 (52.9)
Height (cm)	135.3 ± 7.43	132.7 ± 7.81	134.0 ± 7.72
Weight (kg)	33.2 ± 8.69	30.6 ± 7.75	31.8 ± 8.30
BMI (kg/m ²)	17.9 ± 3.28	17.2 ± 2.78	17.5 ± 3.04

Data presented as mean ± SD, unless otherwise specified. *n*, number of participants; M, males; F, females. BMI, body mass index.

Table 6.4. Comparison for activPAL data measured for intervention and control groups at baseline and follow-up (week 8)

Variables	Baseline		Follow-up (week 8)		Change (95% CI)	p-value*
	Mean	SD	Mean	SD		
Valid day (n)						
Control	5.2	1.31	5.4	1.08	0.20 (-0.34, 0.74)	0.066
Intervention	5.5	1.11	5.0	1.34	-0.50 (-0.06, -1.03)	
Sedentary (minutes/day)						
Control	483.15	90.66	456.19	85.23	-26.97 (-3.39, 57.32)	0.895
Intervention	474.48	73.83	444.74	96.51	-29.74 (-58.90, -0.58)	
Sitting (minutes/day)						
Control	356.50	83.18	344.42	68.58	-12.08 (-36.85, 12.69)	0.431
Intervention	370.87	60.96	345.45	81.91	-25.43 (-48.63, -2.22)	
Standing (minutes/day)						
Control	172.73	50.22	178.92	42.61	6.19 (-10.12, 22.50)	0.615
Intervention	177.58	46.78	177.56	46.77	-0.19 (-19.03, 18.99)	
Stepping (minutes/day)						
Control	129.95	30.15	139.10	39.98	9.15 (-3.43, 21.74)	0.424
Intervention	129.80	34.93	131.82	36.01	2.02 (-10.75, 14.79)	
Sit-to-stand transitions (n)						
Control	96.88	26.44	99.68	24.98	2.80 (-6.84, 12.44)	0.142
Intervention	100.25	24.98	94.17	20.44	-6.08 (-13.07, 0.90)	
Step counts (n)						
Control	9975.02	2387.26	10735.03	3328.75	-760.00 (-1823.68, 303.70)	0.529
Intervention	10099.61	2780.81	10390.26	3190.49	290.74 (-766.30, 1347.79)	

*Differences between groups compared using mixed between-within subjects ANOVA. Data presented as mean $\pm$ SD, unless otherwise specified. n, number of. SD, standard deviation. This table includes data from participants who met the minimum wear time criteria of 10 waking hours for $\geq$ two days at baseline and at follow-up (control n = 40, intervention n = 36)

Table 6.5. Comparison for activPAL data measured for intervention and control groups at baseline and follow-up (week 8) for school time^a

Variables	Baseline		Follow-up (week 8)		Change (95% CI)	p-value*
	Mean	SD	Mean	SD		
Valid school day (n)						
Control	3.55	0.68	3.55	0.88	0.00 (-0.36, 0.36)	0.313
Intervention	3.67	0.83	3.42	0.81	-0.25 (-0.59, 0.09)	
Sitting (minutes/day)						
Control	191.19	46.40	191.62	40.45	0.42 (-14.36, 15.20)	0.235
Intervention	198.63	38.27	187.66	35.35	-10.98 (-22.92, 0.96)	
Standing (minutes/day)						
Control	95.66	35.45	97.47	28.83	1.81 (-9.56, 13.18)	0.594
Intervention	91.33	32.87	97.11	33.84	5.78 (-3.77, 15.32)	
Stepping (minutes/day)						
Control	69.48	17.45	70.15	20.84	0.66 (-5.58, 6.91)	0.465
Intervention	68.53	13.65	72.83	13.90	4.30 (-0.70, 9.30)	
Sit-to-stand transitions (n)						
Control	47.60	19.20	46.69	15.85	-0.91 (-6.30, 4.48)	0.844
Intervention	47.23	16.87	45.66	13.27	-1.57 (-5.39, 2.26)	
Step counts (n)						
Control	5350.30	1495.94	5513.32	1809.76	163.02 (-356.27, 682. 30)	0.684
Intervention	5555.10	1101.76	5854.55	1185.08	299.45 (-118.84, 717.73)	

^aSchool-time filter (09:00 – 15:00); *Differences between groups compared using mixed between-within subjects ANOVA. Data presented as mean $\pm$ SD, unless otherwise specified. *n*, number of. This table includes data from participants who met the minimum wear time criteria of 10 waking hours for $\geq$ two days at baseline and at follow-up. School-time minimum wear-time criteria was set at 75% to ensure all included data had $\geq$ 270 minutes of school-time data for this analysis (control *n* = 40, intervention *n* = 36)

Table 6.6 Anthropometric measurements at baseline and at follow-up (week 8)

	Control (n = 40)	Intervention (n = 36)	Difference (p)^a
Height (cm)			
Baseline	134.98 ± 7.83	135.04 ± 8.22	0.066
Follow- up (week 8)	135.47 ± 7.62	136.54 ± 8.46	
Weight (kg)			
Baseline	31.49 ± 6.91	33.00 ± 8.16	0.015
Follow- up (week 8)	31.86 ± 6.92	33.79 ± 8.32	
BMI (kg/m²)			
Baseline	17.12 ± 2.48	17.87 ± 3.08	0.950
Follow- up (week 8)	17.20 ± 2.42	17.93 ± 3.15	

BMI, body mass index. ^a Differences between groups compared using mixed between-within subjects ANOVA

Chapter 7: Process evaluation of the *Children- Sit Less, Move More* intervention.

Abstract

Background

Primary-school children spend a large proportion of the day sitting at school and at home. When developing interventions to increase physical activity (PA) and reduce sedentary behaviour (SB) in children, it is essential to evaluate the feasibility of these interventions for both participants, the home setting, and the wider school community. The *Children - Sit Less, Move More* (C-SLAMM) intervention was a multicomponent school- and home-based intervention, aiming to reduce SB and increase PA in primary-school children. The purpose of this process evaluation was to use a combination of methods to elicit child and teacher perceptions regarding the feasibility and acceptability of the *C-SLAMM* intervention, with a specific focus on the intervention components.

Methods

A subsample of participants (aged 7-9 years) who participated in the *C-SLAMM* intervention, were randomly selected at the end of the intervention to participate in the process evaluation. In each of the four intervention schools, a write and draw activity and focus group discussions were conducted to explore their experiences of the *C-SLAMM* intervention. During the 8-week intervention, teachers in the intervention schools were asked to complete diary logbooks and weekly fidelity checks. In addition, qualitative semi-structured interviews with teachers were conducted after the intervention had finished (week 9). Focus group and interview discussions were audio-recorded, transcribed verbatim and analysed thematically.

Results

Forty-eight children (25 boys, 23 girls) completed the write and draw activity and focus groups. Teacher interviews (n = 4; 3 female) were conducted within the school setting. Five key themes emerged with results indicating that the delivery of the *C-SLAMM* intervention within the school setting is feasible and can positively influence the classroom experience for children and teachers. Barriers to increasing PA and decreasing SB were identified including lack of parental support, the allocation of sit-to-stand desks to children, and lack of classroom space.

Conclusions

This process evaluation has shown that the *C-SLAMM* intervention was acceptable to children and teachers' and has allowed for greater understanding as to how, and to what extent, the pilot intervention was implemented within the school- and home-based setting. Incorporating strategies such as breaks from sitting, health lessons, and environmental changes to promote PA and reduce SB, may be effective in promoting physical activities during school time. Contextual differences and varied deliveries by teachers in the intervention affected the fidelity of intervention delivery. Pupil engagement was influenced by teacher interest in the intervention. Barriers identified by teachers' in relation to time and staffing concerns should be addressed, and teacher engagement must also be considered before proceeding to a fully powered trial. Future multi-component school- and home-based interventions involving opportunities to stand and participate in PA outside of timetabled physical education (PE), should incorporate environmental changes. Both children and teachers' highlighted that the delivery within the school- and home- setting is feasible and offers a promising tool for engaging children in PA. The refinements identified can be made within the original intervention structure, ahead of proceeding to a definitive trial.

7.1. Introduction

School-based PA interventions have shown mixed results in regard to physical outcomes in primary-school children (Jago *et al.* 2023). Research on school-based physical activity (PA) interventions highlight the need to critically examine the delivery of each intervention component and the processes of any complex intervention (Grant *et al.* 2013). To date, evidence proposes that multi-component interventions that incorporate PA and aim to reduce SB across the whole-school environment and throughout the school day, may have the strongest impact on time spent in MVPA and SB (Van Kann *et al.* 2016; Hegarty *et al.* 2018; Neil-Sztramko *et al.* 2021). However, a systematic review conducted by Naylor *et al.* (2015) identified 20 factors that could hinder the implementation of school-based PA interventions. “Limited time” was the most commonly reported factor, followed by “lack of resources,” “lesson scheduling” and “weather.” Consequently, Naylor and colleagues (2015) call for an urgent need for more school-based PA interventions that assess implementation through comprehensive process evaluation.

School-based interventions can also be complex. Thus, process evaluations are frequently used to explain discrepancies between expected and observed outcomes and the extent to which an intervention was delivered or received as planned (Craig *et al.* 2008), to interpret whether the intervention was effective and denote its suitability and sustainability for translation into practice (Skivington *et al.* 2021). The context, which includes a blend of the cultural, social, economic, political, and/or organisational setting as well as the demographic, epidemiological, and socioeconomic characteristics of those delivering and receiving the intervention, is a key factor to PA interventions (Pfadenhaur *et al.* 2017; Jago *et al.* 2023). Nevertheless, process evaluations have been criticised for failing to report details of context, implementation, and adoption.

The Medical Research Council (MRC) guidelines recommend that both quantitative and qualitative methods have an important role in process evaluations, both independently and in combination (Moore *et al.* 2015). Qualitative methodologies allow for perceptions and experiences of interventions to be explored by those who have experienced them first hand. Thus, approaches such as, semi-structured teacher

interviews and child focus groups are subsequently the main components of school-based process evaluation studies (Naylor *et al.* 2015; Jago *et al.* 2015). Nevertheless, research suggests that some primary-school aged children may struggle to verbalise their thoughts (Noonan *et al.* 2016). Thus, the use of a singular approach to explore children's perceptions may not provide an accurate reflection of children's intended meaning. A combination of approaches (such as the use focus groups with drawings) would be considered a more developmentally appropriate and inclusive approach as drawings are considered a familiar classroom-based activities (Taylor *et al.* 2015). The combination of these approaches (focus group and drawings) can elicit a comprehensive and complimentary account of child perceptions and experiences of interventions with a view to enhancing data credibility and trustworthiness (Noonan *et al.* 2016; Nally *et al.* 2022).

Informed by process evaluation models, a thorough process evaluation was built into the design of the *Children – Sit Less, Move More* (C-SLAMM) intervention and employed mixed-methods approach including several different sources across the intervention to assess the reach, feasibility, acceptability and implementation of the intervention. Data included teacher logbooks, fidelity checks, semi-structured interviews with teachers, a write and draw task and focus groups with children. To measure implementation of planned intervention activities (dose delivered), the teachers kept a daily log of what intervention activities they used. Feasibility and adherence to these components by participants were monitored using the activPAL data (**Chapter 6**). Furthermore, **Chapter 6** provided the quantitative data to assess the impact of the *C-SLAMM* intervention on outcomes relating to sitting time, PA and health outcomes. In line with Merriam and Tisdell (2016) strategies to promote validity and reliability the methods employed for data collection, analysis, interpretation, and presentation of findings were carefully considered. With regards to trustworthiness, using a combination of qualitative research techniques, including sustained interest, enabled the data-generation process to be fun and engaging for participants, prevented bias arising from the overreliance of one method, and served to triangulate and cross-check data (Punch 2002).

This process evaluation aimed to examine intervention reach (the proportion of participants who received the intervention), fidelity (whether the intervention was

delivered as intended) and acceptability. It will be used to elucidate what specific components of *C-SLAMM* intervention are deemed a success by pupils and teachers' to inform any further development and future implementation of this intervention. It is important to understand how the *C-SLAMM* intervention was implemented in practice for it to be further developed for future implementation. In accordance with the MRC guidelines (Moore *et al.* 2015; Skivington *et al.* 2021), a mixed method process evaluation was undertaken and the perspectives of multiple stakeholders (i.e., pupils and teachers) were sought. This allows a robust evaluation of how the intervention was implemented and an accurate interpretation of either positive and/or negative outcomes (Taylor *et al.* 2018). Therefore, this process evaluation, embedded within the pilot cluster-randomised controlled trial (cRCT) aimed to: (1) explore the experiences and perceptions of children and teachers' who participated in the *C-SLAMM* intervention; (2) evaluation of intervention fidelity; and (3) generate recommendations to inform a future fully powered cRCT.

7.2. Methods

All participating schools were informed of the process evaluation requirements of the study prior to consent. Pupils' and teachers' who had consented and were allocated to take part in the *C-SLAMM* intervention were eligible to participate in the process evaluation. Briefly, the *C-SLAMM* intervention was an 8-week school- and home-intervention which aimed to reduce SB and increase PA in primary-school children. Pupils were randomised by school to participate in the intervention or to act as controls. Four intervention schools were allocated to the *C-SLAMM* intervention (see previous **Chapter 6; Figure 6.5**). In the previous chapter, the *C-SLAMM* intervention recruitment strategy, intervention development and a description of the intervention components were described (**Chapter 6**).

Acceptability of the intervention components and outcome measures were determined through interviews with teachers from intervention schools and focus groups with children. All write and draw, focus group discussions and interviews were conducted by a researcher (SN) after the intervention had finished (week 9). All data were anonymised, and any comments or observations relating to specific individuals or schools in a way that could allow them to be recognised was removed. Participants were told that they could withdraw from the study anytime. Verbal consent was

obtained from all participants before discussions began. This study was approved by the Ulster University Research Ethics Committee (REC/21/0027).

7.2.1. Write and Draw Activity

The write and draw activity was completed by participating children prior to the focus groups and were conducted after break-time in participating schools, to ensure each group that is conducted is consistent and each follows a standardised protocol. A sub-sample of children from each intervention school were included in the process evaluation. In each intervention school ($n = 4$), two groups of children, with 6 children in each group, took part ($n = 48$ in total). No inclusion/exclusion criteria were set for children to be included, other than having consented to participate and that both girls and boys were selected, with the aim of an equal gender split. Participants were chosen at random using a random number generator by the lead researcher (SN). Once groups were arranged, the process evaluation activity (write and draw activity and focus group) was conducted in a quiet area within the school where the researcher (SN) and participants could be overlooked but not overheard.

For the purpose of this study, children were asked to express their perceptions and experiences of the *C-SLAMM* intervention components visually, and independently (i.e., not completed in conjunction with peers). The write and draw activity began with the researcher (SN) presenting visual illustrations of each intervention component, to remind children of the key components of the *C-SLAMM* intervention. Visual illustrations included: activity cards (used in a health lesson), a newsletter, a timer, a sit-to-stand desk, classroom box of PA equipment and active homework (**Appendix 8A**). After children were shown the intervention components, they were invited to write down their favourite intervention component. The write and draw activity comprised of a one-sided sheet of paper that contained two interrelated sections, e.g., to describe what their favourite component of the intervention was in writing and to draw a picture of themselves completing the activity (see **Appendix 8A** for a copy of the write and draw activity). The researcher (SN) facilitated the activity and separately engaged with the children in informal conversations to answer any questions. The researcher did not provide any feedback during this activity. Children were given a maximum of 10 minutes to complete both sections, and once each child had completed

the write and draw activity, the researcher progressed onto the more open-ended questions directed at the whole group (focus group component).

7.2.2. Focus Groups

Information regarding the focus group discussion and the role of participants were provided before the focus group began, and all participants were reminded that they did not have to participate in the discussion if they did not want to. Verbal consent was obtained from all participants before the focus group discussion began. Semi-structured guides were developed and used to ensure consistency across the groups. Questions were devised to target the overarching aim of the study which was to elicit children's perceptions of the *C-SLAMM* intervention components (**Appendix 8A**). Focus groups were conducted within the school setting, in an area that was familiar to the participants, to minimise any feelings of discomfort the participants. In addition, the researcher led short ice breakers before the focus group discussions to make participants feel more at ease.

7.2.3. Teacher Interview

Face-to-face interviews (one per teacher) were undertaken with the participating teachers. Semi-structured interview guides were developed and designed to identify barriers and facilitators to the implementation of the intervention, as well as strengths and weaknesses of the programme. Example interview questions included in **Appendix 8B**. The interviews took place in a quiet, private area of the school at a convenient time for the teachers and lasted 17-33 (mean = 25.4) minutes.

7.2.4. Teacher Logbook and Fidelity checks

Throughout the duration of the intervention (8 weeks), teachers responsible for intervention delivery were asked to complete a logbook, to report on the delivery of the *C-SLAMM* intervention components. One logbook was administered to each intervention school and teachers were asked to record in their logbook as and when they could. During weekly fidelity checks, the researcher (SN) visited the teacher or had a brief phone call (depending on teacher preference and availability). During the visit and/or phone call, the researcher completed the fidelity checklist and discussed: (1) what components of the intervention had been completed during the school week, (2) any difficulties the teacher was experiencing, and (3) if the logbook was completed.

The logbooks collected information on the process evaluation dimensions of adherence, exposure and, to some degree, intervention differentiation (e.g., variation in allocated active homework activities in certain schools).

7.2.5. Data Analysis

Semi-structured interviews and focus groups were audio-recorded, transcribed verbatim and anonymised before being coded. The study generated four separate data sources including child frequency counts of most enjoyable intervention components, child drawings, child verbatim data and teacher verbatim data. The separate data sources were pooled together for complimentary purposes in order to expand, enhance and clarify findings from each of the separate data sources. Content analysis was used to analyse the write and draw activity. Text responses for the write tasks were extracted verbatim, while drawings were used to identify additional themes (e.g., sit-to-stand desks, enjoyment). Children's responses to the questions were categorised as a “*mark*”. A “*mark*” within a child's drawing referred to an item which could be identifiable as a theme. It was possible for one mark to identify more than one theme.

The focus group discussions and interviews were audio recorded and transcribed verbatim. The focus group data consisted of 97 pages and the teacher interview data consisted of 45 transcript pages raw transcription data, Times New Roman font, size 12, double spaced. All transcripts were imported into NVivo12 Pro Software (QSR International, Warrington, UK) qualitative analysis software and analysed thematically, using an inductive approach which involved six key phases Braun and Clarke (2019); (1) familiarisation with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Transcripts were systematically coded, responses were transcribed anonymously, and key themes were developed. Quotations from the transcripts were extracted to further contextualize key findings from the discussions. A second researcher acted as a “*critical friend*” by independently reviewing a subsample of transcripts and offering alternative interpretations of the data, encouraging reflection, and challenging the initial thematic structure. Researchers critically discussed all steps and outcomes in each phase of the data analysis process until they reached consensus. In case of disagreements and uncertainties, another member was consulted. Disagreements were resolved through discussion until

consensus was reached. Furthermore, Merriam & Tisdell (2016) strategies to promote validity and reliability were used to enhance trustworthiness. The teacher log diary was also coded in the same way in which transcription data was analysed.

Finally, the data sources (focus group transcripts, interview transcripts, child drawings and log diary data) were pooled to produce the themes which are presented in the results section. This methodology was adopted for complimentary purposes, meaning that each separate data source could expand, enhance, and clarify the others (Noonan *et al.* 2016; Taylor *et al.* 2019). Methodological and researcher triangulation combined with the use of verbatim transcription of data ensures methodological rigour, credibility, and transferability (Carter *et al.* 2014; Mackintosh *et al.* 2011). Where verbatim direct quotes are presented, the school ID and data source of participants are also provided for clarification purposes.

7.3. Results

Eight focus groups, comprising of 48 primary-school aged children (25 boys, 23 girls), completed the write and draw activity and focus group discussions. All children recruited (n=48) completed the process evaluation. There were no blank spaces for any participant in the write and draw activity, and every participant completed the two sections. In total, 203 marks on specific themes were noted across the two sections, with all responses legible. Five teachers (4 female, n=4 schools) were recruited onto the study. In three participating intervention schools, one classroom teacher was responsible for intervention delivery (Figure 7.1). In one participating intervention school (School A), two teachers shared intervention delivery for the duration of the intervention. In each school, on at least one occasion a substitute teacher was allocated to cover the teacher due to illness or due to the classroom teacher having other teaching or extra-curricular commitments e.g., coaching the school football team or supervising a field trip.

Teachers (n = 4, 3 females) representing three (out of the four) intervention schools, completed data collection. However, in the remaining participating school (**School F**), where one teacher was responsible for intervention delivery, from week 5-8 of the intervention, the teacher was unable to participate due to illness and had to drop-out of the process evaluation. The school subsequently reported that the sit-to-stand desks

were turned off for a period of 3-weeks (from week 5 to week 8) due to staff inconsistencies and absence, and other additional school-level constraints impacting implementation. The school principal mentioned teacher staffing and teacher turnaround as an issue for intervention implementation. In the same school (**School F**), the principal disclosed that inspections within the school led to de-prioritisation of *C-SLAMM* intervention in the class over two days. Communication was limited between both the teacher in this school and the researcher during the last three weeks of the intervention and as a result teacher interview was not completed and the teacher logbook was not returned. However, child data was collected and suggested that the intervention was partially implemented (from weeks 1 to 5), for example children were able to talk about their experiences with several of the intervention components e.g., active homework assignments.

Teacher logbooks were returned from School A, School C and School H ($n = 3$). However, no teacher logbook was returned from School F and the fidelity checklist was incomplete (30% completed due to teacher illness and absence). The fidelity checklists (refer to **Appendix 8C**) demonstrated that all the (1) breaks from sitting, (2) active lessons, (3) active homework, (4) health lesson and (5) newsletters for home were completed in School A, School C and School F. Logbooks highlighted that there was a variation regarding teacher ‘buy-in’ e.g., one teacher developed *C-SLAMM* intervention booklets and wall art with the children (refer to Figure 7.2.) and spent more time delivering the intervention than others. Teachers have considerable autonomy in the classroom, and it was impossible to fully quantify or assess teacher input to the delivery this intervention due to the varying nature of the logbooks.

Five themes emerged from all data sources (combined all four sources e.g., write and draw, focus groups, teacher interviews and logbooks): (1) engagement, (2) positive aspects of *C-SLAMM* intervention, (3) barriers teachers faced to *C-SLAMM* intervention delivery, (4) teachers’ perceptions about own capabilities, and (5) recommendations for improvement. These five themes were broken down further into specific sub-themes. Themes are presented in Table 7.1.

7.3.1. Child engagement

Across all sources, the sub-theme of fun and enjoyment emerged under the theme of child engagement. In each of the participating schools, children's most common response to their favourite thing about *C-SLAMM* intervention was the additional movement it provided. Data from the write and draw activity and focus groups indicated that *C-SLAMM* intervention provided children with the opportunity to be more active (n=40) in the classroom via active breaks and/or classroom-based activities (n=21) and the sit-to-stand desks (n=35). Children mentioned how "*fun*" the active classroom PA box component (n=17) was, one child noted: "*...it gave us more toys for outside and encouraged us to do more*". The class-set of pedometers were enjoyed, as children liked how: "*it counted your steps*" (n = 14). Some children referred to the active homework component as their favourite activity (n = 5), one child wrote: "*I liked the active homework because I didn't have to sit down at the table and do my homework I could stand up and move about the house*" (School C, focus group data). Additionally, children referred to *C-SLAMM* intervention as fun (n=24) and that it had some health benefits (n=7), one child wrote: "*my favourite of it was the activity because you're moving more and getting your heart going... and being moving more. I really like it thank you for coming to our primary school*" (School F, write and draw activity) and another wrote "*getting more fit and healthy*" (School H, focus group data).

Children enjoyed the social aspect of the intervention, how it provided an opportunity to stand and play with their friends (n=11). Several wrote that their favourite thing about *C-SLAMM* intervention was "*everything*" (n=7). Drawings generated in the write and draw activity are presented in Figure 7.3. Collectively, children and teachers viewed the additional opportunities to incorporate movement as the most enjoyment element of *C-SLAMM* intervention.

"Getting them [the children] so active, being more conscious of being active in like three/four areas a day, the practical kind of hands-on approach to everything, just getting them out of their seats... They love that. They did just really thrive from that". (School A, interview data)

“The children really bought into the concept about where the whole program was going, they really bought into it. So in terms of engaging and understanding they were very receptive”. (School C, interview data)

Children and teachers felt the *C-SLAMM* intervention offered a “*fun*” and innovative learning experience. One focus group of children (school H) all agreed that the *C-SLAMM* intervention should be made available across the whole school as “*it would be more like fair instead of like one class in one school they get it and like they would have to do all these fun stuffs and the other classes wouldn't*”. Teacher logbooks identified that the children “*loved taking part*” in the health lessons and enjoyed the educational component.

“...active element was our favourite... something that the children enjoyed, the children excelled in that and looked forward to the most, this whole concept of being more active”. (School H, log diary data)

“....was really fun cause there were like different things we could do... like the little throwing the hook on and beanbags and dices”. (School A, focus group data,)

Teachers’ enjoyed delivering the *C-SLAMM* intervention as children were engaged with the various intervention components (see Figure 6.4). Teachers stated that children were more engaged when additional movement was introduced and when children were out of their seats. Teachers commented on the children’s enjoyment and how they looked forward to the health lessons, breaks from sitting and active homework.

“it breaks the monotony...there's something to, to look forward to. There was always that bit of excitement, oh, what lesson are we gonna do this time? Is, is there something that we like, is there something that we know, is something different?” (School H, interview data)

All teachers interviewed (n=3) highlighted that the children enjoyed the intervention:

“The children I think really bought into the concept about where the whole program was going. They really bought into it. So, in terms of, uh, engaging and understanding, they, they were very receptive” (School C, interview data).

7.3.2. Positive aspects of *C-SLAMM* intervention

Six sub-themes relating to positive aspects of *C-SLAMM* intervention were identified by children and teachers: (1) increased range of opportunities, (2) educational, (3) increased competence/body image, (4) increased choice and flexibility, (5) lasting impact, (6) and selection of activities, challenges, and competition. Evidence from child and teacher data relating to these themes are presented in Table 7.2. Children and teachers were generally positive about *C-SLAMM* intervention.

The *C-SLAMM* intervention offered more choice and flexibility in the classroom for children (e.g., they had more opportunities to stand). Children mentioned that the selection of activities, challenges and competition appealed to them (Table 7.2.). Specifically, the health lessons had a lasting impact as it was “*something different*” and offered an opportunity to take part in alternative lesson (see Figure 7.3). Children naturally stood during practical work and sat down when they were doing “*neat handwriting*”. Additionally, children and teachers commented on how some children naturally like to stand and that the increased choice and varying methods of delivering breaks from sitting and health lessons worked well for them. Teachers described the positive impact *C-SLAMM* intervention had on their classroom teaching experience. Teachers liked the degree of flexibility and adaptability of the health lessons, environmental changes and breaks from sitting components.

Children and teachers welcomed all the *C-SLAMM* intervention components. Teachers confirmed that children in their class welcomed the breaks from sitting and sit-to-stand desks. After the initial introductory period (specified by teachers as week 1), children were more focused and demonstrated better concentration levels. Teachers provided positive feedback on the sit-to-stand desks, stating that they offered an increased opportunity for children to stand. Teachers (from School A and H) observed that the sit-to-stand desks helped children with attention deficit hyperactivity disorder (ADHD) and autistic children engage in the classroom. One teacher commented on the engagement of the class and how children with anxiety warmed to the study: “*I’ve*

noticed the children love doing them {sit-to-stand desks} and they're smiling and it's fun. The wee ones with anxiety are loving it... even one boy, he would have quite severe autism, he doesn't really leave his seat, but when we were doing some of the active breaks, I would say, 'move somewhere else in the room' he actually started to move from his chair but before this he would've never moved from his chair" (School A, interview data)

Children and teachers' liked the variety of components, the additional movement in the classroom and ideas. Teachers commented on how the components which are made up of activities (e.g., health lessons, active homework, breaks from sitting) could be adapted and could be used *"more or less incorporated as it is"* and that *"workload was minimal"*. Positive behaviour was evident when regular breaks from sitting were incorporated across the school day *"for attention and listening I think there's definite benefits"*. The classroom box of PA equipment was used to facilitate a variety of classroom-based activities and play outside during lunchbreak/recess. Pedometers were consistently used across all schools to facilitate activity. One teacher explained that the children *"...asked for them every single day"*. Children enjoyed using the pedometers provided as it offered a means to track their PA. In addition, children enjoyed the challenges that used pedometers, such as checking/monitoring how many steps they could do during break.

"[outside at breaktime] more space to do activities... it's fresh air and you come... there's a big space to play and the small step monitors, we more want to run to run around to get more steps.... we move more, run around to get more steps" (School A, focus group data)

7.3.3. Barriers to C-SLAMM intervention delivery

Four sub-themes relating to barriers to C-SLAMM intervention delivery were identified by teachers: (1) parental support, (2) lack of space, and (3) allocation of sit-to-stand desks, and (4) lack of time. A summary of barriers faced by teachers in the delivery of the health lessons can be found in Table 7.3. The most commonly reported barrier to intervention delivery was classroom behaviour. Teachers commented that the initial introductory period (week 1) there was a *'real distraction element'* to the environmental changes, children were excited, and the new routine took a few days

for the classroom to adapt too. In particular, the partial allocation of sit-to-stand desks (as described in **Chapter 6**) were challenging as teachers described how difficult it was to ensure that each child has a similar exposure to the sit-to-stand desks. Grouping children in terms of ability, managing storage, and ensuring a correct seating plan were also cited as obstacles; because of behavioural reasons and friendship groups, some children couldn't be located together on the same desk.

“it was just explaining a new routine and you know what kids are like, they're just so excited and if something new in the classroom and everybody wants to turn, and everyone wants to try every setting. Um, but after a week, after a week, the novelty had worn off and they just really use them very maturely”
(School A, interview data)

However, some teachers stated that after a week the “*novelty had worn off*” and children “*matured in how they used them and became more self-aware*”. Classroom size and space varied across each of the schools. The classrooms were not uniform in their space and each teacher had to adapt and accommodate the desks and *C-SLAMM* intervention materials e.g., the box of PA equipment. Additionally, teachers recognised the requirement to be organised and to put time aside to go through the material and remember the content. Teachers stressed the importance of studying the teaching training manual. Teachers had to invest time into familiarising themselves with the manual and materials. However, teachers noted that it wasn't always necessary making a connection to the curriculum as some of the active lessons were stand alone and were chosen on the basis on what the teacher perceived to be the most beneficial and what the children would get the most enjoyment out of. Every teacher mentioned the challenge of facilitating active homework, due to the lack of home support and feedback from parents/guardians.

Correspondence from parents was lacking in each of the intervention schools regarding newsletters and active homework. Each intervention school shared the newsletter on their virtual learning platform for parents to see. There was very little feedback or engagement evident.

“the resources were brilliant and even the three/four parents that, um, who took it on board, loved the facts and the figures and the research on the sheets. Um, it's it was just getting, getting it off the run, you know, the homework isn't great in this setting. (School A, interview data)

All teachers interviewed highlighted that the COVID-19 pandemic had an impact on parental support.

“.... with the nature of kind of how home-school links are at the minute and how we're connecting with parents...it was hard to deliver and hard to see what was happening or if anything was happening...getting an understanding of what was happening at home was tricky.” (School H, log diary data)

Teachers want parents to reiterate the key learning outcomes children learn in school, however, there is a barrier of communication and ‘buy in’ from parents.

“we want the message to be replicated or repeated by the parents again, just to, to drive it home.” (School C, logbook data)

An additional key barrier reported by both children and teachers involved the use of the activPAL monitor. Children reported finding the monitor uncomfortable to wear: *“it kept rubbing... and then I got a rash when I took it off”* and *“I didn't really like it cause when like you're taking it off, it feels painful.”* Furthermore, children stated that the monitors left a mark, were not practical during sport and children stated that: *“My leg feels like each time I pull my trousers down, it feels like it's still on there”* (School H, focus group data).

“it's like a little bit annoying because when you wear it like itchy a lot and then it hurts when you try to itch it” (School A, focus group data)

Teachers emphasised that they did not receive a lot of feedback from parents regarding the device and that they had to send a number of texts to parents asking them to return the devices.

7.3.4. Teachers' perceptions about own capabilities

Three sub-themes relating to teachers' perceptions about own capabilities were identified by teachers: (1) delivery of resources, (2) trial and error, (3) confidence in using *C-SLAMM* intervention. Teachers were pleased with the variety of activities provided in the *C-SLAMM* intervention manual and reported how active breaks were easy to adapt as the ideas were “*simple*” and “*really helpful*”. Teachers and wider school staff are integral to creating positive physical environments, alongside delivering the intervention. Collectively teachers viewed the teacher training and *C-SLAMM* intervention manual positively. However, teachers noted that there was an element of trial and error attached to the delivery of the new *C-SLAMM* intervention material.

“it's about trying to develop the number of tasks, you know, all the different ideas, and perfecting them” (School A, interview data)

Teachers commented that the workload was “*minimal*”, “*resources were brilliant*” and the “*file is very well laid out...you can really sit down and take all the main things from it*”. Teachers stated that the resources were clear, easy to implement, and that teachers did not have to come from a sporting background to implement the resources. Teachers recognised the importance of the manual, using it to refresh their knowledge of activities and the key messages they needed to deliver: “*...teachers would welcome it....it [C-SLAMM intervention resources] really make your teaching much, much better*”. (Teacher 4, interview data)

“Very teacher friendly and child friendly. Brilliant. And I think it'd be very beneficial for the school.” (Teacher 2, log diary data)

7.3.5. Recommendations for improvement

Four sub-themes describing teachers' recommendations for improvement were recognised: (1) wider engagement, (2) collaborative knowledge sharing, (3) environmental changes, and (4) expand *C-SLAMM* intervention. Quotes from teacher recommendations for possible improvement(s) to the *C-SLAMM* intervention are listed in Table 7.4. Recommendations to enhance the adoption and implementation for other teachers considering adopting *C-SLAMM* intervention related to the following

areas: dissemination of resources online for parents; information session for parents/guardians; collaborative knowledge sharing and changes to the environment. All teachers that were interviewed wanted more materials and ideas to deliver active homework, breaks from sitting and health lessons. They suggested if additional health lessons to be incorporated across the school year as they stated that health lessons were easy to incorporate and engaging.

Of note were recommendations relating to parental and home involvement and collaborative knowledge sharing; with multiple schoolteachers highlighting their importance of moving more and sitting less at school. Specifically, the recommendation that teachers must be given the freedom to deliver the programme on their own terms and allow time and resources for them to take ownership of the programme. Crucially, all children and teachers were in support of rolling this intervention out to schools across Northern Ireland (NI). Focus group and interview data emphasised the need for a change to the allocation and distribution of the sit-to-stand desks. Teachers requested additional under-desk storage and for all children in the class to have individual sit-to-stand desks. Additional parental engagement and communication was suggested; teachers suggested that an information evening for parents or a streamed video to explain the study would help to obtain greater buy-in from parents as incomplete homework sheets were apparent. Wider engagement of parents was recommended: *“...other than the parents sending video clips or sending photographs of the active homework, I didn't really get a lot of feedback because I didn't probe for it. I should have asked. How did that go? Did they enjoy it? Did the kids enjoy it? Did you notice a difference?”*. (School C, interview data)

Recommendations to improve the teacher training and *C-SLAMM* intervention manual were also offered. In relation to the practical element of teacher training, teachers suggested that the training manual could be improved through the inclusion of an online database or portal incorporating videos from different schools demonstrating different active breaks, active lessons, and active homework's. Importantly, all teachers could see *C-SLAMM* intervention being rolled out within their school and across NI.

“Now that my class went through a pilot and my children were engaged and enthusiastic, as was myself. I would have no hesitation in saying to the other classes, right here's a bank of resources, great ideas, implement them.” (School H, interview data)

“.... teachers realising the importance of breaks is so important...we would encourage our children to drink enough water during the day, why not encourage activity, I am going to continue with the idea of wee breaks in between and work in those shorter bursts.” (School C, interview data)

7.4. Discussion

This process evaluation aimed to combine the qualitative data collected from children and teachers within participating *C-SLAMM* intervention schools to identify barriers and facilitators to the implementation of the intervention, as well as strengths and weaknesses of the *C-SLAMM* intervention. The main findings of the study demonstrated that children and teachers considered the *C-SLAMM* intervention to be a positive, fun, and feasible programme in school, adding variation, fun and enjoyment to the school and home-setting. Five themes emerged from the data. Child engagement with the intervention included two sub-themes included fun and enjoyment. Positive aspects of *C-SLAMM* intervention included increased range of opportunities, educational, increased competence/body image, increased choice and flexibility, lasting impact, and selection of activities, challenges, and competition. The main barriers teachers faced in relation to *C-SLAMM* intervention delivery were limited space in the classroom, lack of parental feedback and support, lack of time and the partial allocation of the sit-to-stand desks. Recommendations to enhance the adoption and implementation for other teachers considering adopting *C-SLAMM* intervention related to the following areas: dissemination of resources online for parents; information session for parents/guardians; collaborative knowledge sharing and changes to the environment.

Focus group data found that the intervention provided fun, non-traditional activities within the classroom and confirmed this as a strategy that enhanced engagement. This finding is in line with previous research, suggesting that PA can increase children's enjoyment and engagement at school (Naylor *et al.* 2006; Dyrstad *et al.* 2018). Both

children and teachers in the present study recognised the health benefits of PA for learning (e.g., increasing focus and attention) and had positive perceptions towards the *C-SLAMM* intervention. Teachers' perceptions of the intervention were attributed to several factors, including personal attitudes towards PA, concern for pupils' wellbeing, perceived need for more PA opportunities in school and beneficial for pupils' attention and behaviour. Similar to previous process evaluation research, teachers in our study had positive attitudes towards PA, attributed to the relationship between PA behaviours and academic achievement for their pupils (Howie *et al.* 2014; Brown *et al.* 2015; McMullen *et al.* 2016). Teachers mentioned pupil enjoyment as a factor for their continued integration of breaks from sitting in their classroom. Furthermore, the intervention improved teachers' confidence and willingness to integrate active pedagogies into current and future teaching practice with all the teachers interviewed indicating a willingness to implement strategies. Hence, given that student enjoyment has frequently been recognised as an important factor when considering teacher perceptions of additional movement in the classroom (McMullen *et al.* 2014, Stylianou *et al.* 2016), and acts as a key facilitator to implementation of PA interventions (Cline *et al.* 2021), this is something that should continue to be considered with respect to movement integration interventions.

In line with previous studies, physically active lessons were considered an appropriate method for creating variation in the classroom and were highly appreciated by both children and teachers (Martin & Murtagh, 2015; Stylianou *et al.* 2015). Most children who participated in the process evaluation stated that they could concentrate better standing up. Using task-related movements which can be translated into academic learnings is suggested to be an effective way of learning due to the mental connection of the PA with the cognitive task (Mavilidi *et al.* 2018). Previous school-based literature states that PA during the school day can help improve academic achievement (Raspberry *et al.* 2011), improve attention-to-task (Mahar 2011) and selective attention (Janssen *et al.* 2014; Altenburg *et al.* 2016) in primary- school children. In our study, teachers identified the inclusion of breaks from sitting into the subject curricula as a facilitator. Children provided positive feedback regarding the *C-SLAMM* intervention concerning their ability to focus and teachers noticed an improvement in the children's concentration after the breaks from sitting.

Overall, the present findings support the use of environmental changes within the classroom, that these can be implemented without detriment to the classroom environment or the child's ability to learn. In each of the participating schools, the classroom box of PA equipment was very popular and facilitated activity both in the classroom and outside during lunchbreak/recess. Data from children and teachers indicate that sit-to-stand desks are facilitative, as they allow children to be able to switch between sitting and standing throughout the day, this is consistent with a previous full allocation standing desk study (Sherry *et al.* 2020). The use of partial desk allocation system in the *C-SLAMM* intervention (with several sit-to-stand desks replacing some of the traditional desks and children using these on rotation) was not preferred over a full-class allocation of desks. The predominant challenge to the practicalities of the partial desk allocation system was that both children had to agree whether they wanted to sit or stand, and teachers also had to implement a rotational system to ensure all children had a similar exposure to the sit-to-stand desks. Researchers could focus on future interventions on individual standing desks (e.g., rather than two children sharing a desk) to avoid such issues in the future. Larger trials, implemented within similar high-priority settings, and using more in-depth qualitative and quantitative measures are essential to better establish whether sit-to-stand desks using a full desk allocation system are feasible, or effective in NI primary schools, particularly in classrooms that differ in size and shape (as seen in this study).

School leaders are considered important stakeholders in this school- and home-based intervention; thus, a supportive school environment is essential for intervention delivery (Cassar *et al.* 2019; Naylor *et al.* 2015). Findings indicate that in one school, the teacher did not complete the log diary and the interview due to illness. During focus group interviews, children indicated that they did not use some of the classroom PA equipment (e.g., bean bags, skipping ropes) and indicated that the sit-to-stand desks did not work for an extended time period during the intervention. The feedback from the children who participated in the evaluation, highlight difficulties in ensuring consistent exposure to the intervention across different school, as teachers had an element of choice in what they did. Results highlight that the delivery of the intervention varies amongst teachers which is reflected in their self-reported fidelity logbook. Furthermore, it was not possible to consider dose in this context since differences in how the intervention was delivered across different schools was left with

the teacher to determine and logbooks didn't fully measure these potential differences in dose/exposure to the intervention. Therefore, in future work researchers should standardise the dose of intervention delivery, recognise the importance of teachers and support them through the process of implementing new programmes in their daily practice.

At present, teacher training fails to provide newly qualified teachers with sufficient skill and knowledge to become effective school-based PA practitioners (Domville *et al.* 2018; Lander *et al.* 2019). In the present study, participating teachers suggested that the training manual could be improved through the inclusion of an online database or portal incorporating videos from different schools demonstrating different active breaks, active lessons, and active homework's. The provision of high-quality teacher training and resources for teachers is necessary for promoting fundamental change to children's PA and SB (Riley *et al.* 2016). Therefore, teacher training must evolve, it should enhance delivery skills whilst upskilling teachers to lead a system change in SB and PA. As such, the training provided to teaching staff may have only reached a minority of those who were involved. In addition, staff turnover or staff absence left supply (relief or substitute) teachers to facilitate running a programme they were unfamiliar with.

The most commonly reported issue with the data collection by teachers and children were challenges associated with the activPAL monitor. Children expressed concern over the attachment method used and stated that they removed the device for several reasons including: experienced skin irritation, device fell off, felt uncomfortable, itchy skin, and it was painful, all of which was consistent with previous research in children and adolescents (Decker *et al.* 2013; Shi *et al.* 2019; Clemes *et al.* 2020). In the present study, we adopted a 24-h wear protocol with the anticipation that the dressing would stay on the skin for several days, and the children would not have to frequently remove the device thus increasing the compliance and reducing participant burden. Nevertheless, it was not effective as several children reported that it was painful, caused skin irritation and it was difficult to reattach. According to the feedback from the focus groups, children found the medical dressing tape and the Hypafix adhesive dressing uncomfortable especially when playing sports and when removing the device. Shi *et al.* (2019) also reported a high percentage of skin irritation when using the

monitor, which subsequently resulted in taking off the activPAL. Further research is warranted on the attachment options for the activPAL in children to improve compliance over a 7-day wear time period (**Chapters 6**).

Similar to previous studies (Watson *et al.* 2017), this process evaluation demonstrates that the context, specifically the school setting, the facilities and skill of school staff as well as school size and ethos, played an integral role in the effectiveness of the intervention. All teachers' interviewed stated that they will implement the programme after the intervention. Teachers' noted that the information packs sent out to parents were insufficient and further information was warranted (e.g., an information event, online communications). Overall, teachers would have liked to receive some evaluation from parents/guardians regarding active homework and the newsletters. Pre-planning, preparation time and a period to allow teachers to familiarise themselves with the materials ahead of starting the intervention is critical. Previous school-based PA found that a '*whole school approach*' is feasible to promote PA in primary-schools (Naylor *et al.* 2006). In line with these findings, teachers felt like a wider cultural awareness of the intervention was required across the school- and home-setting, in order to aid intervention sustainability.

7.4.1 Strengths and limitations of the study

This study has a number of strengths, including a mixed methods approach to process evaluation involving participants (children) and intervention delivery agents (teachers) providing comprehensive information regarding the implementation of a school and home-based PA intervention. The main strength of this study is multiple sources from which the data were collected, which provides valuable insight into the feasibility and acceptability of the *C-SLAMM* intervention both from the perspective of the children and of the teachers. Perspectives from children via write and draw activity/focus groups, teachers via interviews and diary logs, helped to provide a comprehensive picture of the intervention and how it was received and implemented. The diversity in data including the perspectives of children from four schools across NI, allowed the triangulation of sources which enhances credibility. Methodological strengths include the exploration of consensus and associated discussion through focus groups. The use of focus group discussion can be seen as a strength of this study, as by using this method it was possible to gather extensive information in a relatively short period of time. A pragmatic sub-sample of participants from schools across NI were recruited.

While this study confirms important insights into perceived likes and dislikes of the *C-SLAMM* intervention among both primary-school children (aged 7-9 years) and their teachers, parental feedback is lacking. Thus, conclusions on the effectiveness of this intervention in the home and home setting may be limited. Moreover, the lack of delivery logs and teacher interview from one school meant that we were unable to assess how many components were delivered and conducted in this particular intervention school. Additionally, it is possible that children and teachers may not have been completely honest when discussing certain aspects of the intervention e.g., compliance when wearing the activPAL monitor (versus actual wear time findings presented in chapter 6), due to social desirability bias as they wanted to present themselves in a positive light to the researcher (Bergen *et al.* 2020). Evaluation in this study would have benefitted from daily or weekly implementation logs for teachers. Barriers to this data collection need to be overcome in future research.

7.5. Conclusions

This process evaluation provides important insights to guide future approaches and implementations of the *C-SLAMM* intervention. Children and teachers' considered the *C-SLAMM* intervention an acceptable programme and emphasised that the delivery within the school- and home setting was feasible. The *C-SLAMM* intervention components were welcomed and were an acceptable method to encourage primary-school children (aged 7-9 years) to sit less and move more. Future multi-component school- and home-based interventions involving opportunities to stand and participate in PA outside of timetabled physical education (PE), should incorporate a classroom box of PA equipment. Incorporating strategies such as breaks from sitting, health lessons and environmental changes to promote PA and reduce SB, may be effective in promoting PA during school time. Variations in dose and fidelity reflect the challenges associated with intervention delivery within school settings and thus a flexible design may be necessary. Barriers identified by children and teachers, in relation to time, parental support and lack of classroom space should be addressed. Positive experiences and recommendations identified in this study by teachers implementing this intervention under real-world settings within the NI educational system, outline important insights for other schools and may inform the future adoption and implementation of this, and other, school- and home-based SB and PA interventions.

Furthermore, this process evaluation suggests that the *C-SLAMM* intervention offers a promising tool for engaging children in physical activities. These findings also suggest the need to consider alternative evaluation designs to account for contextual differences and varied deliveries of an intervention across multiple schools. It is essential that the *C-SLAMM* intervention considers the context of each participating schools as failure to do so would affect generalisability and scalability of the programme.

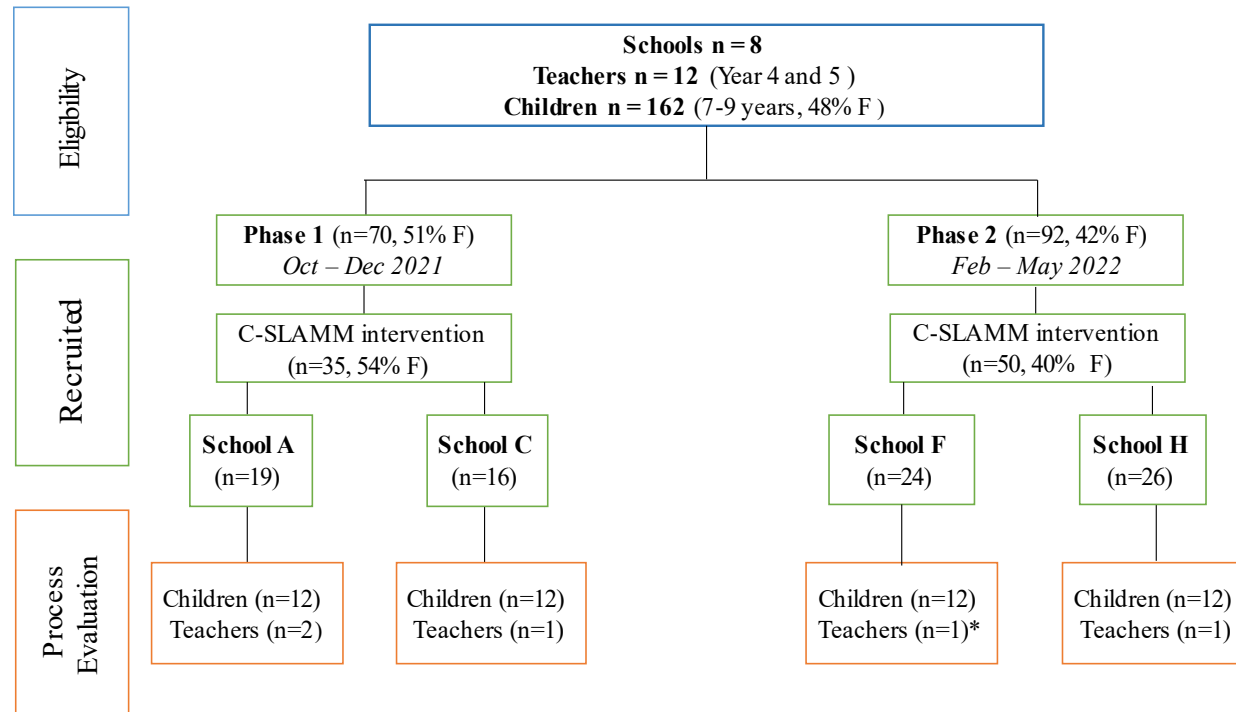


Figure 7.1. Flow diagram of participants allocated to the process evaluation for the *C-SLAMM* intervention.

*Teacher dropped out during week 5 of the intervention. F = Female



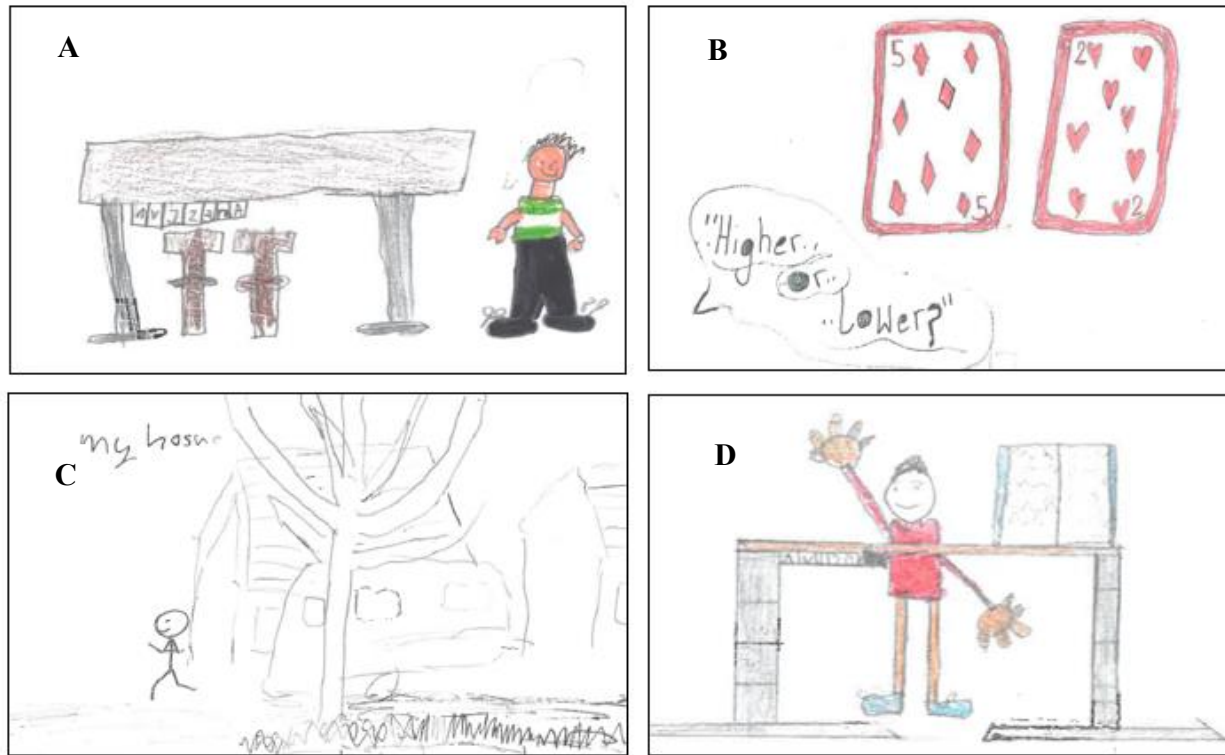
Figure 7.2. C-SLAMM intervention booklets and a classroom display adapted from the intervention in the classroom.

Table 7.1. Overall themes emerging from all the data sources.

Themes	Sub-theme
Engagement	Fun Enjoyment
Positive aspects of C-SLAMM intervention	Increased range of opportunities Educational Increased competence/body image Choice and flexibility Lasting impact Selection of activities, challenges, and competition
Barriers to C-SLAMM intervention delivery	Parental support Lack of classroom space Allocation of sit-to-stand desks Lack of time
Teachers' perceptions about own capabilities	Delivery of resources Trial and error Confidence in using C-SLAMM intervention
Recommendations for improvement	Wider engagement Collaborative knowledge sharing Environmental changes Expand C-SLAMM intervention

C-SLAMM = Children- Sit Less, Move More; COVID-19 = Coronavirus disease 2019

Figure 7.3. Various drawings from the write and draw activity. A sub-sample of children illustrating their favourite thing about the C-SLAMM intervention.



(A) Drawing from a boy (School C) illustrating a sit-to-stand desk. (B) Drawing from a girl (School C) illustrating a classroom-based activity. (C) Drawing from a girl (School A) illustrating the active homework component, where she engages in physical activity at home. (D) Drawing from a boy (School H) illustrating a sit-to-stand desk.

Table 7.2. Data from children and teachers regarding positive aspects of the C-SLAMM intervention.

Positive aspects	Quotes
Increased range of opportunities	<i>...definitely do more activities than what we normally do... doing more exciting things than just like boring work. (School F, focus group data)</i>
	<i>...main strengths would be the variety of breaks that you have introduced there...the active lesson you've covered so much that can be integrated in with English or history or maths it's really very, very good teaching the way you've outlined this. (School H, interview data)</i>
Educational	<i>I liked when we learned more about standing up than sitting down. Cause when you sit down, you don't get that much exercise than when you stand up... (School A, focus group data)</i>
	<i>I just love the layout of the lesson and it really did explain to the children about being active and about being sedentary... I just enjoyed delivering those lessons. I know there was only five but enjoyed delivering those. (School C, interview data)</i>
Increased competence/body image	<i>Made me concentrate and feel better... (School C, write and draw data)</i>
	<i>Those small bursts of learning, you had the children that they weren't exhausted...it wasn't a long monotonous lesson. It was a lesson that was deliberately structured in terms of it breaks so they were more receptive...there's less time looking out the window. (School A, interview data)</i>
Increased choice/flexibility	<i>Throwing and stuff and catch it's fun...I liked everything I want to do it again.... my legs sometimes just wanted to be jumpy, so I like the standing up mode cause I really like standing... it makes me move more. (School H, focus group data)</i>
	<i>...even during play, it was interesting that children wanted to use them standing up during more creative activities, children found that they wanted to stand... it was really a really helpful resource. (School A, interview data)</i>
Lasting impact	<i>... I want to keep it forever...I loved it... like it energizes my body, and it makes me feel happy. (School A, focus group data)</i>
	<i>I do think C-SLAMM in a couple years' time I'll still know what the letters mean (School C, interview data)</i>
Selection of activities, challenges, and competition	<i>liked lots of different games... we got to stand a lot more. (School F, focus group data)</i>
	<i>They loved taking part in all of the different things and different resources...they didn't wanna miss out on their break or their pedometer challenge or anything like that...the kids really got involved. (School H, interview data)</i>



Figure 7.4. Pupils taking part in a health lesson, delivered by the classroom teacher (School A)

Table 7.3. Barriers teachers faced in delivering the *C-SLAMM* intervention.

Barriers to delivery	Quotes
Parental support	<i>you're always reliant on that one or two good parents, my father always told me that one good parent is worth three teachers...I always knew that the parents have to be onboard as well to push that too. That's a big thing that I'm going to take away from this, to really prep my parents on what I'm doing. (School C, interview data)</i> <i>With parent support and with two lockdowns, we're finding it overall very hard to get homework back...if it goes home and we want, we want the message to be replicated or repeated by the parents again, just to, to drive it home...we don't really speak to the parents. You know, they come to the gate and then there away. (School A, interview data)</i>
Lack of space	<i>unless there was a trolley or something with trays or some shelving in place, I felt I was lost for that individual space that the children normally have with storage underneath their desks (School H, interview data)</i> <i>I think it's tricky when there's two kids sitting at a table... there's not a lot of space...they're maybe not wanting to do the same thing (School A, diary log data)</i>
Allocation of sit-to-stand desk	<i>they're a brilliant resource but because we were trying to make it fair and trying to make sure every child got to use it... we didn't get enough time to figure out a system... because of the nature of our class and nature of the abilities, it would've been ideal for children to be able to choose, to go to a sit-to-stand desk...because some kids do just work best standing. It was hard to get a system put in place, that's only having half a class, half class full of desks and half not. (School C, interview data)</i> <i>it was great whenever we collectively stood at the desks, but whenever it was down to the children's choice, both parties had to agree. We're standing, we're sitting (School C, interview data)</i>
Lack of time	<i>a little bit of time to get to know the material, to absorb the material to know, ah, there's an active lesson I think I can link into this (School H, interview data)</i>

Table 7.4. Teacher recommendations for improvement of the *Children - Sit Less, Move More* (C-SLAMM) intervention

Recommendations for improvement	Quotes
Wider engagement	<i>so parents with a little bit of background they too, could have been given the message that I was trying to give in class, you know, so maybe I would say that anything that went home in relation to maybe those newsletters or maybe the part of the health lessons, uh, maybe they could have went home and maybe they could have went a little bit better in terms of more knowledge from the parent so they two could emphasize or they could go over the key points that I was trying to do. So maybe just a wee bit more communication would've made all of the tasks, easy to implement (School C, interview data)</i>
Collaborative knowledge sharing	<i>...so the parents could have been given the message that I was trying to give in class...more knowledge from the parent so they too could emphasize, or they could go over the key points that I was trying to do. So maybe just a bit more communication would've made all the tasks, easy to implement. (School H, interview data)</i> <i>... if teachers can actually see it in motion recordings - a video....So they can see an active break, see a class taking part in it. (School A, log diary data)</i>
Environmental changes	<i>I would've had my own ideas [to integrate the movement in the class], but it was nice to have that bank to go too and say, oh right someone has went to the effort, thought of an idea, I haven't thought of it, I can see how it can be used. (School C, interview data)</i> <i>one [sit-to-stand desk] for everybody would be beneficial, because that's the hardest bit we found is making sure that they all had a turn and, and using them in, in a way that was fair for them to use it as well (School A, interview data)</i>
Expand C-SLAMM intervention	<i>...a portal whereby you could upload or promote or show one class doing something and if you upload it to show what they're doing as part of C-SLAMM, one idea could be developed by another class... all the different ideas that you can get from different teachers like a forum to promote C-SLAMM... the more ideas from different schools you have will be better. So that sharing of knowledge and expertise from different teachers, is something that I would try to encourage. (School C, interview data)</i> <i>...if you can see the benefit of it, health and exercise and the brain working in shorter chunks and more productivity from the children in terms of what to do...if people buy into that concept, which I do think teachers will, I don't see why this couldn't be rolled out or why this couldn't why this couldn't take a greater role within Northern Ireland. (School A, interview data)</i>

Table 7.5. Estimation of cost per intervention school for the *Children- Sit Less, Move More (C-SLAMM)* intervention.

Intervention materials^a	Unit cost	Quantity	Total
Box of PA equipment	£200.00	1	£200
One sit-to-stand desk (including delivery to schools)	£341.00 + VAT	6	£2,046 + VAT
Printing cost	~£ 50.00	1	£50.00
Teacher training	0	1	£0.00
			~ £2,296 + VAT

^a all include *C-SLAMM* intervention material costs, except transportation costs (which varies between schools)

Chapter 8: General Discussion and Conclusions

The overarching aim of the research programme was to evaluate current influences and approaches to reduce sedentary behaviour (SB) and promote physical activity (PA) in children (aged 7-9 years) leading to the development and pilot testing of a multicomponent school- and home-based cluster-randomised controlled trial (cRCT) in primary school-aged children, using a mixed-methods approach. In fulfilment of this aim, this thesis used a mixed-methods approach to: (1) systematically review the literature to assess the effectiveness of school-based interventions at changing obesity-related behaviours in primary school children; (2) explore the current views, barriers, and facilitators to PA in children and (3) parents and teachers of children (aged 7-9 years); (4) explore children, their parents' and teachers' views on the previously trialled and tested '*Transform-Us!*' intervention (Salmon *et al.* 2011) and adapt it for use in Northern Ireland (NI) primary schools; (5) assess the effectiveness and evaluate the processes influencing the feasibility, acceptability, and efficacy of an 8-week school and home-based SB and PA programme namely the *Children – Sit Less, Move More* (C-SLAMM) intervention, on activity levels in primary-school children. This is the first known series of studies to systematically adapt the successful *Transform-Us!* intervention to target PA and SB in NI primary schoolchildren (aged 7-9 years). The findings contribute to the existing literature and knowledge of school-based interventions in primary-school children.

As the studies in **Chapter Three** to **Chapter Seven** had individual discussions, limitations and conclusion sections, this chapter will draw upon the key research findings and will discuss the implications of the overall body of research for those involved in the promotion of PA and will reflect on the strengths and limitations and provide suggestions for future research.

8.1. Summary of key findings

The programme of work included in the thesis adheres to the Medical Research Council (MRC) guidance for developing and evaluating complex interventions, which advocates the combined use of qualitative and quantitative methods when assessing feasibility (Skivington *et al.* 2021). In order to better understand the efficacy of school-based interventions to prevent obesity, a systematic review and meta-analysis examining the effectiveness of school-based randomised controlled trials (RCTs)/cRCTs at changing obesity-related behaviours (e.g., PA, SB and/or nutrition)

and/or body mass index (BMI) in primary school children (aged 5 to 12 years) was undertaken. After an extensive literature search, interventions included in the qualitative synthesis ($n = 48$) were predominantly multi-component interventions ($n = 35$, 71%), with almost half of all included studies ($n = 21$, 44%) targeting a change in PA, SB and nutrition behaviour (**Chapter 3**). A range of intervention strategies and components were qualitatively synthesised (e.g., variation to school environment adaptations, modified physical education (PE) and varied lesson plans that promote healthy eating, provide additional educational sessions and promote activity breaks in the classroom. Despite this, the review found no associations between intervention components and effectiveness in the multi-component interventions. Multi-component interventions that incorporate diet, PA and SB-change components were not as effective as the single-component interventions at changing obesity-related behaviours in primary-school children (**Chapter 3**). It was not possible to determine which were the most effective components within these interventions due to the varied methodological quality of the included studies (**Chapter 3**).

Although previous research has shown that schools are ideal settings for preventative nutrition education (Dudley *et al.* 2015) and can positively influence children's overall energy intake (Murimi *et al.* 2018), few studies provided sufficient detail on selected primary outcomes for meta-analysis synthesis (**Chapter 3**). The meta-analysis results highlighted how difficult it is to compare outcomes between school based RCTs/cRCTs due to the differing nature of the study design, target population and selected primary outcomes (**Chapter 3**). For example, the outcome measures used in the systematic review to estimate the effectiveness of obesity-related interventions at targeting PA varied greatly (e.g., accelerometers, pedometers, self-report questionnaire and parental surveys). Therefore, in line with previous research, our findings suggest that more robust outcome measures should be used to estimate changes to obesity-related behaviours, as researchers would be able to detect the extent to which any compensation takes place as a result of the intervention (Sylvia *et al.* 2014; Higgins *et al.* 2019).

Transform-Us! is one intervention which demonstrated favourable behavioural effects on PA and SB in Australian primary school children (aged 7 to 9 years) (Salmon *et al.* 2023). As previously described (see **Chapter Two; Section 2.9**), the *Transform-Us!*

school- and home-based intervention was developed by colleagues at Deakin University, Australia to determine the impact of strategies to promote children's PA, to reduce SB, or a combination of these strategies, on behavioural and health outcomes (Salmon *et al.* 2011). Due to the high levels of physical inactivity in NI primary-school children and the lack of a similar multi-component intervention in NI, researchers sought to adapt the existing '*Transform-Us!*' intervention for potential delivery across primary schools in NI in the future (**Chapters 6 and 7**). In line with the MRC framework (described in detail in **Chapter One; Section 1.2**), the first phase of complex intervention research involves the development and/or identification of an existing intervention (Skivington *et al.* 2021). A qualitative exploration was undertaken to gain a more detailed understanding of NI school childrens' (aged 7–9 years) perceptions of context specific PA, the barriers they face and the factors that support them to lead a physically active lifestyle (**Chapter 4**). A combination of qualitative techniques were employed (**Chapter 4**) including a write and draw methodology alongside focus groups, to understand the perceived barriers and facilitators of children's PA. This qualitative study was the first in NI to explore the identification of barriers and facilitators of children's PA during the COVID-19 pandemic.

Using a co-design process (Constantin *et al.* 2022), a formative exploration was conducted to actively engage parents' and teachers' of primary schoolchildren, to assist in the development of the *C-SLAMM* intervention by investigating their perceptions, views, and experiences regarding classroom, school- and home-based PA (**Chapter 5**). Co-design is an emerging methodology used in public health research, that aims to actively engage specific groups of individuals, such as parents and teachers (e.g., the end-users), to assist in the development of products or services through knowledge sharing (Batalden *et al.* 2016; Constantin *et al.* 2022). Research suggests that the most effective interventions involve a range of stakeholders in the development process and include parents and families in implementation (Goldthorpe *et al.* 2020). Through in-depth semi-structured interviews parents and teachers highlighted that a degree of flexibility was required to increase enjoyment, engagement and teacher buy-in. Parents and teachers noted that a '*one-size-fits-all approach*' was not applicable when designing a PA intervention, as some degree of flexibility may be required. Lack of space, uneven distribution of PA equipment and limited access to play and sporting

facilities at school were key barriers to PA participation observed by the schoolchildren, their parents and teachers (**Chapters 4 and 5**). During the interviews, the acceptability of *Transform-Us!* intervention components were examined and were considered appropriate by parents and teachers; however, lack of time, lack of teacher and parental support were highlighted as key barriers for intervention delivery (**Chapter 5**). The qualitative exploration revealed that children recognised the potential benefits of some of the proposed intervention components (e.g., additional movement in the classroom), but opinions differed amongst the participating children on the sit-to-stand desks (**Chapter 4**). Pen profiles in **Chapter 4**, identified the key themes from the transcripts/write and draw data and provided further context and insight to the discussions. Consequently, the contextual information gathered from **Chapters 4 and 5** provided valuable insights, specifically into children's, their parents' and teachers' perceptions of school- and home-based PA and into the connotations children ascribe to PA. The co-design methodology informed the subsequent intervention design of future PA promotion and SB reduction strategies targeting primary-school aged children. For research to be applicable within a real-world setting, having this insight is noteworthy as it helps to foresee and reduce issues that may compromise the implementation of an intervention as intended (Koorts *et al.* 2018).

All *C-SLAMM* intervention components were adapted from the *Transform-Us!* intervention by the research team with input from current primary school teachers, to ensure the intervention was potentially suitable in a NI classroom. Each of these studies (**Chapters 1 to 5**) iteratively contributed to the development of the *C-SLAMM* intervention, which was implemented and evaluated in **Chapters 6 and 7**. The *C-SLAMM* intervention was the first multicomponent school- and home-based intervention to be undertaken in primary school children (aged 7-9 years) in NI. No significant changes were observed between intervention and control groups for the primary outcome of total weekly sitting time (**Chapter 6**). One possible explanation for the lack of intervention effect, seems to be high levels of PA in the control group, which is not uncommon in PA school-based interventions (Reasland *et al.* 2016). Additionally, the poor compliance rates ($n = 76$) observed highlight that improvements to protocols for assessing proposed primary outcomes (activPAL determined sitting time) are warranted. The mixed methods research conducted in **Chapters 6 and 7**,

facilitated both the device-based measurement of PA in the school setting (quantitative measure) and obtained personal accounts from children regarding the meaning behind their PA behaviours (qualitative measure). The qualitative findings indicated that some children experienced some skin irritation from the medical dressing(s) and subsequently removed the activPAL monitor.

In line with the MRC recommendations for process evaluation of complex interventions (Skivington *et al.* 2021), a mixed-methods analysis was implemented to investigate the unanticipated barriers and facilitators to implementation of the *C-SLAMM* intervention (**Chapter 7**). Feasibility and acceptability of the intervention were determined through interviews with teachers and focus groups with children from intervention schools (**Chapter 7**). The process evaluation revealed that the intervention was acceptable to both children and teachers, as data from the write and draw, focus groups and interviews highlighted the positive aspects of the intervention (e.g., the long-lasting impact, increased range of PA opportunities and increased competence). Additionally, both children and teachers highlighted that the delivery within the school-and-home setting is feasible, it could be “*more or less incorporated as it is*” and offers a promising tool for engaging children in PA. Incorporating strategies such as breaks from sitting, health lessons, and environmental changes to promote PA and reduce SB, may be effective in promoting physical activities during school time. Children stated that the active homework provided were enjoyable and facilitated joint effort from parents and the child to complete the given exercises and tasks. However, due to inadequate intervention implementation (e.g. teachers limited children’s exposure to the PA equipment and sit-to-stand desks) (**Chapter 7**), clear conclusions could not be made in relation to the impact of the intervention on children’s sitting time and PA levels.

Barriers identified by teachers’ such as lack of time for staff training and staffing concerns due to illness (**Chapter 7**) were consistent with implementer-level barriers reported in other classroom behavioural interventions (Collier-Meek *et al.* 2019; Lawson *et al.* 2022). Similar to findings generated from the *Transform-Us!* process evaluation (Koorts *et al.* 2022), the *C-SLAMM* intervention was perceived as being appropriate according to teachers, due to low amounts of preparation required to implement, ease of delivery and integration into teachers’ current lesson plans.

Nonetheless, a key finding with the *C-SLAMM* intervention, was the substantial variability in implementation amongst participating teachers, which varied by intervention component. For example in each school, on at least one occasion a substitute teacher was allocated to cover the teacher due to illness or due to the classroom teacher having other teaching or extra-curricular commitments (e.g., coaching the school football team or supervising a field trip).

It is important policy makers continue to recognise the school setting as a vehicle for tackling childhood inactivity (Jago *et al.* 2020) as research suggests schools offer a unique setting to influence health behaviours (Kriemler *et al.* 2011). However, as seen throughout this thesis, putting ‘theory’ into ‘practice’ is challenging. Primary school children in the present thesis identified key school-based barriers to PA including: the unavailability of indoor and outdoor PA equipment, inaccessibility of facilities and the size of indoor and outdoor spaces available for play and movement (**Chapter 4**). Within the present thesis, teachers highlighted the important role schools could play in providing children with opportunities to engage in PA (**Chapters 5 and 7**). Both children (**Chapter 4**), their teachers and parents (**Chapter 5**), found that primary-schools across NI experience many challenges in translating evidence-based interventions into routine practice, for example: funding, school climate, resources, teacher self-belief, curriculum demands and implementation support (**Chapters 4, 5 and 7**). Interestingly, parents were perceived by teachers as both significant barriers and enablers to children's PA participation (**Chapter 4**), indicating that parents have a great influence over their children's involvement in PA with the ability to both facilitate and impede participation (Noonan *et al.* 2016). By testing school-based interventions in ‘real-world’ conditions (e.g., interventions delivered by school staff during their standard practice) a better understanding of the complex systems in which contextual factors is achieved (Jago *et al.* 2023).

Qualitative responses generated from the formative work (**Chapters 4 and 5**) and the process evaluation (**Chapter 7**) highlighted that the key elements that impede intervention delivery include parental restrictions, lack of time and space in the different environments. However, despite the current barriers to PA in NI schools and the insignificant intervention effect on sitting time (quantified from the activPAL device in **Chapter 6**), the process evaluation highlighted that the *C-SLAMM*

intervention was suitable for the school setting, and participating teachers and children were pleased with the strategies involved (**Chapter 7**). Both children and their teachers reported that the *C-SLAMM* intervention to be a positive, fun, and feasible programme in school, adding variation, fun and enjoyment to the school and home-setting (**Chapter 7**). A key and novel aspect of the *C-SLAMM* intervention was the flexibility which schools were provided with in terms of the intervention components they opted to deliver and the timing of delivery. For example, intervention components could be embedded into the timetable when it suited the teachers and implementation differed by schools (e.g., box of equipment was used freely for one school at lunchtime versus used sparingly in another school, sit-to-stand desk implementation varied) (**Chapter 7**). Thus, the findings indicate (**Chapter 7**) that the proposed *C-SLAMM* intervention is acceptable and feasible to implement into primary school settings subject to specific changes (e.g., alternative evaluation designs to account for contextual differences and varied deliveries of an intervention across multiple school).

School leaders are considered important stakeholders in the *C-SLAMM* school- and home-based intervention; thus, a supportive school environment is essential for intervention delivery (Cassar *et al.* 2019; Naylor *et al.* 2015). The formative work (**Chapters 4 and 5**) and the process evaluation of the *C-SLAMM* intervention (**Chapter 7**) highlight the important role peers and family play in children's PA participation. Therefore, the provision of high-quality teacher training and resources for teachers is necessary for promoting fundamental change to children's PA and SB (Riley *et al.* 2016). Although, teachers thought the in-person teacher training and online resources were clear, easy to implement and designed appropriately, the intervention was not implemented across all participating schools (**Chapters 6 and 7**). Findings demonstrated that the *C-SLAMM* teacher training may be improved through the development of an online database, it should enhance delivery skills whilst upskilling teachers to lead a system change in SB and PA (**Chapter 7**).

Along with the strengths and limitations highlighted within each chapter, the overall strengths and limitations of this thesis should be noted. This thesis is unique in using a broad range of qualitative and quantitative methods, including a mixed methods approach providing comprehensive information regarding the implementation of a school and home-based PA intervention. A major strength of this thesis is the potential

scalable intervention design and the evaluation of multiple aspects of feasibility, including the recruitment, *C-SLAMM* intervention components and device-based outcome measures. The novel pen profile analyses and originality of the intervention add to the current literature, as the design includes the ability to investigate the phenomenon in natural settings (e.g., at school) and the use of semi-structured interviews, focus groups, write and draw techniques to obtain rich descriptions and deep insights. Limitations of the work are also acknowledged. Conclusions on the effectiveness of school-based interventions at targeting obesity-related behaviours should be interpreted with caution, as there was a high level of variability across the included interventions synthesised (**Chapter 3**). Additionally, researchers had to rely on limited descriptions of interventions to classify the studies, and subsequently the assessment of the intervention content was difficult due to inconsistent reporting. Further RCTs should provide a clear and comprehensive report of the components and outcomes used in the school-based intervention, to aid the comparability between studies and to ensure computation of effect sizes can occur in future meta-analyses.

As the causes of physical inactivity and sedentary lifestyles are influenced by multiple factors (Park *et al.* 2020), behavioural theories and models are used to guide the development of strategies that are most likely to result in changes in behaviour through targeting the key mechanisms or mediating constructs of change (Bauman *et al.* 2012). The thesis was underpinned by behaviour change theory throughout. The *C-SLAMM* intervention was theoretically underpinned by three conceptual theories specifically; a cognitive theory (Bandura 1986; Bronfenbrenner 1986; Rachlin 1989) behavioural choice theory (Rachlin 1989) and ecological systems theory (Bronfenbrenner 1986). Using theories and frameworks (e.g., MRC framework, the Consolidated Criteria for Reporting Qualitative Studies (COREQ) checklist, Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann *et al.* 2014), and the PRISMA guidelines) assisted the design of the interventions and structured the results in an impactful way. The reporting of the *C-SLAMM* intervention results (**Chapters 6 and 7**) followed the CONSORT framework for feasibility and pilot trials (Eldridge *et al.* 2016; Butcher *et al.* 2022) to ensure consistency and rigour. However, it is important to note, that the *C-SLAMM* intervention (**Chapter 6**) did not use a pre-existing adaptation framework to guide the adaption process e.g., the Cultural Adaption Framework (Barrera *et al.* 2016). A systematic review by Escoffery

et al. (2018) highlighted the lack of pre-existing research on adaptation models and frameworks. The review examined 42 evidence-based interventions and noted that only 35.7% of included interventions used an adaptation framework to inform their process. Thus, the current evidence suggests that many researchers may not be aware of the frameworks that exist due to limited studies and future research should examine the use and effectiveness of these frameworks in evidence-based intervention design (Escoffery *et al.* 2018).

Research suggests that it is necessary to follow a standardised phased approach to intervention development and understand the mechanisms behind intervention effectiveness (Skivington *et al.* 2021). A major strength of the thesis draws on guidance from the MRC framework and focused on the identification/development, feasibility, evaluation but not all implementation stages of the framework (Skivington *et al.* 2021). The methodological procedures used to adapt the *Transform-Us!* intervention involved a formative stepwise, iterative approach. A deficiency of many studies is that few authors report the step-by-step process of intervention development methods (Love *et al.* 2019), hampering transparent evidence synthesis. Thus, the systematic approach for formative adaptation and evaluation was a particular strength of this thesis. Consulting with children (**Chapter 4**), parents, and teachers (**Chapter 5**) before conceptualisation of the intervention ensured any issues of acceptability, feasibility were addressed prior. This formative, collaborative and multidisciplinary approach harnessed insight and experiences from multiple fields to optimise design and development to meet the needs of participants. The thesis includes methodological strengths using the exploration of consensus and associated discussion through focus groups, interviews and the novel write and draw technique. The use of (1) focus group and interview discussions and (2) write and draw activities can be seen as a strength of this thesis, as by using these methods it was possible to gather extensive information in a relatively short period of time (**Chapters 4, 5 and 7**). Additionally, this thesis has added to the current evidence base relating to PA in primary-school children (aged 7-9 years) by offering novel insight into their perceived likes and dislikes of PA (**Chapter 4**) and of the *C-SLAMM* intervention (**Chapter 7**). One possible limitation to the in-depth interview data was that the data was gathered remotely during the COVID-19 pandemic (**Chapter 5**). This could be seen as a limitation, as the main aim of this work was to adapt a multi-component school- and home-based intervention for

traditional, in-person instruction, to mitigate against this. Teachers were instructed during the interviews to report on their experiences during their most recent face-to-face instruction. As this study recruited teachers who were currently employed to teacher children (aged 7-9 years), they were able to draw upon prior experience (**Chapter 5**). Nonetheless, despite this it is possible that teachers may have varied in the accuracy of their recall.

The strengths of the *C-SLAMM* intervention included the pilot cRCT design which limited potential bias (e.g., randomisation of clusters rather than individuals may prevent contamination). Mixed methods research can facilitate both the device-based measurement of PA in the school setting (quantitative measure) and personal accounts from children regarding the meaning behind their PA behaviours (qualitative measure). It is important to note, due to the nature of the study it was not possible to blind the participants/outcome assessors (**Chapter 6**). The exploratory design of the pilot study restricted the types of analyses that were appropriate (e.g., principle of intention to treat is challenged due to the lack of any statistical method to handle non-recruited participants). Additionally, the feasibility of implementing interventions within the home environment was not fully explored due to the lack of parental engagement and parental feedback across all participating schools (**Chapter 7**). The thesis was successful in recruiting children from several geographical locations across NI during the COVID-19 pandemic, however the schools recruited were only recruited in NI and therefore, potentially limits the generalisability of results. Thus, the perceptions and opinions of the primary-school children may not reflect the views of those in other settings/areas/contexts in the UK (**Chapters 4 and 7**). Furthermore, it must be noted that the majority of participants were of white ethnicity and no participants had physical disabilities.

Previous interventions using the activPAL measurement tool, rarely provide sufficient information on activPAL data processing methods (Edwardson *et al.* 2017). On the contrary, this thesis presented a thorough and transparent methodology on the activPAL data reductive methods and processing used (**Chapter 6**). The direct assessment of sitting, standing and movement patterns using activPAL inclinometers is an element of robustness of this thesis due to the ability of inclinometers have the ability to discriminated between sitting, standing and stepping behaviours compared

to accelerometers (Edwardson *et al.* 2017). Although the activPAL device is a valid, reliable accurate measure of SB (van der Berg *et al.* 2016), it is not a comprehensive data processing or analytical tool (Xu *et al.* 2022). At present, there is no gold standard processing and analysis procedure, and the data reduction methods are subjected to researcher bias when excluding periods of non-wear or isolating periods of interest (Xu *et al.* 2022). ActivPAL software exports daily time spent in stepping cadences ≥ 100 steps per minute (spm), which is a well-established experiential threshold of moderate-to-vigorous PA (MVPA) for public health communication (Tudor-Locke *et al.* 2018). Nevertheless, the step rate threshold for MVPA differs based on inter-individual factors (e.g., BMI). Thus, stating that 100 spm is MVPA for all individuals likely misclassifies true time spent in physical activity intensities. This type of validation is beyond the scope of this thesis, but future research should address this concern as well as continue to identify additional variables that are important to health outcomes.

Furthermore, there were poorer-than-expected wear time rates to the *C-SLAMM* intervention, and consequently, the data relating to the effect of the *C-SLAMM* intervention on health outcomes may not reflect the likely effect of the intervention (**Chapter 6**). It is possible that children and teachers may not have been completely honest when discussing certain aspects of the intervention during the process evaluation (**Chapter 7**) e.g., compliance when wearing the activPAL monitor (versus actual wear time findings presented in **Chapter 6**), due to social desirability bias as they wanted to present themselves in a positive light to the researcher (Bergen *et al.* 2020).

Process evaluations are essential to understanding whether the intervention activities were delivered as intended and the contextual factors that influence how an intervention works. The process evaluation of the *C-SLAMM* intervention (**Chapter 7**) included perspectives from children via write and draw activity/focus groups, teachers via interviews and diary logs, which helped to provide a comprehensive picture of the intervention and how it was received and implemented. The triangulation of data sources allowed for the comparison of data, which provided the study with a high degree of credibility and methodological rigour (Noonan *et al.* 2016). However, while this thesis confirms important insights into children's perceptions of PA and

among both parents and their teachers, parental feedback is lacking. It was not possible to consider dose in the process evaluation, as the principles of the *C-SLAMM* intervention was based on teacher autonomy and logbooks did not fully measure these potential differences in dose/exposure to the intervention. Additional stakeholders (e.g., teaching assistance, school principals) were not included. A future limitation of this thesis is the lack of long-term follow-up and assessment in the *C-SLAMM* intervention (**Chapter 6**), as outcomes were only measured at baseline and at follow-up (8 weeks).

8.2. Recommendations for future research

The findings and results from this thesis suggest several potential research areas for future exploration.

- This thesis demonstrates feasibility and acceptability of the pilot C-SLAMM intervention, however the effectiveness on PA in children was inconclusive. Thus, further refinements around intervention delivery may be required prior to progressing to a definitive, fully powered cRCT. Upon completing the refinements, a full-scale trial with randomisation at school level, implemented at different regions in NI and within areas of varied socioeconomic status and diverse ethnicities is recommended. To determine short- and long-term changes in children's levels of PA and SB under '*real world*' conditions, an embedded effectiveness trial should be carefully planned and undertaken.
- As further development of the intervention depends on available budgeting, considerations for sustainability must also be considered. Future studies should consider assessing a range of health behaviours using validated device-based measures and use standardised reporting of key outcomes (e.g., sedentary and PA changes). More robust outcome measures should be used to estimate changes to obesity-related behaviours, as researchers would be able to detect the extent to which any compensation takes place as a result of the intervention.
- Future work should consider if another setting to gather qualitative data is more appropriate to capture children's experiences of non-school related PA, however researchers should consider the recruitment difficulties in a community setting.

- Future research should ensure that there is an emphasis on fun, social support, and sufficient space to allow for the adaptation and maintenance of PA among primary-school children.
- Findings from the C-SLAMM intervention highlight that improvements to compliance for assessing proposed primary outcome (activPAL determined sitting time) are warranted. Explore various attachment methods and protocols for the activPAL monitor in order to improve compliance and wear-time in future studies.
- For sustained improvements, future research should focus on the exploration of stakeholder (e.g., teachers and parents) beliefs and attitudes surrounding primary school children (aged 7-9 years) involvement in PA to better inform the implementation and delivery of PA. interventions. Future work should recognise the importance of teachers and support them through the process of implementing new programmes in their daily practice.
- Future research should consider implementation models to better plan and understand PA interventions as evidence suggests that these models are mostly used for the interpretation of the results after the interventions have been completed (Cassar *et al.* 2019).
- Long-term interventions delivered in the school- and home-setting, targeting movement behaviours are lacking. More research is required in the field on the impact of these interventions over a long time period (e.g., more than one academic school year) on obesity-related behaviour change.
- In 2021, the *Transform-Us!* website was developed which includes a substantial range of resources. In terms of resources available on the website; there are over 300 active academic lessons, over 100 active breaks, over 200 active-homework tasks and over 20 health-based lessons offered. Future work in NI should formulate an online ‘bank’ of C-SLAMM intervention resources, that would allow teachers in NI to develop the skills and knowledge to embed active teaching in the classroom. Researchers should improve the C-SLAMM intervention training manual through the development of an online database or portal (e.g., incorporating videos from different schools demonstrating different active breaks, active lessons, and active homework).

- To better understand how interventions run in a real-world setting, a mixed methods process evaluation is warranted that includes age-appropriate surveys and questionnaires to better understand what primary-school children find acceptable and appropriate. In addition, the process evaluation should include daily or weekly implementation logs for teachers to measure implementation of intervention development.
- For sustained improvements, future research should focus on the exploration of parental support and involvement. Future research should plan and explore ways to improve dissemination of resources online for parents; information session for parents/guardians; collaborative knowledge sharing and changes to the environment.

8.3. Practical implications

This thesis has led to several findings of practical relevance for those involved in the promotion of PA in primary-school children specifically, researchers, policymakers and practitioners to schools. These practical implications and potential actions have been summarised below:

Researchers

- Ensure when designing, conducting, and implementing research that the intervention is described in full and follows the CONSORT reporting guidelines (Eldridge *et al.* 2010) to allow for the identification of effective components, allow for direct comparison of findings and replication of studies. Authors should provide adequate detail about their treatment strategies, theoretical basis and components and intensity of the interventions, as well as any implementation and assessment of programme fidelity, as this may be a promising approach for future intervention attempts. Future studies should clearly and systematically label intervention strategies and outcomes (Hailemariam *et al.* 2019) and follow recommended reporting mechanisms to ensure comparability between future intervention design, strategies and outcomes.
- Conduct further acceptability and feasibility research to determine the most appropriate method to implement additional components such as sleep and/or nutrition into the *C-SLAMM* intervention.

- School settings should focus on providing non-team-based PA options that focus on fun and enjoyment over competition. Examples include skipping and dancing. Activity promotion strategies that are based around co-participation with peers and family members within schools could be an effective means of engaging in PA.
- Wide-scale adoption of evidence-based PA interventions is lacking (Reis *et al.* 2016). Thus, the implementation and scalability of the *C-SLAMM* intervention to promote PA and reduce SB among primary school children in NI should be carefully planned. The intervention should preserve its effectiveness when implemented across schools in NI. An evaluation of the *Transform-Us!* intervention comprised of an implementation trial to determine the assessment of the uptake and implementation of the interventions in participating schools (Cassar *et al.* 2019; Salmon *et al.* 2023). Consequently, the *Transform-Us!* scale-up will help guide future implementation of interventions aimed at school settings.
- If the *C-SLAMM* intervention is found to be effective in a definitive cRCT, it is important to identify a logistically and financially sustainable dissemination that is appropriate to policymakers.
- Discussions with local and national educational authorities and additional stakeholders should be included in future research design as it is possible that their opinion will inform the incorporation of school-based interventions. Consider the recruitment process and devise a strategy to ensure that there is diversity among stakeholders.
- Due to concerns regarding COVID-19 infection control, remote data collection took place (**Chapter 5**). Remote data collection is likely to have contributed to the successful recruitment of participants by greatly reducing the participant/guardian/school burden of traveling, as well as the added value of saving money and time. Remote data collection could be considered in future work.
- Efforts to further investigate the use of raw accelerometry metrics (e.g., mean amplitude deviation), alternative cadence or counts models, or other artificial intelligence-based approaches are required to improve the measurement of PA intensity. Cut points for activPAL should be addressed in future work.

Schools

- Involve children, parents, and teachers in the planning of a PA programme within the school. Stakeholder and pupil engagement in future research is warranted to understand the factors influencing children's PA and SB and to help inform future intervention design.
- Incorporate an element of fun and play within school-based PA approaches. Provide more PA opportunities that enable children to play outdoors and that allow children to socialise with their peers.
- Ensure PA programmes and strategies can be incorporated into the school day, without putting too much burden on teachers.
- Take into consideration staff turnover or staff absence when planning a PA intervention. Put contingency measures in place for substitute teachers, to ensure they can adopt and deliver an ongoing PA programme.
- Classroom-based activities should be embedded as part of the whole of school approach to tackle the high levels of sitting time in NI primary-schools (observed in **Chapter 6**).
- Consider that both peers and family are the main influences on children's PA. They can facilitate or impede on PA participation. Design PA components to incorporate peers and/or family members to enhance children's PA.
- Future multi-component school-and home-based interventions involving opportunities to stand and participate in PA outside of timetabled PE, should incorporate environmental changes. The refinements identified can be made within the original intervention structure, ahead of proceeding to a definitive trial.

Policy

- The *C-SLAMM* intervention is a promising intervention approach as when compared with other multicomponent interventions, this intervention is fun, easy to implement and relatively low-cost (observed in **Chapter 7**).

- Policymakers should continue to recognise the school environment as a key setting for targeting children's sitting and PA levels.
- When designing interventions and strategies to increase PA levels amongst children, it is pivotal that policymakers actively consult with their target populations to gain an understanding of how best to promote PA in this age group.
- Policymakers should regularly review the influences on PA in children and identify any barriers or facilitators to PA in the target population.
- The need for investment into early intervention to offset these trends of SB and PA. Government funding is required to promote and deliver PA initiatives and programmes in primary schools across NI.

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Appendices

Appendix 1: Example of database search strategy for systematic review

Search strategy for Medline
1. child/
2. minors/
3. (child* OR young person OR young people OR minORs OR minOR).mp.
4. 1 OR 2 OR 3
5. schools/
6. education/
7. students/
8. (school* OR educat* OR classroom OR student*).mp.
9. 5 OR 6 OR 7 OR 8
10. exercise/
11. sports/
12. (exercise* OR sport* OR physical activit*).mp.
13. 10 OR 11 OR 12
14. diet/
15. feeding behavior/
16. eating/
17. energy intake/
18. nutritional status/
19. (diet* OR feeding behavio?r OR eat* OR energy intake* OR nutritional status).mp.
20. sedentary lifestyle/
21. sedentary.mp.
22. 20 OR 21
23. randomized controlled trials as Topic/
24. cross-over studies/
25. double-blind method/
26. (randomised OR randomized).mp.
27. 23 OR 24 OR 25 OR 26
28. 14 OR 15 OR 16 OR 17 OR 18 OR 19
29. 13 OR 22 OR 28
30. 4 AND 9 AND 27 AND 29

Appendix 2: Confirmation of ethical approval (Chapters 4, 5, 7 & 8)

UNIVERSITY OF ULSTER

RESEARCH GOVERNANCE

RG3 Filter Committee Report Form

Project Title	Perceived barriers and facilitators of physical activity within the classroom, school and/or home environment
Chief Investigator	Professor Marie Murphy (Sarah Nally PhD researcher)
Filter Committee	School of Sport REFC

This form should be completed by Filter Committees for all research project applications in categories A to D (*for categories A, B, and D the University's own application form – RG1a and RG1b – will have been submitted; for category C, the national, or ORECNI, application form will have been submitted).

Where substantial changes are required the Filter Committee should return an application to the Chief Investigator for clarification/amendment; the Filter Committee can reject an application if it is thought to be unethical, inappropriate, incomplete or not valid/viable.

Only when satisfied that its requirements have been met in full and any amendments are complete, the Filter Committee should make one of the following recommendations:

The research proposal is complete, of an appropriate standard and is in

- category A and the study may proceed* ☐
- category B and the study must be submitted to the University's Research Ethics Committee** Please indicate briefly the reason(s) for this categorisation ☒

Research involving U18's
- category C and the study must be submitted to ORECNI along with the necessary supporting materials from the Research Governance Section*** ☐
- category D and the study must be submitted to the University's Research Ethics Committee** ☐

Signed: <i>Cover M. Cleary</i>	Date: 13/03/20
Chair of Filter Committee	

*The application form and this assessment should now be returned to the Chief Investigator. The Filter Committee should retain a copy of the complete set of forms.

** The application form and this assessment should now be returned to the Chief Investigator so that he/she can submit the application to the UUREC via the Research Governance section. The Filter Committee should retain a copy of the complete set of forms for their own records.

*** The application form and this assessment should now be returned to the Chief Investigator so that he/she can prepare for application to a NRES/ORECNI committee. The Filter Committee should retain a copy of the complete set of forms for their own records.

For all categories, details of the application and review outcome should be minuted using the agreed format and forwarded to the Research Governance section

Our Ref: NC/gc

21 May 2020

Professor M Murphy
Ulster University Doctoral College
Room 14G15
Jordanstown Campus



Dear Professor Murphy

Research Ethics Committee Application Number: REC/20/0033

Study Title: Perceived barriers and facilitators of physical activity within the classroom, school and/or home environment?

Thank you for your recent response to matters raised by the committee. This has been considered and ethical approval has been granted for the study to proceed when COVID-19 restrictions are no longer in place and it is safe to do so.

Please also note the additional documentation relating to research governance and indemnity matters, including the requirements placed upon you as Chief Investigator.

The committee's decision is valid for a period of three years from today's date (this means that the study should be completed by that date). If you require this period to be extended, please contact the Research Governance section.

1. Please complete and return the Chief Investigator Statement of Compliance prior to commencing the study and keep a copy for your file.
2. Please retain all other documents.

Further details of the University's policy along with guidance notes, procedures, terms of reference and forms are available at the following web address:

<http://research.ulster.ac.uk/office/rofficeeg.html>

If you need any further information or clarification of any points, please do not hesitate to contact me.

Yours sincerely


pp
Nick Curry
Head of Research Governance
028 9036 6629
n.curry@ulster.ac.uk



Memo

To: Professor M Murphy

From: Elaine Bell, Research Governance, 26A20,
Jordanstown

Date: 19 May 2021

Ref: EM/JD

Ulster University
Research Ethics Committee

Project Number: REC/21/0027

Project Title: Children- Sit Less, Move More (C-SLAMM): a pilot study to increase physical activity and decrease sedentary behaviour in primary-school children

Outcome: Approved to proceed subject to amendment – to be reviewed by the Research Office and lead reviewer

Please find attached the comments of the Research Ethics Committee on your recent application.

You should address these comments point by point in a covering letter and highlight or underline any revisions made to the application and associated materials. Please send your response by e-mail to e.bell2@ulster.ac.uk. You should note that your application does not require to be resubmitted for reconsideration at a future meeting, but you should also note that you cannot commence any research on human subjects until your response has been considered and a letter of approval has been issued.

Please note that all Ulster staff and student members of the research team must provide evidence that they have successfully completed the University's online Research Integrity course. Final approval for the study will not be confirmed until this has been provided.

If you have any queries, please contact Nick Curry or Elaine Bell.

If you do not intend to proceed with the project or if you anticipate a significant delay in responding to the concerns of the committee, please contact the Research Governance section.

I look forward to hearing from you in the near future. Please quote the **Project Number** in all correspondence.

Thank you and best wishes.

A handwritten signature in blue ink that reads 'E Bell'.

Elaine Bell
Research Governance Officer
e.bell2@ulster.ac.uk
Ext: 66518



Ulster University
Shore Road
Newtownabbey
County Antrim
BT37 0QB
Northern Ireland
T: +44 (0)28 9036 6700
ulster.ac.uk

17 June 2021

Professor M Murphy
Doctoral College
Ulster University
Jordanstown Campus

Dear Professor Murphy

Research Ethics Committee Application Number: REC/21/0027

Study Title: Children- Sit Less, Move More (C-SLAMM): a pilot study to increase physical activity and decrease sedentary behaviour in primary-school children

Thank you for your recent response to matters raised by the committee. This has been considered and the decision of the committee is to grant ethical approval for this study.

Research is currently impacted by the COVID-19 pandemic and Ulster researchers must follow all Government regulations and guidance and, where appropriate:

- University guidance, recovery and risk assessment processes for research in the community and on campus, and/or
 - The NHS/HSC research restart framework specific to the trust(s) involved
- If the study includes NHS/HSC sites and research in the community and/or on campus all appropriate processes must be followed.

Please also note the additional documentation relating to research governance and indemnity matters, including the requirements placed upon you as Chief Investigator.

The committee's decision is valid for a period of three years from today's date (this means that the study should be completed by that date). If you require this period to be extended, please contact the Research Governance section.

1. **Please complete and return the Chief Investigator Statement of Compliance prior to commencing the study and keep a copy for your file.**
2. **Please retain all other documents.**

Further details of the University's policy along with guidance notes, procedures, terms of reference and forms are available on the Ulster University Portal.

If you need any further information or clarification of any points, please do not hesitate to contact me.

Yours sincerely

pp
Nick Curry
Head of Research Governance
028 9036 6629
n.curry@ulster.ac.uk

Appendix 3: Supplementary files for Chapter 4

Appendix 3A: The write and draw activity



Appendix 11. Write and draw activity (version 2, 22.04.2020)

Write and draw activity



What does physical activity mean to you?

	What I like about physical activity		What I dislike about physical activity

If you could change your classroom, what would you change?

Appendix 3A: The write and draw activity

Appendix 11. Write and draw activity (version 2, 22.04.2020)

Where are you most likely to take part in physical activity?



Over the past week what sort of physical activities did you do outside of school?



Appendix 3B: Semi-structured focus group discussion guide

Questions	Focus Group Question
Introductions and icebreaker	What is favourite physical activity and why?
Photo activity	What photo is the most active? What photo is the least active? What would you like to spend more time doing?
Knowledge	How much physical activity do you think you should be doing every day? Why are some activities more active than others?
School	What is your favourite thing to play or do in your classroom? How do you feel about using a sit-to-stand desk in your classroom? * On school days, what do you do at breaktime? How would you feel if your teacher sent home active homework for you to do with your parents/guardian?
Family	What stops you from doing physical activity at home? Do you take part in any physical activity after school?

*Including a photograph of a child working from a sit-to-stand desk.

Appendix 4: Published paper (Chapter 4)



“When You Move You Have Fun”: Perceived Barriers, and Facilitators of Physical Activity From a Child’s Perspective

Sarah Nally^{1*}, Nicola D. Ridgers², Alison M. Gallagher², Marie H. Murphy¹, Jo Salmon² and Angela Carlin¹

¹ Centre for Exercise Medicine, Physical Activity and Health, Sports and Exercise Sciences Research Institute, Ulster University, Newtownabbey, United Kingdom, ² School of Exercise and Nutrition Sciences, Institute for Physical Activity and Nutrition (IPAN), Deakin University, Geelong, VIC, Australia, ³ Nutrition Innovation Centre for Food and Health (NICHE), Biomedical Sciences Research Institute, University of Ulster, Coleraine, United Kingdom

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John G. Morris,
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United Kingdom

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Jana Vasičková,
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Sarah Taylor,
Liverpool John Moores University,
United Kingdom

*Correspondence:

Sarah Nally
Nally-s@ulster.ac.uk

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In Northern Ireland (NI), many children do not meet the recommended levels of physical activity (PA). To reduce the prevalence of physical inactivity and associated health conditions, it is important to understand the influences on children’s PA, which in turn has the potential to inform future intervention design. The purpose of this formative study was to examine the current views, barriers, facilitators, experiences, and perceptions of children in relation to PA in the classroom, school, and home environments, and to assess the acceptability of components for a school-based intervention. Write and draw tasks and semi-structured focus groups ($n = 10$) were conducted with 50 children aged 7–9 years (22 boys, 28 girls) from six primary schools. Focus groups were recorded, transcribed, and analyzed thematically. Pen profiles were constructed from the transcripts in a deductive manner and represent key emergent themes. Results indicated that children’s perception and knowledge of PA was mainly structured and sport-based, while some referred to fun, play and health. Fun, social support and outdoor activity were identified as key facilitators. Barriers included parental restrictions, lack of time and space in the different environments. The acceptability of intervention components was examined, children recognized the potential benefits of additional movement in the classroom, but opinions differed on the sit-to-stand desks. Findings contribute to a more detailed understanding of children’s perceptions of context specific PA, the barriers they face, in addition to factors that support them to lead a physically active lifestyle, which may inform future PA promotion strategies.

Keywords: children, health, qualitative—quantitative analysis, school, physical activity

INTRODUCTION

Developing effective health promotion strategies targeting primary school-aged children is necessary to reduce the future burden of preventable non-communicable diseases (Janssen and LeBlanc, 2010). Regular physical activity (PA) provides children with broad-ranging physical and psychological health benefits (Poitras et al., 2016), including improved cardiometabolic health,

academic performance (Rasberry et al., 2011), cognitive function, and prosocial behavior (Donnelly et al., 2016; Sampasa-Kanyinga et al., 2020). According to the World Health Organization (WHO), a major public health concern is the increasing number of children who fail to meet the current PA guidelines of an average of 60 min/day of moderate- to -vigorous-intensity aerobic PA across the week (Bull et al., 2020; Guthold et al., 2020). This issue is particularly prevalent among primary-school children in Northern Ireland (NI), who are least likely to meet the recommended levels of PA, when compared with other countries in the United Kingdom (UK) (Griffiths et al., 2013) and in Europe (Verloigne et al., 2016). The Children's Participation and Physical Activity Study found that only 20% of primary school children in NI meet PA guidelines (Woods et al., 2019). Research suggests that moderate-to-vigorous physical activity (MVPA) decline begins in early to mid-childhood (Farooq et al., 2020). There are also concerns about coexisting sedentary behavior (SB) in children, specifically screen-based activities like television viewing, which has unfavorable effects on various health indicators, independent of PA (Tremblay et al., 2011).

Schools have been identified as an important setting to promote PA (Neil-Sztramko et al., 2021) and reduce SB (Hegarty et al., 2016), with the WHO specifying that the principle of a whole-of-school approach should be applied (World Health Organization, 2018; Milton et al., 2021). Children spend a significant amount of their waking time at school (Nickel et al., 2021) and many schools have the facilities, equipment, and large amount of contact time to deliver PA interventions. Timing of PA program implementation is important (Milat et al., 2015), teaching staff must not feel over-burdened, and children should not lose out on class time (Day et al., 2019). Several systematic reviews examine efficacy trials provide evidence of a slight increase of time spent in PA for children exposed to school-based interventions (Kriemler et al., 2011; Dobbins et al., 2013; Nally et al., 2021). Neil-Sztramko and colleagues found school-based PA interventions do not result in meaningful changes in MVPA, however, these findings should be interrupted with caution as there was a high degree of heterogeneity across all studies (Neil-Sztramko et al., 2021). The out-of-school period offers additional opportunities for family-based PA. Parents can serve as role models through their parenting practices (Maric et al., 2020), sources of support, and gatekeepers through their control over children's opportunities for PA (Lindsay et al., 2006; Mitchell et al., 2012). Xu et al. (2015) found that there was a positive association between parental encouragement and support with children's PA. Additionally, parents also govern the home environment and can impact PA behavior through the provision of opportunities to be physically active (e.g., accessibility of play and sports equipment) (Maitland et al., 2013).

Despite large-scale quantitative research being able to assess the direction and strengths of the trends of children's participation in PA, they are unable to explain the reasons why children maintain or cease PA. Despite years of such intervention research, increases in PA remain both modest and short term (Mitchell et al., 2012; Craike et al., 2018). There is now widespread recognition that health behaviors are difficult to change (Sheeran et al., 2016). As such, PA interventions

have shifted focus to include the factors that influence these behaviors beyond individual choice alone. The socioecological model recognizes that efforts to change health behaviors are more likely to be successful when multiple levels of influence including individual, social, environmental and policy levels are addressed at the same time. To be successful, future intervention development needs to address these multiple influences on behavior, including the family and home setting (Sallis, 2001). The evidence base is not as extensive, as research to date designed to increase PA in children and inform intervention design has largely underrepresented children's perceptions (Noonan et al., 2016) and has been limited to singular qualitative methods that omit children's verbal ability and interaction preference (Morgan et al., 2002). There is a paucity of data analyzing PA barriers and facilitators in the school setting, particularly from the perspective of children aged 7–9 years. Previous literature in this age group examines children's perceptions of obesity prevention (Clarke et al., 2015; Hesketh et al., 2017), not PA.

Transform-Us! was designed in response to the aforementioned low levels of PA and high levels of SB. It is a multi-component school- and family-based intervention which was developed through a series of extensive iterative work in Australia (Salmon et al., 2011). *Transform-Us!* aims to increase children's PA and decrease SB across the school day incorporating a mixture of educational, pedagogical, behavioral, and environmental approaches to integrate movement into everyday class lessons and recess/lunchtime. Family-based components comprise of newsletters and homework assignments containing family-based activities for parents to complete with their children. The study is based on elements from the social cognitive theory (Bandura, 1986), theory of planned behavior (Rachlin, 1989) and behavioral choice theory (Bronfenbrenner, 1986). Although the *Transform-Us!* intervention has proved very promising as a multi-component program (Carson et al., 2013; Yildirim et al., 2014) and is in the final stages of longer-term evaluation in Australia (under review), we do not have similar multi-component programs which have been subjected to rigorous evaluation within NI. Several local contextual differences between the Australia and NI, in particular the educational system, social and environmental influences on PA and policy level differences mean that whole scale replication would be inappropriate. Formative research is important in the development and implementation of the intervention, as it identifies specific behaviors, the determinants of these behaviors and collects as much information as possible to assist in forming the intervention aims and objectives (Bleijenberg et al., 2018).

A more detailed understanding of NI children's perceptions of context specific PA, the participation barriers they face, in addition to factors that support them to lead a physically active lifestyle may inform future PA promotion strategies. This exploratory study used a formative assessment to inform the adaptation of a pre-existing PA and SB intervention *Transform-Us!* This study aimed to use a combination of qualitative techniques to explore children's current views, experiences and perceptions of classroom, school, and family-based PA. It was envisaged that the contextual information gathered from this study will provide valuable insights into

the connotations children ascribe toward PA and inform the subsequent intervention design of future PA promotion and SB reduction strategies targeting primary-school aged children.

MATERIALS AND METHODS

Reporting of this study was guided by the consolidated criteria for reporting qualitative research (COREQ, Tong et al., 2007) (Supplementary Table 1). Ethical approval was granted by the University Ethics Committee (REC/20/0033), and informed written consent and assent was obtained from parents and participants prior to participation. Data collection took place between November 2020 and April 2021, during the second wave of the COVID-19 pandemic. Schools in NI had been closed during the period of March to August 2020 due to a period of 'lockdown' through public health legislation.

Recruitment

Participants were recruited from a convenience sample of primary schools spanning a range of socio-economic areas and from both rural and urban areas of NI. Ten primary schools were invited to take part in the study via e-mail/telephone. Eight primary schools agreed to participate in the study. Following school principal consent, information packs containing child and parent information sheets and consent forms were sent to parents/guardians of pupils in Primary 4 (7–8 years old) and/or Primary 5 (8–9 years old). The pupils who returned written assent forms and consent forms from parents/guardians were eligible to participate. The participants did not receive an incentive or compensation for taking part in the study. Prior to the visit, all the pupils were informed about the purpose and procedure of the study. Participants were told that they could withdraw from the study anytime.

Data Collection

There were two complimentary qualitative methods used in the formative study: a write and draw activity and focus groups exploring children's perceptions of PA and experiences in greater depth. Previous studies have shown that a write and draw activity can provide children with greater control over their expression and the drawings themselves are visual drawings that directly represent children's perspectives and/or experiences (Knowles et al., 2013; Noonan et al., 2016). The drawing task is also appropriate for younger children as it can demonstrate thinking at their own levels of cognitive development (Knowles et al., 2013). Likewise, focus groups are an effective method to explore the ideas and perspectives of children (Gibson, 2007). Using a combination of qualitative research techniques, including sustained interest, enabled the data-generation process to be fun and engaging for participants, prevented bias arising from the overreliance of one method, and served to triangulate and cross-check data (Punch, 2002). Other than participant age, there were no specific inclusion criteria employed. Data collection was facilitated by the first author, in the school's assembly hall or in an outdoor classroom where participants and researcher alike could be overlooked but not overheard. By interviewing children in a group setting at school, we aimed to create a friendly and safe

space which would encourage children to share their ideas and thoughts (Adler et al., 2019).

Write and Draw Activity

The write and draw activity was completed prior to the focus groups and prior to break time (i.e., morning recess) to reduce the influence recent experiences may have on participants' thoughts and perceptions. The write and draw activity was double sided and contained five sections (Supplementary Material 2). For the purpose of this study, children were asked to express their perceptions of PA visually, and independently, (i.e., not completed in conjunction with peers) during class time in each school. To minimize distraction from the task, no written instructions were provided (Knowles et al., 2013). The first author (SN) facilitated the activity and separately engaged with the children in informal conversations to answer any questions. The first author refrained from providing any feedback.

Focus Groups

To further triangulate the data and ensure the credibility and dependability of the findings, participants were invited to express their perceptions of PA through discussions via focus groups. A semi-structured topic guide standardized discussions between subjects and allowed for participants to respond freely whilst also ensuring key topics were covered in detail to allow a degree of comparability across the transcripts (Punch and Graham, 2016). The topic guide was derived from reviewing the existing literature in relation to PA and were designed to be exploratory. The questions focused on the current views, barriers, facilitators, experiences, and perceptions of children in relation to PA in the classroom, school, and home environments, and aimed to evaluate and assess the acceptability of components used in *Transform-Us!* for a school-based intervention (topic guide available in Supplementary Material 3). The topic guide was pilot tested with a group of four primary-school children, from a school that was not included in this study, to ensure that questions were deemed appropriate for this age group. Probing questions were used throughout the focus group to facilitate discussion (Elo et al., 2014).

The first author (female Ph.D. candidate holding an MRes, trained in running focus groups) facilitated separate semi-structured focus groups that included 4–6 children (10 focus groups, $n = 50$). To reduce the potential power imbalance that may arise when an adult facilitates a children's focus group, it was made clear that the moderator was not a teacher, there were no right or wrong answers, and the children were free to express their own opinions (Heary and Hennessy, 2002; Morgan et al., 2002). First names were used to moderate the hierarchical adult-child relationship. Following an explanation of the procedure, verbal assent was obtained from all participants. At the beginning of the focus group, participants were informed that the definition of "physical activity" was any movement of the body that uses energy, and this included all forms of sport, physical education (PE), indoor and outdoor play, adventurous activities, active travel, and normal activities such as using the stairs, doing housework and gardening. The questions asked during the focus groups and the PA definition used were

purposely kept broad to capture what types of PA and settings were meaningful from the perspective of the participants. A short icebreaker was used at the beginning of the focus group to help children feel comfortable and relaxed. Photographs presenting a range of active and inactive activities were used to encourage discussion amongst children, having previously been shown to be an effective method (Hesketh et al., 2005). Examples of the activities included children skipping outside, watching television, and a child brushing the floor. Participants were asked several questions regarding the activities (**Supplementary Material 3**). Moreover, a photograph of a sit-to-stand desk was used to elicit conversation, ensuring the topic was covered in detail and allowed a degree of comparability across the transcripts (Ereaut, 2002). Open-ended questions starting with "what", "why" and "how" were posed to participants to stimulate conversation. To maintain the interest and enthusiasm of participants and accommodate short attention spans (Colucci, 2007), each focus group discussion lasted between 16 and 30 (mean 20.11) min. With the participants' permission, the interviews were audio recorded using a Homder digital voice recorder.

Data Management and Analysis

A form of content analysis was used to analyze the write and draw activity. Text responses for the write tasks were extracted verbatim, while drawings were used to identify additional key themes (e.g., playing sport, social interaction, fun). The following procedure and terminology were used to analyze the questions. Drawings had to be legible. Children's responses to the questions were categorized as a "mark". A "mark" within a child's drawing referred to an item which could be identifiable as theme. It was possible for one mark to identify more than one theme. For example, the identification of how many "times" a theme was identified (e.g., a child drawing a football game and writing "playing football") would be counted as two times. Ten write and draw sheets were independently reviewed by a second author (N. R.) and a discussion was had about the findings until a consensus of the themes were reached. Subsequently, the data were then analyzed using pen profiles analysis.

The focus group discussions were audio recorded and transcribed verbatim. The analysis consisted of all together 102 pages of double-spaced transcription. All data were managed in NVivo12 (Version 12.6.0; QSR International Pty Ltd., Victoria, Australia) and analyzed independently by SN. To ensure children were unhindered by researchers' previous views about PA in children, in our study we chose a deductive followed by an inductive approach. Braun and Clarke's phases of thematic analysis were used to inform the coding process once SN had become familiar with the transcripts (Braun and Clarke, 2019). Transcripts were systematically coded, responses were transcribed anonymously, and key themes were developed. The socio-ecological model was used as an initial framework to initially examine the data. The inductive approach allowed different themes within the broader socioecological model constructs to emerge. Quotes that were considered to represent a similar meaning or pattern were clustered together into potential themes and subthemes. During this process, themes were identified and were broadly reflective of the socio-ecological model (Elder et al., 2007) which has been used

in previous research to demonstrate the influence various factors have on children's participation in PA, i.e., intrapersonal, interpersonal, and organizational factors (Hesketh et al., 2017; Martínez-Andrés et al., 2020). Quotations from the transcripts were extracted to further contextualize key findings from the discussions. The second author acted as a "critical friend" by independently reviewing a subsample of transcripts and offering alternative interpretations of the data, encouraging reflection, and challenging the initial thematic structure. The research group critically discussed all steps and outcomes in each phase of the data analysis process until they reached consensus. In case of disagreements and uncertainties, another member was consulted. Furthermore, Merriam and Tisdell (2016) strategies to promote validity and reliability were used to enhance trustworthiness.

The pen profile approach has been utilized in studies examining youth PA (Mackintosh et al., 2011; Ridgers et al., 2012; Noonan et al., 2016; Taylor et al., 2018). Pen profiles are a visual approach for presenting key themes identified during data analysis through combining verbatim quotes taken directly from the transcripts and write and draw to provide further context and insight to the discussions. The authors critically questioned the analysis and interrogated the data, tracking the process in reverse from the pen profiles to the write and data sheets and/or the transcripts, until a consensus had been reached. Thus, methodological rigor, credibility and transferability was reached via verbatim transcription of data and triangular consensus procedure. In some cases, visual illustrations were added to add further context to the data. Triangulation of the analysis occurred through presentation of the pen profiles together with associated verbatim/illustrative material by the research team.

RESULTS

Data are presented in five pen profiles, and focus on children's perspectives on PA, PA knowledge, PA barriers and facilitators and intervention approaches.

Write and Draw

Fifty primary-school aged children (22 boys, 28 girls) completed the write and draw activity. Blank spaces and answers were due to children not having sufficient time to complete the activity or not providing an answer. A total of 49 participants completed the "what does physical activity mean to you?" section, with all the responses legible. PA was mostly associated with sport-based activity e.g., football ($n = 10$), dancing ($n = 7$) and structured activity e.g., PE ($n = 8$), with participants also defining PA as "sport" ($n = 17$). Furthermore, participants refer to fun ($n = 6$), health ($n = 6$) and play-based activities ($n = 3$). Several reported "movement" as their definition of PA. For example, one child wrote that: "any movement that keeps your health up" (ID37) and another child wrote: "it means to me it is sports and help your body. Any sort of movement" (ID39). Drawings linked to the write and draw activity are presented in **Figure 1**.

Forty-nine participants completed the "what I like about physical activity" section, and 215 marks on specific themes with two unidentifiable responses were noted within the data analysis. Forty-seven participants completed the "what I dislike about physical activity" section, and 108 marks on specific

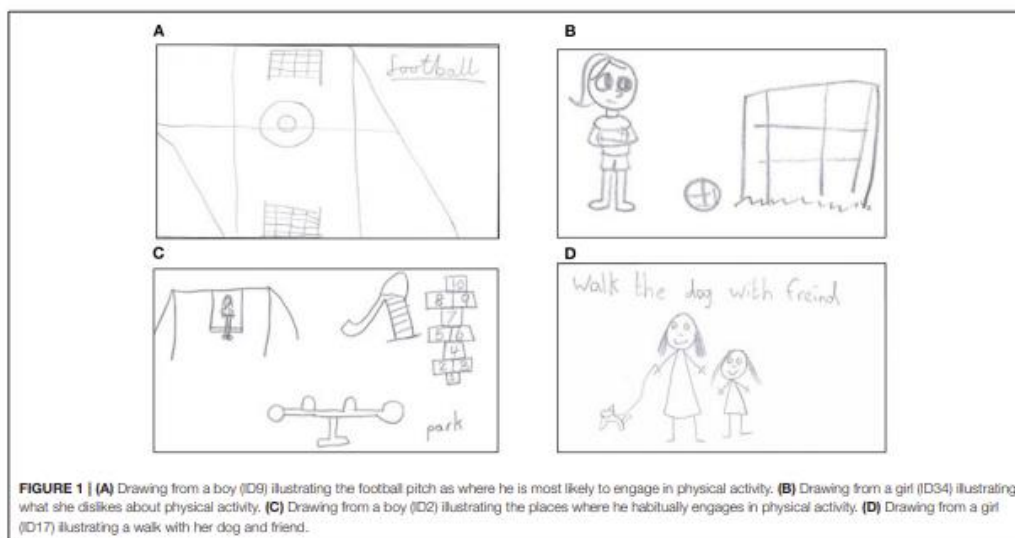


FIGURE 1 | (A) Drawing from a boy (ID9) illustrating the football pitch as where he is most likely to engage in physical activity. (B) Drawing from a girl (ID34) illustrating what she dislikes about physical activity. (C) Drawing from a boy (ID2) illustrating the places where he habitually engages in physical activity. (D) Drawing from a girl (ID17) illustrating a walk with her dog and friend.

TABLE 1 | Write and draw task completion by section.

Section	Writing in the box		Drawing in the box	
	Provided	Legible	Provided	Legible
PA likes	84%	92%	31%	100%
PA dislikes	87%	100%	54%	89%
Place most likely to take part in PA	94%	100%	40%	96%
Types of PA participated outside of school	96%	100%	29%	100%

PA, Physical activity.

themes were noted within the data analysis and there were no unidentifiable responses. **Table 1** illustrates completion by write or draw section. **Figure 2** demonstrates the combined pen profiles of children's likes and dislikes regarding PA. A range of physical activities participated in by the children were described, with the most common being organized sports ($n = 20$) (i.e., football, hockey) cycling, swimming, tennis, and walking. Though the activities undertaken varied across the cohort, a consistent reason for PA participation was for fun ($n = 9$) and for peer interaction ($n = 19$). Many pupils suggested that there was nothing that they disliked ($n = 15$) about PA. Physical exertion ($n = 11$) and going on walks ($n = 10$) were also commonly reported as dislikes.

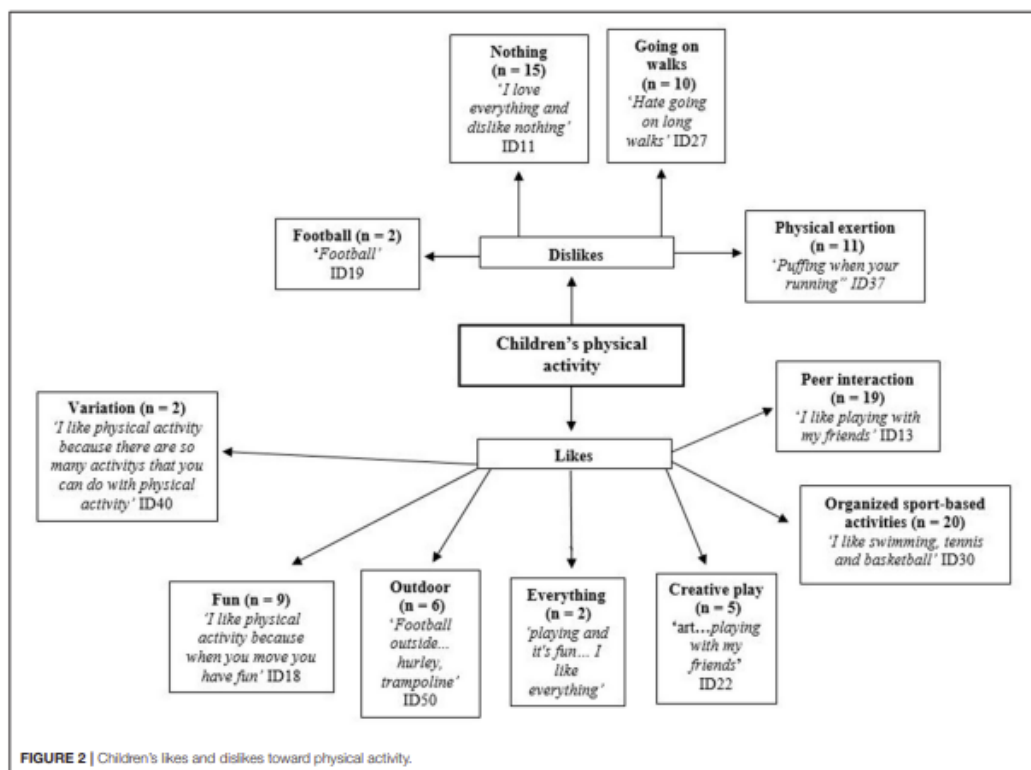
Figure 3 illustrates the composite pen profile which denotes the key themes from the following two questions from the write and draw activity: "if you could change your classroom, what would you change?" and "where are you most likely to take part in physical activity?". Blank returns were due to insufficient time to

complete the task. Fifty participants completed the "if you could change your classroom, what would you change?" section. All the written responses were identifiable and there were 125 marks on specific themes within the data analysis. Physical changes to the classroom were the most requested classroom changes by the children. The "Where are you most likely to take part in physical activity?" section was completed by all the participants ($n = 50$). A total of 138 marks on specific themes within the data analysis were found and data revealed that outdoor ($n = 30$) and sports facilities ($n = 19$) were the commonly reported themes. Forty-eight participants completed the "Over the past week what sort of physical activities did you do outside of school?" section. A total of 172 marks on specific themes within the data analysis were noted, structured sport-based activities ($n = 28$), outdoor play ($n = 26$) and social interaction ($n = 19$) were identified as the highest frequency themes.

Facilitators of Physical Activity

Overall, children reported a diverse range of PA facilitators within the school and family environments (**Figure 4**). One of the primary motivations reported by children was the sense of fun experienced through the social aspect of PA. Children in all focus groups highlighted the importance of social support from their friends, but family members were also noted. Being able to go outside, and enjoyment of PA were also commonly reported facilitators.

Some children expressed a strong desire to exercise, with PA allowing them an outlet from daily routines and the ability to share enjoyment with friends. The competitive and vigorous nature of organized physical activities appeared particularly appealing and enjoyable for many children as they perceived them to be more engaging and beneficial to physical health.



Peers also played an important role in influencing participants to be active, with some having a positive experience with their classmates (Figure 4). At school, children noted unstructured and structured PA opportunities as facilitators. Boys tended to mention organized sports, especially football, whereas girls commonly referred to creative play, drawing and art. PE seen as an opportunity practice PA and was described as a structured PA opportunity. At school, children were enthusiastic about the competitive element and challenges occasionally posed amongst peers in PE class or during breaktime. Children specified that family and school play a role in promoting and raising PA awareness. Parental co-participation in the children's activities were also deemed to facilitate activity (Figure 4).

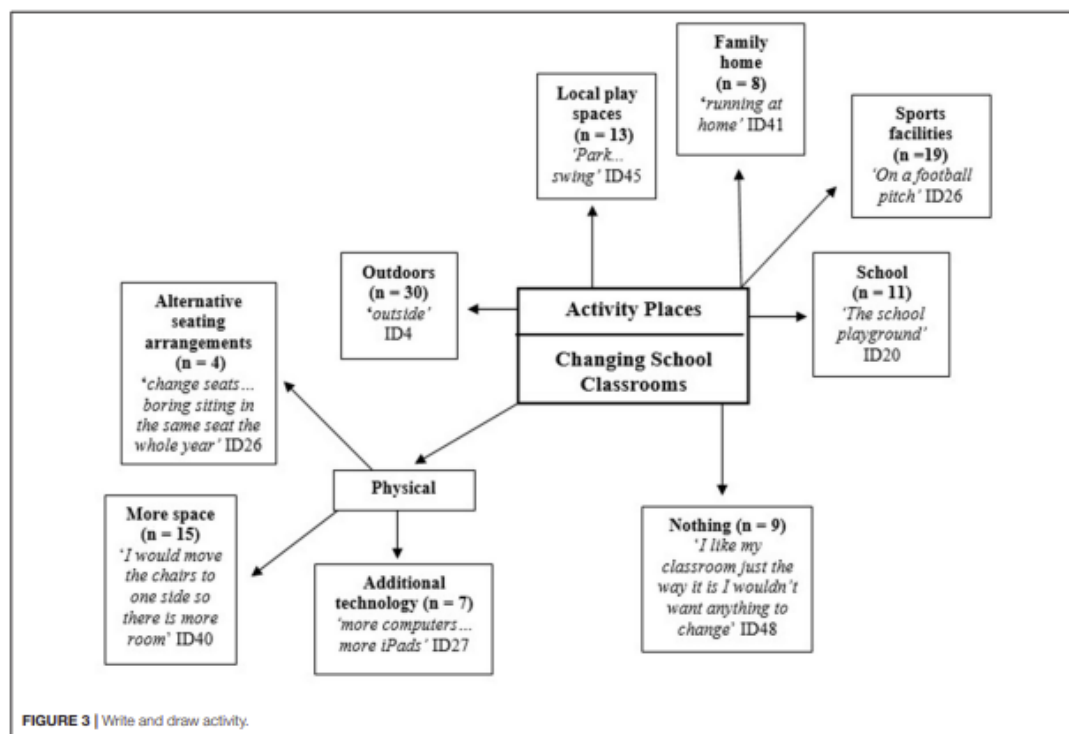
Barriers of Physical Activity

A range of barriers were reported by the children in relation to PA participation both at home and within school environment (Figure 5). In the home environment, parents restricting PA and being able to freely access and watch TV were key barriers. Using other electronic devices was less commonly reported by these children. Parental restrictions were due to parental time restraints, safety concerns, time, and costs. Children were not

allowed go to the park or play near their houses without adult supervision. In contrast, few children spoke about siblings and peers limiting engagement in PA. Children expressed the negative impact weather has on the ability to do PA outdoors.

Regarding the physical environment, children noted that a lack of space, both at school and home, as well as limited/no access to equipment/facilities were barriers. The size of indoor and outdoor space available for play, movement in the classroom and for PE was identified as a challenge in every focus group. The unavailability and the inaccessibility of spaces were also identified as key barriers to children's PA. Due to the lack of space noted inside the sports hall, children favored the outdoor environment for PE at school.

Furthermore, many children stated that they wanted to participate in PA, however, due to lack of discretionary time they were not able to do so. Children also indicated that they do not get time to be active, sometimes owing to external commitments such as homework. Each focus group raised issues of physical ability and explained that these insecurities often prevented them from taking part in PA. Concerns regarding physical ability included tiredness, being unfit, and having an illness or injury. Many children explained that they did not like



to participate in PA after school as they were tired. Teachers who limit movement in the classroom were also identified as barriers to maintaining PA.

Children stated that the COVID-19 pandemic was a key barrier to PA participation. Similar to many countries, NI imposed restrictions requiring physical distancing (two meters), and limited community and social gatherings and interactions, sport, and playground and park use. All organized after-school activities were canceled. Thus, most children had to comply with physical distancing, activity constraints and behavior restrictions (Fegert et al., 2020).

Intervention Approaches

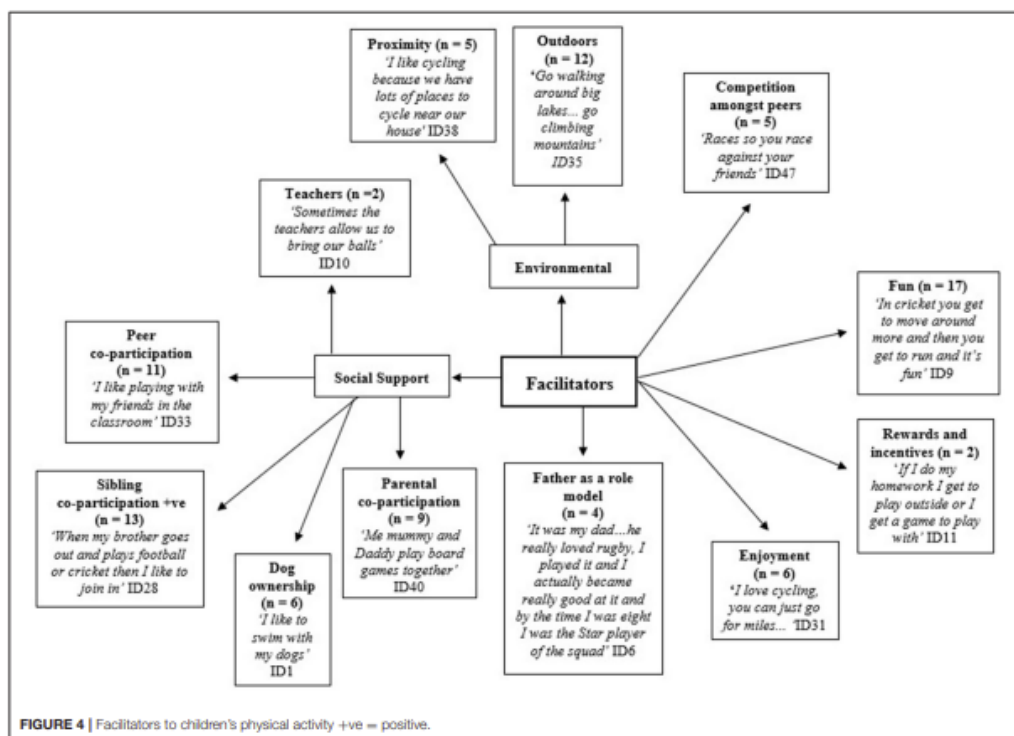
Children discussed a number of intervention components, including active homework, sit-to-stand desks, and active breaks (Figure 6). In each focus group, children stated that they enjoyed the opportunity to be active during the school day. The flexibility and adaptability of active homework appealed to children. The idea of incorporating movement and active breaks into the classroom were perceived as fun. Children were enthusiastic about the additional movement in the classroom component and suggested that it may help them with their academic performance and health.

Children had a mixed response to the sit-to-stand desks. Children were apprehensive regarding the mechanical and

logistical side of the sit-to-stand desks. Furthermore, children voiced their concerns regarding the flexibility and adaptability of the desks in the classroom. Additional barriers to the implementation of sit-to-stand desks included time within an intense curriculum, space, and tiredness after prolonged standing. Children noted that they wanted to change the seating and table arrangements to make different patterns to create more space.

DISCUSSION

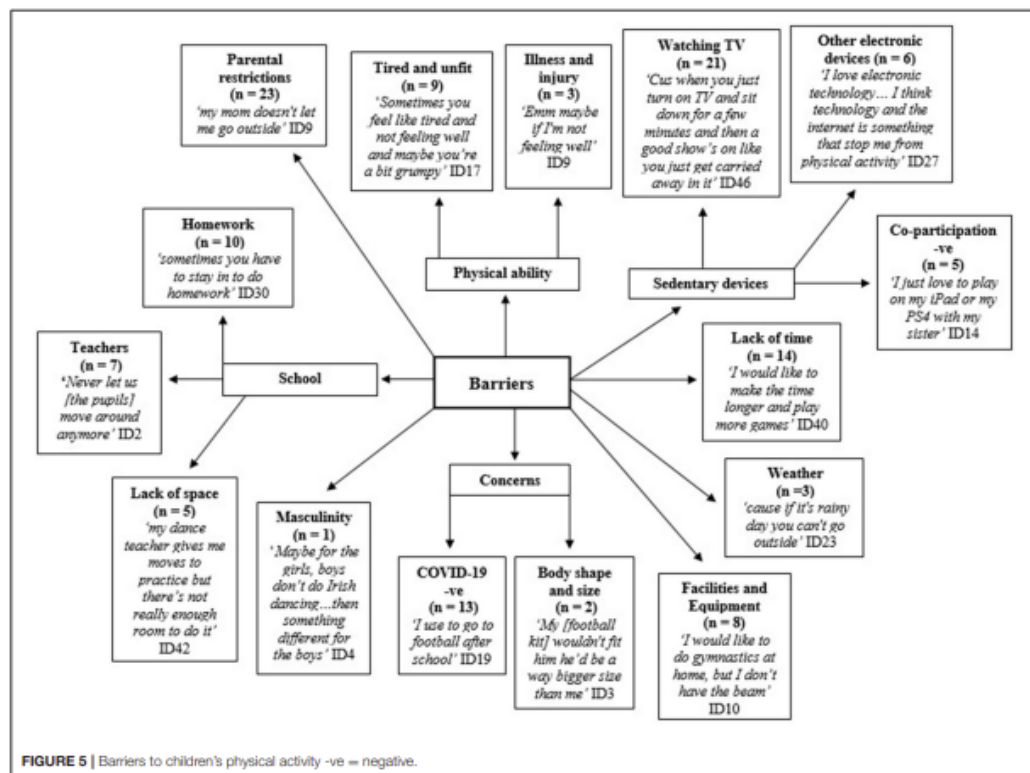
The aim of this research was to examine the influences on children's PA current views, experiences, and perceptions of PA in the classroom, school, and home environment and to examine the perceived benefits and barriers of participation. Although previous qualitative research has examined barriers and facilitators to primary-school children being physically active (Brunton et al., 2003; Hesketh et al., 2017), most studies were based in the USA, making their generalizability to the UK setting uncertain. This exploratory study has identified factors that facilitate and inhibit children's participation in PA from the child's perspective and has provided important considerations for adapting *Transform-Us!* to the NI context. Findings from the current study suggest parental restrictions,



being able to access and watch TV and lack of discretionary time are barriers to PA participation at home for children aged 7–9 years. Children identified access to, and high levels of, screen time negatively impacted on PA. Other important school-based barriers included a lack of space, in addition to limited or no access to equipment and facilities. The ability to have fun, play, go outside and enjoy PA were important facilitators of PA. These identified issues should be areas of focus for program developers as well as school staff to ensure that strategies are available to mitigate these factors when they serve as barriers, to support program implementation. Based on the data from the present study, many children recognized the physical health benefits of PA. However, data revealed a lack of knowledge and identified lack of PA recognition, which is comparable to previous formative research (Mackintosh et al., 2011) where some children demonstrated a limited understanding of what constitutes PA. When describing the likes and dislikes, children were more inclined to focus on their favorite activity. Participants "likes" were predominantly structured and sport-based activities were more common than play activities and feelings. Consistent with other studies (Timperio et al., 2013; Watson et al., 2015) children generally conflated PA with sport, which was confirmed within the write and draw data, with children expressing a greater

recollection of structured physical activities, games (i.e., football) (refer to **Figures 1A,B**). In contrast, during the focus groups children ascribed PA with fun and tended to participate in PA if they perceived themselves to be physically capable; that is, they had the necessary skills and it felt it was worthwhile. Educators could teach children the meaning of PA and emphasize that it does not have to equate to sport. Providing opportunities to try different activities at school, beyond PE and organized sport, may help to redefine children's perceptions of PA to include a range of activities that they may enjoy.

Interestingly, many of the themes identified were reported to act as both facilitators and barriers across the different schools (e.g., role of parents, school environment, peer influence and interrelationships). Similar to findings from other qualitative studies, parents were perceived as both significant barriers and enablers to children's PA participation, indicating that parents have a great influence over their children's involvement in PA with the ability to both facilitate and impede participation (Brockman et al., 2009; Stenhammar et al., 2012; Noonan et al., 2016). In this study, some children specifically identified their father as a role model for PA participation (**Figure 4**). The findings are in line with previous research by Lijuan et al. (2017), who found that 23.3% of the variance in MVPA for boys



(aged 7–11) was explained by the MVPA engagement of fathers. Sigmundová et al. (2018), found that mother's and father's levels of PA are associated with children's weekly PA. Furthermore, research suggests that active parents, who could act as role models for children, facilitate children's activity (Rodrigues et al., 2018). Consequently, targeting parents to increase their own PA levels, particularly through the participation in organized PA, may be an effective way to increase the activity levels of their children while providing health benefits for the whole family.

Within the home and family environment, our findings found that being able to go outside appeared fundamentally important to children's PA within drawings (refer to Figures 1A–D), so much so that many children reported traveling with parents to parks farther afield that are larger in size and have "better" provision. PA participation through family walks were discussed by participants alongside dog ownership. Dog ownership is associated with a number of health benefits and research indicates that children from dog-owning families accumulate more PA (Westgarth et al., 2019). Data also revealed siblings were perceived as a barrier and as a facilitator. Participants indicated that siblings may increase activity through co-participation and social support but can also persuade each other to co-participate

in sedentary pursuits, including television viewing or electronic device use. Participants identified siblings' preferences for sedentary activities as a deterrent to being active, stating that the sibling was not at the same developmental level as they were in sport, in most cases mentioning that the younger sibling was not at the same level. However, participants also emphasized the positive influence siblings have on sports participation and play. Other studies looking at sibling influence on sports participation have reported similar findings (Hohepa et al., 2007; Silva et al., 2016). Kracht and Sisson (2018) reviewed siblings influence on children's objectively measured PA and found that children with siblings have a healthier PA pattern with more PA and potentially less SB. Thus, the involvement of parents, pet and/or family members appear to be fundamental to children's PA levels and it is therefore important that the key components of the intervention are structured around both parents and schools.

Whilst parents clearly have a significant role in shaping young children's health behaviors, our findings revealed that children see peer interaction as reasons to be physically active and the role of friendship groups was key in helping to promote and influence the participation of PA at home and within the school environment. Play, fun and social support were reported as

the intrinsic enjoyment of PA that was expressed by these primary-school children.

Previous systematic reviews of PA interventions in schools found favorable effects of classroom movement breaks on increasing PA (Norris et al., 2015; Martin and Murtagh, 2017; Watson et al., 2017). In this qualitative study, the majority of children found the idea of active breaks and/or incorporating movement in the classroom to be desirable. Participants perceived the additional movement as being “*very good for your body*” and suggested that the addition of activity in the classroom may have possible health benefits. However, some children noted that having to engage in active breaks or perform activities within the confined space of their classroom served as a limitation. This finding is in line with previous process evaluations exploring children’s perceptions of active breaks, where some participants did not like taking part in active breaks due to lack of space (Howie et al., 2014; Watson et al., 2019). Overall, this finding suggests that researchers should consider the classroom space when adapting the *Transform-Us!* Standing workstations have the potential to be integrated in the primary-school classroom environment (Blake et al., 2012; Hinckson et al., 2013). In this study, contradictory opinions in relation to the sit-to-stand desks were apparent, with participants voicing concern over the possibility of class disruption, the practicalities and stability of the desks. Several participants mentioned potential benefits of using the sit-to-stand desks, such as improved academic performance and increased alertness. A pilot study conducted in primary schools in Australia and England, found that irrespective of implementation, integrating sit-to-stand desks into classrooms may be an effective method of reducing classroom sitting (Clemes et al., 2016). However, the acceptability and feasibility of implementing sit-to-stand desks within NI primary schools is unknown, such information is essential for determining full-scale randomized controlled trials where intervention effectiveness can be evaluated.

Data from this study reveals that several limits were placed on where and how children could play and highlights those children had little access to organized sport. In line with our results, a research study found that COVID-19 restrictions were both a barrier and a facilitator for PA in Irish adolescents (Ng et al., 2020). COVID-19 and lockdown presented opportunities with more time as a facilitator to take part in activities not done previously, like PA. Children had been working on finding new and innovative ways to remain physically active. During the period of the study, children were forced to adapt to a new “normal” due to COVID-19 restrictions, which may have caused a substantial decrease in excursions outside of the home. Recent studies highlight the decline in PA participation, with only 2.6% of children meeting the Canadian 24-Hour Movement Behaviors Guidelines, compared to rates between 12 and 17% before lockdown (Moore et al., 2020) and a three-fold reduction in PA was observed in Chinese adolescents (Xiang et al., 2020). A study conducted in Western Australia found no change in overall PA among children during the COVID-19 pandemic, and an increase in children’s unstructured PA and outdoor play was observed (Nathan et al., 2021). However, as a result of the context-specific nature of the pandemic contextual factors should

be taken into consideration and the imposed restrictions within and between countries, thus this finding may not be generalizable to other countries.

The weather was reported as a barrier to PA. In line with our findings, several studies have found relationships between various weather conditions and children’s PA. Rainfall has been associated with decreased activity (Harrison et al., 2011; Goodman et al., 2012). Internationally, research indicates that children in Northern Europe and Melbourne, Australia were active given the weather conditions they experienced (Harrison et al., 2017). Contrary to previous research that winter weather (e.g., snow) is a barrier to outdoor playtime (Burdette et al., 2004), this research found that it was rain that hindered children. Nevertheless, it is important to note that contextual differences between North America and in the UK are apparent, and snowfall is quite infrequent and short-lived. Thus, there is a need to provide seasonal and meteorological data, when developing interventions to increase children’s outdoor PA. Seasonal variation in young children’s PA is apparent (Carson and Spence, 2010; McKee et al., 2012). Overcoming weather issues can be a challenge. Thus, learning to adapt to weather conditions that may provide fun opportunities for PA (i.e., wet weather) or providing parents with feasible contingency opportunities in locations where weather extremes are common, may be beneficial and may lead to consistently higher levels of PA in primary-school age children (Hesketh et al., 2017). The data also suggests that lack of time for activities is a factor that appeared to constrain family and school-based activity. Lack of time has previously been reported by youth as a significant barrier to PA (Brockman et al., 2009).

STRENGTHS AND LIMITATIONS

This study utilized a write and draw methodology alongside focus groups, which has not been widely used in primary-school children in NI. Nevertheless, the participants in this study responded well to the combination of interactive tasks, providing important evidence for future studies to adopt a similar methodological approach. The strength of this study is the design as it includes the ability to investigate the phenomenon in natural settings and the use of a variety of research methods to obtain rich descriptions and deep insights. The drawings informed about the main environments the participants participated in PA, helped to express their opinions and experiences, and added different levels of depth to the children’s responses. Triangulation of qualitative methods allowed the identification of possibly overlooked stressors, nuances in theory, and put an emphasis on the importance of context. Thus, the dual-method approach provided the participants with alternative ways to express their perceptions and experiences.

There are some limitations to this study that should be considered when interpreting the results. Due to COVID-19 protocols and curriculum restrictions, the length of the data collection was restricted, and a 45-min data collection session was stipulated by participating schools. Thus, each group completed both the write and draw task and a focus group within a 45-min

timeframe, and this was standardized across all participating schools. Despite this time limitation, the results of this study offer novel findings into the experiences and understandings of PA in primary-school children, and 15–20 min write and draw activity length has been used in previous research. Furthermore, we were successful in recruiting children from several geographical locations across NI during the COVID-19 pandemic. This helps in gaining a better understanding of PA determinants in children and increases the generalizability of the study findings. It must be noted that the majority of participants were of white ethnicity and no participants had physical disabilities. Thus, future work should include a more diverse sample of participants to reflect the diversity of NI cultures. Future research should consider if another setting is more appropriate to capture children's experiences of non-school related PA, however researchers should consider the recruitment difficulties in a community setting (Brown et al., 2015).

CONCLUSIONS

This qualitative study is the first in NI to explore the identification of barriers and facilitators of children's PA during the COVID-19 pandemic. Peers and family were main influences on children's PA and could both facilitate and impede on PA participation. Collectively these findings highlight that elements of fun, social support, time, space and are likely to be central to the adaptation and maintenance of PA among primary-school children and that activity promotion strategies that are based around co-participation with peers and family members could be an effective means of engaging in PA. Furthermore, the study findings offer suggestions to educators regarding the school and family environment. The study emphasizes social opportunities for activity may be effective activity promotion methods to provide the intrinsic enjoyment of PA that was expressed by these primary-school children.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author/s.

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ETHICS STATEMENT

Ethical approval was granted by the Ulster University Ethics Committee (REC/20/0033). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

SN, AC, MM, and AG: conceptualization. SN: conducted the interviews. SN and NR: initial analysis and interpretation of the data. SN, NR, AC, MM, and AG: discussions. All authors drafted the manuscript and were part of the revision process and agreed to the final version of the paper before submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fspor.2022.789259/full#supplementary-material>

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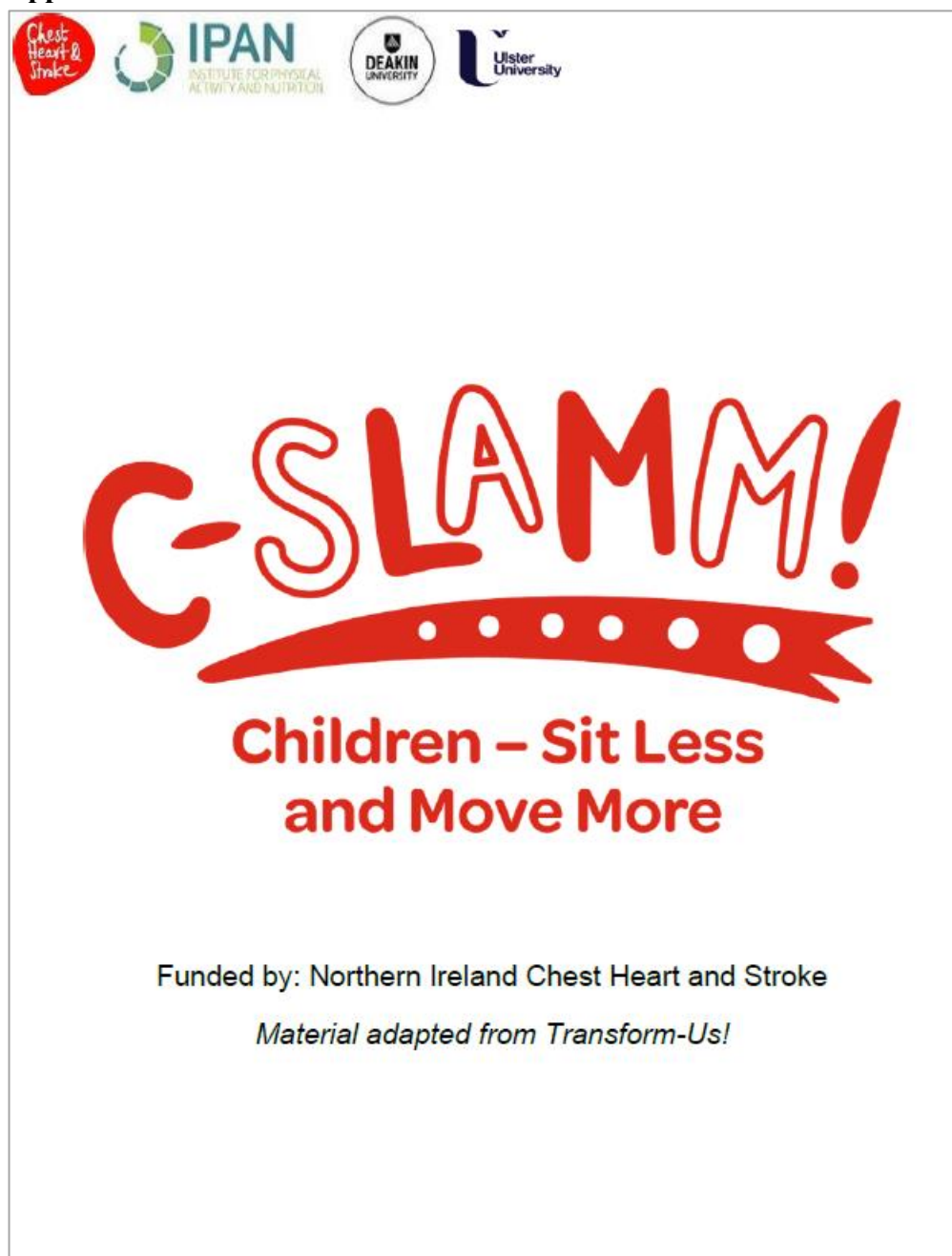
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Appendix 5: Examples of some of the *C-SLAMM* intervention components (Chapter 6)

Appendix 5: The front cover of the Teachers Manual

Appendix 5: Breaks from sitting

8) Heads or tails?

Aim: To attempt to predict a random event and gain a greater understanding of chance.

Description: Students stand at their desks. The teacher asks them to predict if the result of the coin toss will be heads or tails. If the student believes the coin will land on heads, they place their hands on their head. If the student thinks it will be tails, the student places their hands on their hips. The teacher then tosses the coin and the students who had the incorrect answer sit down. The procedure is repeated until there is one student remaining standing.

Modifications/variations: Use two dice or two coins

Equipment/preparation required: Coin, dice, deck of cards or alternative object.

Teacher may use some of the suggestions below:

Alternatives to a coin toss	Chance of occurring	Instruction
Roll a dice	1/6	Uses fingers to indicate what number they think will be rolled.
Randomly choose a letter from the alphabet	1/26	Students don't predict but remain standing if their name begins/contains that letter.
Deck of cards (use either suits or numbers)	1/4 or 1/40	Students write down which suit, or number will be pulled out of the deck. A student helper can select the card

Appendix 5: Active lessons

9. Bean-bag spelling/counting

Aim: To practice spelling or simple number patterns verbally while standing and passing a soft ball/beanbag.

Description: The students are broken up into small groups (4-5 students) and asked to stand. The teacher nominates a number sequence (*e.g.*, 3, 6, 9) or a set of words relevant to the current lesson. The teacher gives a ball to one student in each group, who states the first number in the pattern or letter in the word. That student then throws the ball to another student in their group, who says the next number/letter then passes the ball on, and so on.

All students remain standing throughout the game, but once a student has passed the ball, they must change their posture/position to signify that they have had their turn. Teachers can specify.

Equipment/preparation required:

- ✓ Soft ball, beanbag or newspaper balls to throw
- ✓ Spelling-list on the board (optional)

Teachers can specify:

Categories	Instruction
Spell "..." (Word from the current spelling list or story being read)	Everyone stand up, when you've had your turn stand on one leg
Multiples of... (during a mathematics lesson)	Everyone stand up, after your turn bend down and touch your toes
Count to 100 by twos/fives	Everyone stand with their arms out to the sides, after your turn place hands on head
	Everyone jog on the spot, after you've had your turn start hopping

Appendix 5: Active homework

1. ROLLING SPELLING WORDS Assign an activity to each number on a dice (e.g., 1= jump; 2= hop; etc.). Roll the dice. Spell out your spelling words while doing the chosen activity on the dice. Roll the dice for each new spelling word. Simplification: Recite the alphabet (forwards or backwards) while doing the activity indicated by the dice. Extension: Assign an activity to each number from 1 to 12. Roll 2 dice and add up the total. Spell out your spelling words while performing the corresponding activity.	2. FAMILY SPELLING BEE Ask a family member to quiz you on your spelling words. For every word you spell out correctly (aloud), do 5 jumping jacks (or movement chosen by your family member). For every word you spell incorrectly, do 5 push ups (or movement specified by your family member). Your family member can join in the activities too. Extension: Ask your family member to add some extra challenging words.
3. WHAT HAPPENS NEXT? Choose a story to read aloud to a family member. At the end of a chapter, act out what you think will happen next. Simplification: For stories without chapters, choose a point in the book to pause and act out what you think will happen next. Extension: When you finish reading the book, act out what you think will happen if the story continued.	4. ALPHABET CHALLENGE Assign an activity to each letter of the alphabet on your spelling word list (e.g., A= skip; B= bounce; etc.). Spell out your spelling words by performing the activity corresponding to each letter of your spelling words. Simplification: Perform an activity for each letter of the alphabet, e.g., A = walk "around" something; B = throw a "basketball" etc. Extension: Spell out the longest word you can, using the activities corresponding to each letter of the word.

Appendix 5: Health lesson

Topic 1: Physical activity, sitting time and health

Content descriptions: Recognise situations and opportunities to promote their own health, safety and wellbeing. Discuss the body's reactions to participating in physical activities.

Learning intention: To explain the detrimental effects of sedentary behaviour (sitting time) and the benefits of physical activity to health.

ACTIVITY (15-20 minutes) - Physical activity picture cards

Give a set of 'Physical activity picture cards' (supplied) to each pair/small group and ask them to cut the cards out along the lines. Students then sort the cards into activities that are physical and activities that are sedentary.

Equipment: 'Physical activity picture cards' (supplied) and scissors

CLASS DISCUSSION (5 minutes)

What is sedentary behaviour? (Could complete while standing up)

- After students have finished sorting their Physical activity picture cards ask, "What are some similarities of the two piles of cards?" "What are some differences?"
- Explain that the cards placed in the second pile show activities that are 'sedentary' where our whole body is not moving and we're usually sitting down.
- Ask, "What are some sedentary behaviours you placed in that pile?"
- Being sedentary too often is not good for our health. All our organs, like our heart and lungs need us to move often to keep us healthy on the inside as well as the outside of our bodies.

Allow students some time to relook at their piles and move any cards that they think are in the wrong spot.

ACTIVITY (5-10 minutes) - What's happening to my body? (Complete while standing up)

Instruct students to participate in the following movements and after each one describes, using a few words, what is happening to their body (that they can't control):

- Walking around the room
- Hopping on one leg on the spot
- Jumping around the room
- Walking on the spot
- Sitting
- Doing star jumps
- Dancing

EXTENSION IDEA

Ask students to write down in their workbook all the movements that they did and how their body reacted to those movements.

Appendix 5: Newsletter 01



**Children – Sit Less
and Move More**

C-SLAMM aims to get children to move more and sit less. We are interested in all types of physical activity including moderate activity that makes you breathe a little harder than normal (e.g., cycling) and vigorous activity that makes you breathe much harder than normal (e.g., running).

2018 Children's Sport Participation and Physical Activity Study (CSPPA)

NORTHERN IRELAND

PRIMARY CHILDREN	PHYSICAL ACTIVITY	POST PRIMARY CHILDREN
20% meet the physical activity guidelines		11% meet the physical activity guidelines
65% participate in community sport at least 1 time a week	SPORT PLAYED IN THE COMMUNITY	49% participate in community sport at least 1 time a week
65% participate in school sport at least 1 time a week	SPORT PLAYED IN SCHOOL	58% participate in school sport at least 1 time a week
19% receive no more than 30 minutes of PE per week	PHYSICAL EDUCATION (PE)	40% meet the PE guidelines of 120 minutes per week
36% actively travel to/from school	ACTIVE TRAVEL	18% actively travel to/from school
59% meet the 2 hour screen time threshold	SEDENTARY BEHAVIOUR	40% meet the 2 hour screen time threshold

Newsletter 01

Physical activity, sitting time and health

What are sedentary behaviours?
Activities that are done while sitting or lying down (e.g., watching TV, iPad or computer, homework).

What is physical activity?
Moving your muscles. You feel warm and a little out of breath (e.g., walking, climbing trees, skipping, running).

Recommendations:
No more than two hours a day using screens (e.g., TV, electronic tablets, video games) for entertainment and break up long periods of sitting as often as possible.

Recommendations:
An average of 60 minutes of physical activity every day and doing activities that help strengthen bones at least three days per week.

BENEFITS OF SITTING LESS AND MOVING MORE:

					
Less likely to be overweight or obese	Develop motor skills, coordination and balance	Less likely to develop heart disease and diabetes later in life	Improved bone health	Improved self-esteem	Improved academic outcomes

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Appendix 6: Accelerometer Diary

Appendix 16: Accelerometer Diary (Version 1, 13/04/2021)

Participant ID:
Timepoint:



Physical Activity Monitor – Diary

Please get your mum, dad or person who looks after you to help you fill in this diary.
Please record the times that you put on your accelerometer each morning and when you take it off at night.

Please remember to also record the times you take your accelerometer off during the day, for example, when you are bathing or taking part in water-based activities, for example, swimming.

Day of the week	 Start time (Morning)	 End time (At night)	Please record any other times you put on/took off the device during the day in the space below
Example	7:05	8:30	Bath: 6:00 – 6:45 PM
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			

Appendix 7: Activity monitor instructions



ACTIVITY MONITOR INSTRUCTIONS

How do you attach the monitor?

1. Ensure your son/daughter is sitting down on a chair when attaching the monitor so that his/her thigh is in a horizontal position. This will also make it easier to find the top of his/her thigh (the crease between the leg and his/her upper body).
2. The Thigh Monitor is attached directly onto the skin and positioned on the front of the thigh, roughly 1/3 of the way between hip and knee with the stick man standing up. Position the monitor in the midline of the right thigh as shown in the picture.
3. Swab the area where the monitor is to be attached with the provided alcohol pad and let the area dry for a few seconds.
4. Peel the backing off an adhesive patch (provided in your activity monitor pack) and place it over the monitor. Press the patch onto your skin, starting from the middle out towards the edges and smooth out the air bubbles and wrinkles as much as possible to ensure that the monitor is firmly secured.
5. Please ensure that your child wears the **monitor continuously (24 hours/day) every day for 7 days**
6. The Thigh Monitor can be worn during sleep and is water resistant (to 1m) so you can wear it whilst showering and bathing but please do not wear it in the swimming pool in case it falls off.
7. The adhesive patch, that sticks the Thigh Monitor to your skin, may last up to 7 days. However, to avoid skin irritation you may want to change the adhesive patch.



Note: The Thigh Monitor will emit a green flash every 6 seconds. This is an indication that it is working and recording data.

If your child needs to change the adhesive patch

- Remove the Thigh Monitor from your child's thigh (note that this may cause some slight discomfort) and peel the



adhesive patch off the Thigh Monitor. The monitor is covered in a waterproof sleeve and wrapped in one adhesive patch—please make sure that these remain on the monitor when you do this.



- With an alcohol prep pad provided in your Activity Monitor Pack, thoroughly wipe down the monitor and the area of the leg where the Thigh Monitor was attached.
- Position the Thigh Monitor in the same spot as previously positioned on the thigh (or on the other thigh if he/she has had a slight irritation), ensuring that the stick man on the front of the Thigh Monitor is standing up (head facing upwards).
- Peel the backing off an adhesive patch and place it over the Thigh Monitor. Press the patch onto the skin, peel back the top layer of the patch and smooth out the air bubbles and wrinkles as much as possible to ensure that the Thigh Monitor is firmly secured to your child's thigh.
- If you require assistance re-attaching your Thigh Monitor, or if your child experiences any skin irritation whilst wearing it, please call **07599890673**

What else do I need to do?

- It is important that you and your child fill in the Physical Activity Monitor Diary.
- Please remember to **record the times your child takes the monitor off** during the day, for example, swimming.
- If your child removes the monitor for longer than 10 minutes during the day, please

Day of the week	Start time (Morning)	End time (At night)	Please record any other times you put on/take off the device during the day in the space below
Example	7:05	8:30	Bath - 6:00 - 6:45 PM
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			

record the time that he/she removed the device, the time that he/she re-attached it and the reason why the device was removed. This is particularly important as we cannot tell from the data if your child is lying down or whether he/she has removed the device (the data looks the same when we look at it).

Please contact Sarah Nally if you have any queries on (+44) 7599890673

or email Nally-S@ulster.ac.uk

Appendix 8: Process evaluation

Appendix 8A: Write and draw activity

Appendix 10. Write, Draw, Show and Tell (version 1, 2.03.2021)



Write, Draw, Show and Tell activity

What was your favourite part of the C-SLAMM study?

Draw a picture of yourself completing your favourite part of the C-SLAMM study.

Think about:

- **where** in the school you were doing or using this part?
- **who** were you with?
- **how did you feel** when you were taking part?

Appendix 8A: Write and draw activity

Appendix 10. Write, Draw, Show and Tell (version 1, 2.03.2021)

Write, Draw, Show and Tell

The WDST methodology (Noonan *et al.* 2016) will be used with participating children to elicit their perceptions and experiences of the intervention components.

A semi-structured WDST guide is developed below and will be used to ensure consistency across WDST groups. Questions will target the overarching aim of the study which is the effectiveness of the pilot study at increasing physical activity and decreasing sedentary behaviour in children.

The WDST process will begin with the researcher (SN) presenting visual illustrations of each intervention component to children (e.g., an activity card, a newsletter, a teddy timer, an image of a standing desk, equipment, signs, and posters). This opening ice breaker is not to initiate any form of conversation but to remind the children of the various intervention components. Children will be given paper and will be invited to write down their favourite intervention component and why.

Each child will tell the group what their favourite component was and explain why. Once each child has spoken, the open-ended focus group directed to the whole group will begin.

Open-ended questions:

1. Were the classroom-based exercises hard or easy to complete?
2. What was it about the exercises which made them easy/hard?
3. Do you feel different doing the classroom-based activities now compared to when you first started them?
4. What did you think of the intervention and was it enjoyable?
5. What did you like / not like?
6. Would you get involved in any other physical activities since participating in this intervention?
7. How did you feel using the standing desks?
8. Did you prefer the indoor or outdoor activities?
9. Do you think all schools should run C-SLAMM?
10. How do you normally spend your breaktime?
11. Can you think of how your body feels different?
12. If you could change one thing about your classroom, what would you change?
13. Were the active homework lessons hard or easy to complete?
14. If you could change one thing about C-SLAMM, what would you change and why?

Appendix 8A: Write and draw activity - visual cues

1. BREAKS FROM SITTING



2. HEALTH LESSONS

PHYSICAL ACTIVITY PICTURE CARDS



3. ACTIVITIES TO DO AT HOME

MAKE THE SWITCH-OFF A SCREEN CONTRACT

I (my name) _____ declare that this week I will switch-off a screen on:
(what day) _____ at (what time) _____
and do something else instead.

Circle the picture to show what screen you will switch off or draw your own picture in the empty boxes.



I also promise that the activity I do instead of watching the screen will be SOMETHING ACTIVE (e.g., play outside, ride a bike).
Some ideas of active things I could do instead include:

My Signature: _____ Date: _____
My Parent's Signature: _____ Date: _____

4. ACTIVE CLASSROOM BOX



5. SIT-TO-STAND DESK



6. NEWSLETTERS

G-SLAMM!
Children - Sit Less and Move More

G-SLAMM aims to get children to move more and sit less. We are interested in all types of physical activity including moderate activity that makes you breathe a little harder than normal (e.g., cycling) and vigorous activity that makes you breathe much harder than normal (e.g., running).

NORTHERN IRELAND

20%	11%
65%	49%
45%	14%
19%	40%
34%	18%
59%	40%

What are sedentary behaviours?
Activities that are done while sitting or lying down (e.g., watching TV, iPad or computer, homework).

What is physical activity?
Moving your muscles. You feel warm and a little out of breath (e.g., walking, climbing trees, skipping, running).

Recommendations:
No more than two hours a day using screens (e.g., TV, electronic tablets, video games) for entertainment and break up long periods of sitting as often as possible.

Recommendations:
An average of 60 minutes of physical activity every day and doing activities that help strengthen bones or least three days per week.

BENEFITS OF SITTING LESS AND MOVING MORE:

Less likely to be overweight or obese	Develops motor skills, coordination and balance	Less likely to develop heart disease and diabetes later in life	Improved bone health	Improved self-esteem	Improved academic outcomes

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Appendix 8B: Semi-structured topic guide for Teachers (Interviews)

1. What has been your favourite and least favourite component of the C-SLAMM study?
2. What were the strengths and weaknesses of the teacher training?
3. Do you have any suggestions and/or ideas that will assist us in future teacher trainings in this topic?
4. During the eight-week study, what components of the study were the easiest to deliver to the class? Conversely, what components were more challenging to deliver/maintain to the class?
5. What has been the biggest problems, barriers, or challenges for you as a teacher involved in the C-SLAMM study?
6. In relation to the equipment package, what equipment has been most used and what equipment has not been used? Is there any additional equipment, that has not been included in the study, that could be used in further work?
7. If you could change anything about the study, what would you change and why?
8. Do you have any further recommendations or ideas that could be used in a physical activity intervention in P4/P5 children?
9. Is there any components or techniques within in the C-SLAMM study that you will continue to use in your classroom/school?
10. How practical do you think it is to run this permanently the school?
11. Would you consider it feasible to roll out this intervention to all schools?

Appendix 8C: Fidelity checklists

Additional resources

Breaks from sitting checklist

1	Represent the answer	
2	Answer me this	
3	Stand and discuss	
4	Standing spelling/moving mathematics	
5	Find a...!	
6	Move like a...!	
7	Make a masterpiece	
8	Heads or tails?	
9	True of tails?	
10	Find and share	
11	Bingo	
12	North, south, east and west	

Active lesson checklist

1	Road trip/stations around the room	
2	On the board	
3	Vote with your feet	
4	Guess what...	
5	Stencil yourself	
6	Talking clipboards	
7	Get in line	
8	Human letters/numbers	
9	Bean-bag spelling/counting	
10	Becoming a story character	
11	Getting active with grammar	
12	Human scrabble	
13	Spelling relay	
14	Measure that space	
15	Times tables teams	
16	Multiples of...	

Appendix 8C: Fidelity checklists

Active homework checklist

1	Rolling spelling words	
2	Family spelling bee	
3	What happens next	
4	Alphabet challenge	
5	Action charades	
6	Active punctuation	
7	Shapes around my house	
8	Plane distance	
9	My steps	
10	Human measuring tape	
11	Date challenge	
12	Activity cards	
13	Family dance	
14	Active Simon says	
15	Paper challenge	
16	Create a game	
17	Blast from the past	
18	Family obstacle course	
19	Ad break challenge	
20	Sports challenge	
21	Dance videos	
22	Invent a new sport	
23	Active homework ideas	
24	Chair challenge	

Health lesson and family newsletter checklist

	Health lesson	✓	Newsletter for home	✓
1	Physical activity, sitting time and health		Physical activity, sitting time and health	
2	Self-management of sitting time and physical activity for children		Why it's important to be active and not spend too much time sitting	
3	Decision making (Choosing to move or sit)		Choosing to move or sit	
4	Active families		Active families	