Improving physical activity and movement skill competency in Gloucestershire's key stage two children

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A thesis submitted in partial fulfilment of the requirements of the University of the West of England, Bristol for the degree of Doctor of Philosophy

Hartpury University

February 2022

Abstract

Sport England's 'Active Lives, Children and Young People' survey for the academic year 2019 to 2020 identified that 66% of children in England aged between 5 and 18 were not meeting the recommended amount of physical activity. In addition to low levels of physical activity, research suggests that children are not developing effective foundational movement skills which can decrease their likelihood of engaging in physical activity. The first aim of this project was to explore possible associations between physical activity (PA) levels, movement skill competency (MSC), PA enjoyment, self-perception, and strength. Before using teaching practitioner's knowledge and experience to help design, implement and evaluate a pilot movement-based intervention. Pupils (n=700) from 11 primary schools in Gloucestershire were tested over a 12-week period. Five-hundred and fifty-eight students scored between 16-26 out of 48 with 142 students scoring 27 or above. *In relation to potential maximum score, children's movement skill competency is low.* The findings of the study identified positive associations between MSC and strength (0.263, p=<.001), PA (0.180, p=<.001), PA enjoyment (0.172, p=<.001), self-perceived ability (0.473, p=<.001), and total amount of sports played (0.215, p=<.001),). The analysis of quartile data was able to highlight that as movement scores increase, as do PA engagement, enjoyment, self-perception scores as well as total amount of sports played. The findings of the cross-sectional study should encourage future researchers to take a holistic approach when designing interventions, considering not only physical outcomes such as PA and MSC but also psychological outcomes such as enjoyment and self-perceived ability.

Semi-structured focus groups were conducted with 24 teaching staff from six schools across Gloucestershire. The analysis indicated that the participants perceived time, workload, children's behaviour, and lack of classroom space as barriers to implementing a movement-based intervention within the classroom. Having an awareness of the benefits of PA, good quality resources and having an intervention that was flexible and easy to

implement were all viewed as potential facilitators. The results of the study helped to inform ‘Busy Brain Breaks’, an intervention designed to improve MSC whilst increasing PA within the classroom. The intervention was implemented within 28 classrooms across three schools in Gloucestershire for 10-weeks, with all 28 classrooms engaging with intervention to some extent, before the Covid-19 pandemic closed schools. The findings of this project suggest that using teaching practitioner’s knowledge and experience to help design school-based movement interventions is likely to increase feasibility, adoption, and implementation.

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Acknowledgements

This project was funded by Hartpury University, I'd like to thank them for the opportunity and for putting their trust in me as their first sport PhD student, which I am so very grateful for. My supervisory team, Stephen Draper, Gareth Knox, and Luciana De Martin Silva whose on-going support and advice has been invaluable. I'd like to thank the 11 schools who participated in my research, who this project wouldn't have been possible without. With special thanks to the hundreds of children who threw themselves into whatever I asked them to do that week, and to the teaching staff for being both supportive and accommodating during my weekly visits. To Rebecca De Filippo, who helped me successfully navigate the operational challenges of collecting data from 700 children and managed to keep me smiling throughout. Finally, to Will, our spaniel Hugo (who must think PhD stands for Pet Hugo Daily) and my parents who have all helped me tackle the ups and downs that completing a PhD during a pandemic has thrown my way, thank you!

Glossary of Terms

Physical Activity

Any bodily movement that is produced by the skeletal muscles that requires energy expenditure

Fundamental Movement Skills

Basic learnt movement patterns that do not occur naturally and are suggested to be foundational for more complex physical and sporting activities

Movement Skill Competency

The demonstration and practice of context-specific movements, performed with consistency and efficiency both physiologically and psychologically

Foundational Movement Skills

Goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active that can be developed to enhance physical activity participation and promote health across the lifespan

Perceived Movement Skill Competency

An individual's perception of their actual movement skill competency

Sedentary Behaviour

Behaviour that occurs when an individual is engaging in an activity that requires minimal movement and energy expenditure

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Chapter 1
Introduction

1:1 Background and Rationale

Physical activity is defined as any bodily movement that is produced by the skeletal muscles that requires energy expenditure (World Health Organisation 2018a). The health benefits of childhood physical activity are well investigated and have been widely documented (Chaput *et al* 2020). Benefits include, but are not limited to, a reduced risk of obesity (Janssen *et al* 2010), hypertension (Torrance *et al* 2007) and type II diabetes (Henderson *et al* 2016) with improvements being identified in skeletal health (Behringer *et al* 2013), psychological well-being (Bailey *et al* 2018) and academic achievement (Ma *et al* 2015). Both national and international public health authorities agree that children should be accumulating an average of 60 minutes of moderate to vigorous physical activity per day (Bull *et al* 2020). In England, 44% of children aged between 5 and 18 meet the recommended amount of physical activity (Sport England 2021). The statistics for Gloucestershire are in line with the national average, with 44% of children aged between 5 and 15 meeting the physical activity guidelines.

Physical activity research has faced critique for not focusing on the developmental nature of movement skill and the influence it has on physical activity engagement (Dobell *et al* 2020). If children are unable to run, jump and catch they lack the necessary skills to be active and will face limited opportunities for engagement in physical activity (Clark 2002). Perceived movement skill competency, an individual's perception of their actual movement skill competence, is a developmental concept that changes across time (Harter *et al* 2006). Perceived competence is an important determinant of a child's behaviours and actions (Deci and Ryan 2012). Children with high perceived competence often have higher self-esteem, exert more effort, and select challenging tasks (Weiss and Amorose 2005). On the other hand, children with poorer movement skills have lower perceived competence, and are less likely to engage in physically demanding activities (McCullough *et al* 2009). Stodden *et al* (2008) note that previous work has primarily focused on measuring physical activity levels, without acknowledging that learning to move is an essential skill that underpins physical activity. Whilst it is of common belief that children naturally learn FMS, evidence suggests that many children cannot perform FMS proficiently (Cliff *et al* 2012). More recently, FMS and movement skill competency have been referred to together as foundational movement skills, which can be defined as goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active, and can be developed to enhance physical activity participation and promote health across the lifespan (Hulteen *et al* 2018).The awareness of the importance of movement ability has been highlighted in the Chief Medical Officers Report, which emphasised the importance of quality of movement in addition to the quantity for the first time in 2019. Unfortunately, little is known about the movement skill competency of children aged between 7-11 in Gloucestershire.

Sedentary behaviour can be defined as behaviour that occurs when an individual is engaging in an activity that requires minimal movement and energy expenditure (Department of Health 2010). It is important to note that sedentary behaviour should not be defined as failure to be physically active, as an individual can be highly sedentary but still meet physical activity recommendations (Pate *et al* 2011). Pate *et al* (2011) therefore note that it is important to recognise sedentary behaviour as a distinct construct from physical activity with its own independent links to health outcomes. Being sedentary for more than two hours a day has been consistently associated with unfavourable body weight, decreased fitness, low self-esteem and decreased academic achievement (Mitchell *et al* 2009; Lin *et al* 2014; Hjorth *et al* 2016). As a result of this, Trembley *et al* (2012) highlights the importance of attempting to both increase physical activity whilst decreasing sedentary behaviours.

The World Health Organisation (2012) identify schools as primary sites for health interventions aiming to increase physical activity due to their ability to reach the vast majority of school aged children. In 2013 it was recognised that primary school children spend much of their school day being sedentary (Abbott *et al* 2013). In 2019, the United Kingdom's Department of Education suggested that primary schools should be providing their pupils with 30 minutes of physical activity per day in addition to breaktime and lunchtime. In addition to sedentary teaching practices, opportunities for physical activity outside of the classroom, such as breaktimes and physical education, have decreased as a result of increased focus on academic performance (Hardman and Green 2011). As a result, interventions are being designed and implemented to reduce sedentary behaviour and increase physical activity within primary school classrooms.

Behaviour change interventions, defined as coordinated sets of activities designed to change specific behavioural patterns, are fundamental in the efforts to improve public health, given that behaviour change is often dependent on the implementation of evidence-based practice (Mitchie *et al* 2011). However, the gap between development of effective interventions and the wide-scale adoption of these interventions in real-world settings has been reported since the early 2000's (Glasgow and Emmons 2007). Research has been critiqued for failing to report details on context, in addition to clarity of implementation making it difficult for interventions to be replicated (Durlak and DuPre 2008). Given what is currently known about childhood physical activity and movement skill competency in the UK, the need to bridge the gap is urgent. Naylor and McKay (2009) argue that effective physical activity interventions, delivered in settings where children learn, are an important part of the solution. Despite this, there is a lack of research that addresses the translatability of the research into health promotion practice or its impact on public health. It has been argued that existing research and subsequent reviews have focused on the internal validity of childhood physical activity interventions, thus neglecting issues related to external validity (McGoey *et al* 2015).

For policy makers, practitioners, and future researchers to understand how an intervention might be replicated, or how outcomes may be reproduced, it is important for intervention studies to report on efficacy, adoption, implementation, and maintenance (Moore *et al* 2015). To draw conclusions about which elements of an intervention works, an evaluation of how it was delivered and received is required. High variability of design features, such as intervention delivery, duration, frequency, intensity, and outcome measures make this type of evaluation critical. The RE-AIM framework developed by Glasgow *et al* (1999) is a health promotion evaluation framework that enables complex settings-based interventions, such as those in school settings, to be comprehensively evaluated, the framework is frequently used to evaluate primary school physical activity interventions (Jenkinson *et al* 2012; Austin *et al* 2011; Collard *et al* 2010; De Meij *et al* 2008).

1:2 Aims and Objectives

The aim of the project was to investigate the development of children's movement skill competency and physical activity within a primary school setting. In order to do so, a number of objectives were addressed:

a) Establish the movement competency of Gloucestershire's primary school aged children, aged between 7-11 years old, whilst exploring possible associations between physical activity levels, movement skill competency, physical activity enjoyment, self-perception, and strength

b) Identify the perceived barriers and facilitators to implementing movement breaks inside the classroom with primary school teaching staff

c) Map the facilitators and barriers onto the COM-B model to identify suitable intervention functions

d) In accordance with the COM-B Model and Behaviour Change Wheel, use teaching practitioner's knowledge and experience to help develop a pilot movement-based intervention to be implemented and evaluated within primary schools in Gloucestershire

e) Explore teaching practitioner's adoption and implementation of a pilot intervention aiming to improve key stage two children's movement within the classroom

f) Understand which facilitators and barriers to implementation were experienced whilst exploring solutions used to overcome them

g) Discuss efficacy and maintenance of the intervention in relation to sustained behaviour change

1:3 Overview of Thesis

This thesis addresses the aims and objectives across seven chapters. The literature review in chapter two covers physical activity and sedentary behaviour, their guidelines, prevalence, and associated health benefits, followed by details of movement skills and self-perception. The importance of public health interventions is then outlined, followed by a critique of existing interventions that have aimed to improve children's physical activity and movement skill within school-based settings. The thesis is comprised of three research studies. Each study took place sequentially with each one informing the next, which is reflected in how each chapter is presented within the thesis. The cross-sectional study, presented in chapter three, aimed to address objective (a). Chapter four provides details of the focus groups that took place in order to address objectives (b) and (c). Chapter five includes the process in which the findings from chapter four were mapped onto the COM-B model, to help design the pilot intervention which addresses objective (d). Chapter six outlines the implementation and evaluation of the pilot intervention, to address the final objectives (e), (f) and (g).

1:4 Mixed Methods Approach

In order to address the project's objectives, a fixed mixed methods approach was adopted. The well documented justification for using a mixed methods approach is that it provides a way to harness strengths that help to offset the weaknesses of both quantitative and qualitative research (Leone and Ward 2013; Creswell and Clark 2017; Almalki *et al* 2016). It has been argued that quantitative research is often unable to provide understanding of the context or setting in which the participants find themselves (Queiros *et al* 2017), with the voices of the participants themselves not always being directly heard in quantitative analysis (Hancock *et al* 2010). For this project, quantitative research was able to provide a cross-sectional picture of certain physical and psychological variables of Gloucestershire's primary school children. In doing so, the researcher adopted a positivist perspective, selecting measures, variables and assessing statistical results (Aliyu *et al* 2014; Prasad

2017). The quantitative research was however unable to provide information on how the variables investigated might be improved. The qualitative work, using focus groups and semi-structured interviews was able to address this, with the researcher adopting a constructivist approach to make sense of the participant's knowledge and experiences (Motjahed *et al* 2014; Mogashoa 2014). The explanatory sequential design (Creswell and Clark 2017) helped to answer the research question, which could not have been done with either quantitative or qualitative research alone.

Chapter 2

Literature Review

2:1 Childhood Physical Activity

2:1:1 Physical Activity Definitions, Guidelines and Prevalence

Physical activity is defined as any bodily movement that is produced by the skeletal muscles that requires energy expenditure (World Health Organisation 2018a). Physical activity can vary in type, frequency, duration, and intensity (Ainsworth *et al* 2015). Moderate physical activity refers to activities that children can easily do without getting out of breath, such as walking and cycling on a flat pavement whilst vigorous physical activity refers to activities that quickly make children tired, such as running and cycling uphill (ACSM 2021). Moderate and vigorous activity can be quantified using metabolic equivalents (METs), with moderate activity being equal to >3 METs and vigorous activity as >6 METs (Garber *et al* 2011). In addition to aerobic activities, physical activity also includes activities that require children to lift their own body weight or work against a resistance to strengthen their muscles and bones such as jumping, climbing, and skipping (Sticker *et al* 2020).

Both national and international public health authorities agree that children should be accumulating an average of 60 minutes of moderate to vigorous physical activity per day (Bull *et al* 2020). However, the most recently available global statistics indicate that 81% of children aged between 5-16 do not meet this recommended amount (World Health Organisation 2020b). The prevalence of inactivity varies considerably between countries, with levels of inactivity being highest in the United States and Europe. It is estimated by the World Health Organisation (2020b) that physical inactivity costs $54 billion in direct healthcare globally, with an extra $14 billion as a result of loss of productivity.

Sport England's 'Active Lives, Children and Young People' survey for the academic year 2019 to 2020 identified that 44% of children between 5 and 18 were meeting the recommended guidelines (Sport England 2021). This is a statistically significant decrease from 2018 to 2019, in which 46% of children were meeting the recommended amount of physical activity (Sport England 2020a). Children in years three to six reported lower levels of physical activity (41%) than their peers in years one and two (45%) and years seven to eight (47%) (Sport England 2020a) and boys continued to report a higher level of physical activity (47%) compared to girls (42%) (Sport England 2021). In their follow-up report, which captured the impact of the COVID-19 pandemic, the report suggested that children's confidence had dropped by 4.6% from previous years, and their competence had fallen by 3.5% (Sport England 2021). As a result of the pandemic, 14% of children were engaging in more than an hour of physical activity, with 37% of children completing between half an hour and an hour, 37% completing less than half an hour and 13% completing no physical activity (Sport England 2021). When asked if this was more or less than before the pandemic, 37% of children said it was less (Sport England 2021).

When this thesis was designed, in 2018, Sport England completed their Health Survey for England and reported that in the Gloucestershire, 18% of children were active for 60 minutes or more every day. In 2019, Sport England reported that this figure had increased, suggesting that 48% of children in Gloucestershire reported being active for 60 minutes or more a day. In the most recent report, published in 2020, the figure has decreased to 44% which is in line with the national average. The questionnaire had not been used in previous literature and was designed specifically for use within the Health Survey for England. Accelerometer data from 92 children was used to validate the questionnaire, with findings suggesting evidence of under and over measurement of physical activity. In 2019, the questionnaire changed from asking children if they were active for 'at least' 60 minutes a day, to if they were active for 'an average' of 60 minutes per day. In 2018, the survey included 2331 children from Gloucestershire, but in 2019 and 2020 this decreased, and the study included 1995 and 1552 participants respectively. Each year a different number of children from each district are included in the sample, which means participation varies, for example in 2018 768 children from Cheltenham were included, but in 2020 there were 76 participants from the district included. Both the sample of participants included and subtle change in questionnaire warrant further investigation into childhood physical activity levels in Gloucestershire.

2:1:2 Measurement of Physical Activity

2:1:2:1 Objective Measures

Physical activity plays a crucial role during childhood, meaning it is important for physical activity levels to be measured as precisely and accurately as possible (Sylvia *et al* 2014). Measuring children's total physical activity can be problematic given the complexity of physical activity and the multiple domains in which it can occur (Dobell *et al* 2020). A variety of units are used to quantify physical activity and include energy expenditure per unit of time, metabolic equivalents, time spent in light, moderate or vigorous activity and ordinal activity classifications (Ainsworth *et al* 2000).

Objective measures of children's physical activity levels have developed substantially over the past decade. As a result of the advances in technology, methods such as direct and indirect observation (Adamo *et al* 2009) are now often replaced by heart rate monitors and accelerometers (Sylvia *et al* 2014). Inexpensive heart rate monitors that have the capacity to store multiple days-worth of minute-by-minute data are now a feasible and frequently used measurement tool (Butte *et al* 2012). Using heart rate monitors to measure physical activity is a suitable approach given the linear relationship between heart rate and energy expenditure during activity (Hills *et al* 2014). However, it is important to consider that heart rate can be influenced by multiple factors such as age, weight and cardiovascular fitness (Loprinzi *et al* 2011). Moreover, heart rate monitors cannot classify the type of physical activity being carried out, nor can it put the activity into context (Wallen *et al* 2016).

One of the most commonly used objective measures of physical activity are accelerometers. (Lee *et al* 2014). Using information taken from the vertical acceleration of the trunk or other body segments, accelerometers can quantify physical activity and provide information on frequency, intensity, type and duration. (Troiano *et al* 2014) A growing body of research has validated the use of accelerometers, suggesting there is a strong positive correlation between their output and energy expenditure (Konstabel *et al* 2014; Trost *et al*

2007; Freedson *et al* 2005). Their small size, wearability, and ability to detect intermittent movement patterns position them as a favourable tool for measuring childhood physical activity (Troiano *et al* 2014). However, given that they are worn on the hip they miss upper body movements which may contribute to physical activity (Drystad *et al* 2014). Furthermore, they cannot determine what type of physical activity is being carried out (Lee *et al* 2014).

2:1:2:2 Subjective Measures

Self-report measures such as self-administered recalls, diaries and proxy questionnaires completed by parents, are frequently used by researchers to understand physical activity levels in children (Hagstromer et al 2010). The key strengths of using such methods are the ease of administration and low cost, both of which are beneficial when attempting to measure physical activity at a population level when compared to objective measures such as accelerometry (Trost *et al* 2006). Self-report measures such as questionnaires allow for the type of physical activity to be recorded, as well as the context in which it was performed (Hardy et al 2013). Although convenient, there is ongoing debate as to whether it is appropriate to use self-report measures of physical activity with children because the ability to recall physical activity is a highly complex cognitive task (Baranowski 1992), meaning chances of measurement error are high (Van Der Ploeg *et al* 2010). Social desirability bias may also influence children's responses, with tendency to over-report physical activity being common (Trost *et al* 2006). To address these limitations, self-report data is often validated using a number of objective measures. For example, the physical activity questionnaire for children (PAQ-C) has been reviewed as having acceptable validity, reliability and practically for use with children and adolescents (Biddle et al 2011).

Originally developed for the use in the Saskatchewan Pediatric Bone Mineral Accrual Study (Trost 2007), the PAQ-C is a self-administered seven-day recall questionnaire which intends to measure habitual moderate-to-vigorous physical activity in children. Importantly, the questionnaire has been specifically validated for children aged between 7 and 13

(Kowalski *et al* 2004). The 7-day recall questionnaire has nine items, each scored on a 5-point scale, and is used to derive a total activity score. A systematic review of 100 physical activity questionnaires conducted by Biddle *et al* (2007) suggested that the Physical Activity Questionnaire for Children (PAQ-C) was one of the top three favoured questionnaires due to its consistent high validity against a variety of direct measures including doubly labelled water. Additionally, one-week test-retest reliability of the PAQ-C was identified as r=.75 for males and r=.82 for females (Kowalski *et al* 1997). A common limitation regarding self-reported physical activity in children is measurement error due to issues of recall (Biddle *et al* 2007). Additionally, questionnaires such as the PAQ-C are only likely to pick up activities that are more retrievable from memory, thus missing short and sporadic bursts of activity that are common among young children (Biddle *et al* 2007). Research conducted by Saint-Maurice *et al* (2014) developed a calibration model to cross validate PAQ-C scores with accelerometer data. These results indicated that there was no significant difference between estimated and recorded activity values (mean diff. = 25.3 ± 18.1 min; p = .17), thus suggesting the PAQ-C is a valid tool for measuring physical activity in children (Saint-Maurice *et al* 2014).

2:1:3 Benefits of Childhood Physical Activity

The health benefits of childhood physical activity are well investigated and have been widely documented (Loprinzi et al 2012; Longmuir et al 2014; Basterfield et al 2015; Sims et al 2015; Shahidi et al 2020). A full review of these benefits is beyond the scope of this thesis; therefore, the aim of this sub-section is to outline the key benefits briefly before moving on to discuss potential determinants of childhood physical activity.

2:1:3:1 Obesity

The current prevalence of obesity in Gloucestershire's reception aged children is 9.2%, compared to 8.8% in the South West region and 9.6% in England (Gloucestershire County Council 2020). For year six children, prevalence is 17.1% in Gloucestershire, compared to

16.2% in the South West and 20% in England (Gloucestershire County Council 2020). Both cross-sectional and longitudinal research consistently report that children who participate in regular physical activity are less likely to be overweight or obese (Tremblay and Williams 2003; Janssen *et al* 2010; Ness *et al* 2007; Telford *et al* 2016; Martin *et al* 2018). Data analysis of the 'Health Behaviour of School Aged Children' study identified an inverse relationship between physical activity participation and body mass index (BMI) classification in 29 out of 33 countries (Janssen *et al* 2010). One explanation for the association between physical activity and obesity is reciprocal causality, due to physical activity enabling children to control their weight more easily through increased energy expenditure (Hill *et al* 2011). Unfortunately, being overweight or obese has been identified as a key barrier to participation in childhood physical activity (Solomon *et al* 2015; Kesketh 2017). Fifty-five percent of obese children enter adolescence as obese, with around 80% of these obese adolescents becoming obese adults, it has been predicted that by 2050, 35% of boys and 20% of girls aged 6-10 will be obese (Butland 2006).

2:1:3:2 Blood Pressure

High blood pressure, known medically as hypertension, develops progressively over time in adults (Rahmouni *et al* 2005). In children however, hypertension develops much more rapidly and continues to persist into adulthood (Sorof and Daniels 2005; Vik et al 2013; Lurbe *et al* 2016). Multiple intervention studies have reported significant reductions in children's systolic blood pressure as a result of aerobic exercise training (Hagberg *et al* 1983; Jago *et al* 2006; Ribeiro *et al* 2005; Bell *et al* 2007). Two of which (Hagberg *et al* 1983; Bell *et al* 2007) also reported significant reductions in diastolic blood pressure. A review conducted by Torrance *et al* (2007) concluded that 40 minutes of vigorous to moderate activity per day is effective in reducing high blood pressure in children.

2:1:3:3 Type II Diabetes

In adults, regular physical activity reduces insulin resistance, improves glucose intolerance, and reduces the risk of type II diabetes (Herzig 2014). This effect is often a result of reduction in visceral fat and improved cardiovascular fitness (Herzig 2014). Whilst research is still emerging, the available data suggests that regular physical activity plays an important role in improving insulin sensitivity in children with type II diabetes (Goran *et al* 2003; Berman 2012; Henderson *et al* 2016). Over a six-year period, children who were consistently categorised as physically active had lower fasting glucose levels compared to their sedentary peers (Raitakari *et al* 2004). Whilst the body of evidence is growing, it has been suggested that further studies should investigate the effect of physical activity on insulin resistance, independent of calorie restriction (Kim and Park 2013).

2:1:3:4 Skeletal Health

Weight-bearing physical activities such as walking, jumping, and weightlifting are effective in increasing bone mineral density in children (French *et al* 2005; MacKelvie *et al* 2002; Behringer *et al* 2013). One quarter of final adult bone is accumulated during the two years surrounding peak bone velocity (French 2005). This provides a window of opportunity during early puberty to promote healthy bone development (MacKaelvie *et al* 2002; Tan *et al* 2014; Beck *et al* 2014). Alternative research has identified the pre-pubertal years as the optimal opportunity for exercise-induced bone development (Bass *et al* 2000; Tan *et al* 2014). Both theories help to emphasize the importance of physical activity for bone health pre, and during, puberty due to the optimal amounts of growth hormones available (Janz et al 2010). This is important given that in the UK approximately 536,000 new fragility fractures occur each year, with risk of fractures increasing as bone mineral density decreases (Compston 2017).

2:1:3:5 Psychological Health

Research exploring the effects of physical activity on psychological wellbeing in children primarily focuses on depression, anxiety, and self-esteem. A meta-analysis of 73 studies exploring the effects of childhood physical activity on mental health noted that increased levels of physical activity significantly reduced depression and anxiety whilst increasing self-esteem (Ahn and Fedewa 2011). Research has identified that behaviour, happiness, intellect, and confidence scores are significantly lower in children who reported low levels of physical activity (Strauss *et al* 2001). Whilst the research regarding mental health and physical activity in children is largely correlational, and should therefore being interpreted with caution, a small number of longitudinal studies exist. A meta-analysis of 16 studies, involving 771 participants, conducted by Bailey *et al* (2018) identified a significant effect of light, moderate and vigorous physical activity intensities on depressive symptoms compared to control groups (standardised mean difference = -0.82, 95% CI = -1.02 to -0.61 p = <0.05).

2:1:3:6 Academic Achievement

It has been proposed that exercise has the ability to alter thinking, decision making, and behaviour in specific regions of the brain, the prefrontal cortex, which is the area responsible for those functions (Kopp 2012). Recently, this theory has extended to children with the consensus that these executive functions are crucial for a child's development (Diamond 2013) and broadly underpin learning and cognition, which are frequently associated with academic achievement (Hoffman 2012). The studies exploring the association between physical activity and academic achievement have mixed results. A 3-year randomised cluster trial, conducted by Donnelley *et al* (2017), found no improvements to academic outcomes as a result of physically active lessons, however the authors note that their aim of 100 minutes of physical activity per week was not achieved which may indicate that the dose of physical activity was not sufficient. However, a study conducted by Mullender-Wijnsma *et al* (2016) identified an improvement in math speed, general maths scores (ES = 0.42, p = <0.001) and spelling scores (ES = 0.45, p = <0.001) amongst children who received physically active maths lessons three times a week for 22 weeks compared with children in the control group. The lack of consistency between physical activity dose implemented and academic outcomes measured make it difficult to draw reliable conclusions (Donnelley *et al* 2016; Watson *et al* 2017; Daly-Smith *et al* 2018).

The research on time on task behaviour, the amount of time a child can spend concentrating on a task, has produced more consistent results. A study conducted by Carlson *et al* 2015, reported that classrooms that implemented a 10-minute physical activity break reported fewer students who were off task, fewer behavioural problems and fewer students who lacked effort or gave up easily (ES = -0.17, p = <0.001). Similar findings were identified by Ma *et al* (2015) who noted that 4-minute physical activity breaks improved selective attention in the children receiving the intervention, compared to those in the control (ES = 0.23, p = <0.001). Interventions aiming to improve time on task behaviour that delivered short five-minute bouts of vigorous activity resulted in larger effect sizes than short breaks of moderate to vigorous intensity (Lucht et al 2013; Howie et al 2014; Mavilidi et al 2020).

2:1:4 Determinants of Childhood Physical Activity

Given the benefits of childhood physical activity, it is important to understand the factors that are likely to affect the frequency, intensity, type, and duration of children's physical activity behaviour. Understanding these determinants of childhood physical activity can help to enable the development of effective interventions (Sallis *et al* 1992).

2:1:4:1 Social Environment

The family is considered a powerful agent of socialisation with family members, especially parents, playing an important role in the development of a child's health behaviours (Lau *et al* 1990). Strong positive correlations between parent's and children's physical activity levels have frequently been identified, with directly modelling hypothesis acting as one possible explanation for this (Simonen *et al* 2002; Edwardson and Gorley 2010; Fuemmeler *et al* 2011). The effects of parental beliefs and encouragement of children's physical activity levels have also been explored, with a strong positive correlation suggesting that a positive and encouraging narrative around physical activity may be able to increase childhood physical activity levels (Gustafson and Rhodes 2006). In addition to parental support, peer support is also positively associated with physical activity levels (Duncan *et al* 2005; Springer *et al* 2006). Hohepa *et al* (2007) identified a strong positive correlation to perceived peer support and lunchtime physical activity among primary school children in England. On the other hand, negative peer experiences such as verbal abuse are inversely associated with physical activity levels (Gray *et al* 2008). Consequently, children who receive criticism about their weight are less likely to engage in physical activity compared to their normal weight peers (Storch *et al* 2007). As a result of this influential nature, positive peer networks should be utilised when attempting to promote childhood physical activity (Salvy *et al* 2012).

2:1:4:2 Physical Environment

Acknowledging social determinants of childhood physical activity has multiple benefits, however the context in which health behaviours take place also requires exploration (McCormack et al 2004). Stokolos (1996) suggests that a social ecological perspective of behaviour is necessary to explore interactions between the individual, social and physical environment. The physical environment in relation to physical activity has been of interest since the 1980s, with research identifying the environment as having both a passive influence over physical activity, via the design of the urban environment and buildings, and an active influence, via the provision of accessible, safe, and appealing physical activity environments (Sallis and Glanz 2009).

Whilst there is substantial research that indicates an association between the built environment and physical activity in adults (Sallis and Glanz 2009; Davidson and Lawson 2006), the associations are less understood in children. Understanding this association is important given that children have less autonomy in their behaviours and are more likely than adults to be influenced by their environment (Panter *et al* 2008; McMillan 2005). Lack of pavements, long distances to schools and the need to cross busy streets can discourage children's engagement in physical activity (Sallis and Glanz 2009). Furthermore, rural children in the UK spend an average of 14-minutes being less sedentary than those from urban settlements (p = <.005) (McCrorie et al 2020). Physical environment research is being translated to the classroom environment in which school-aged children spend a large majority of their time. A study by Clemes *et al* (2020) introduced sit stand desks to 8 primary schools which resulted in a mean difference in sitting time of -30.6 minutes per day (95% CI: -56.42 to -4.84). Research conducted by Martin *et al* (2015) emphasises the importance of creating a cultural shift in the way in which classrooms are viewed, by creating 'active classrooms' it is hypothesised that teachers will be able to implement physical activity more frequently.

Children of low socio-economic status risk delays in developing their movement abilities (Hardy *et al* 2012) and it has been argued that children from deprived areas often have limited access to safe outdoor play or lack opportunities to engage in activities or sports that help to promote movement competency (Giagazoglou *et al* 2013, Goodway *et al* 2005, Spengler *et al* 2011). A cross-sectional study conducted by Noonan *et al* (2015) explored the correlation between neighbourhood characteristics and health-related variables. The study concluded that children living in highly deprived areas, quantified by neighbourhood walkability, had the least favourable health-related variables such as physical activity levels and cardiorespiratory fitness compared with children from moderately deprived areas. As previously noted, children who display lower movement competencies are likely to have lower levels of perceived ability and therefore disengage in physical activity (Stodden *et al* 2008). If children from deprived areas are less likely to engage in physical activity, they are likely to have lower self-perceived ability, which could be one possible explanation for the statistically significant negative correlation. Fortunately, targeted interventions have begun to work with children from low socioeconomic groups, or highly deprived areas, with the aim of reducing the health inequality gap rather than widen it further (Johnstone *et al* 2019).

2:1:4:3 Individual Factors

Whilst there is extensive literature that examines the social and environmental factors that influence childhood physical activity, little is known about individual factors that influence younger children's engagement in physical activity with most research focusing on adolescents and adults. Research aiming to investigate individual factors that may influence a child's physical activity engagement began to develop in the early 2000s. A study conducted by Humbert *et al* (2006) interviewed 160 children, aged between 12 and 18 years, and identified perceived competency as a key factor that either encouraged or discouraged their participants to take part in physical activity. Humbert and colleagues (2006) reported that feelings of confidence and skill were essential for the participants to have fun and significantly influenced their participation. On the other hand, participants who reported being made fun of, being picked last for a team or not being included had negative impacts on their attitude and subsequent engagement in physical activity (Humbert *et al* 2006). This is supported by the work of Lubans *et al (*2008) who note that self-efficacy is the most commonly assessed and supported mediating variable within physical activity interventions for youths.

In addition to enjoyment and self-efficacy, the differences between male and female engagement in physical activity has been evident in the research for decades, with lower levels of physical activity being consistently reported for girls compared to boys (Van Hecke *et al* 2016, Kalman *et al* 2015, Bucksch *et al* 2016). It's important to note that gender is considered multidimensional and includes gender roles, such as behavioural norms, gender relations and, gender identities (Johnson *et al* 2014). A qualitative study conducted by Vu *et al* (2006) noted that girls who engaged in regular physical activity were often referred to as tomboys. The female participants who did not frequently engage in physical activity reported that name calling and taunting from their male peers was influential in their reluctance to be more physically active (Vu *et al* 2006). Increasing girls physical activity level is a public health priority, however a recent review conducted by Biddle *et al* (2014) identified that most physical activity interventions aimed at improving childhood physical activity have produced only small overall effects on girl's physical activity.

2:2 Movement Skills

2:2:1 Fundamental Movement Skills

Physical activity research has faced critique for not focusing on the developmental nature of fundamental movement skills and the influence they have on physical activity engagement (Stodden et al 2008). Fundamental movement skills can be defined as:

"Basic learnt movement patterns that do not occur naturally and are suggested to be foundational for more complex physical and sporting activities" (Barnett et al 2016, p. 224).

Stodden *et al* (2008) note that previous work has primarily focused on measuring physical activity levels, without acknowledging that learning to move is an essential skill that underpins physical activity. During the lifespan a child's movement skills develop over six qualitatively different periods. These periods include reflexive, preadapted, fundamental movement, context-specific, skilful, and compensation (Clark 2005).

Suggested by Clarke in 2005, and widely accepted in the literature, reflexive and preadapted movement skills develop in early infancy, before children begin to develop fundamental movement skills. Fundamental movement skills are often referred to as the building blocks of movement (Clark 2005). They are broken down into locomotor (running, skipping), object control (throwing, catching) and stability skills (balancing, twisting) (Haywood at al 2009). Clark and Metcalfe (2002) note:

"The overall goal of the fundamental movement period is to build a sufficiently diverse motor repertoire that will allow for later learning of adaptive, skilled actions that can be flexibly tailored to different and specific movement contexts." (p.176).

If children are unable to run, jump and catch they lack the necessary skills to be active and will face limited opportunities for engagement in physical activity. (Balyi et al 2013). Whilst it is of common belief that children naturally learn FMS, many children cannot perform FMS proficiently (Lawson *et al* 2021), as measured by the Test of Gross Motor Development (TGMD). As a result, an increasing number of children are displaying poor levels of movement skill competency as they get older (Malina 2008).

During childhood the central nervous system matures at an accelerated rate, creating a heightened neural plasticity which allows for greater skill acquisition (Borms 1986). This unique time frame offers the potential for children to improve FMS and neuromuscular coordination (Lloyd *et al* 2014). As children reach puberty the volume of grey matter in the brain decreases, making it harder for adolescences to develop new motor skills (Gogtay *et al* 2004). This highlights the years of 7 to 11 in early childhood, when a child is key-stage two, as a vital period for developing FMS and improving movement skill competency (Faigenbaum *et al* 2013).

The Youth Physical Development Model, developed by Lloyd and Oliver (2012) shown in Figure 2:1, indicates the physical qualities children should be developing based on their age. Those qualities that are presented in larger text are deemed to be the most important. The figure helps to depict the importance of FMS in early and middle childhood for both boys and girls, with it becoming less of a priority, although still important, as children reach adolescents.

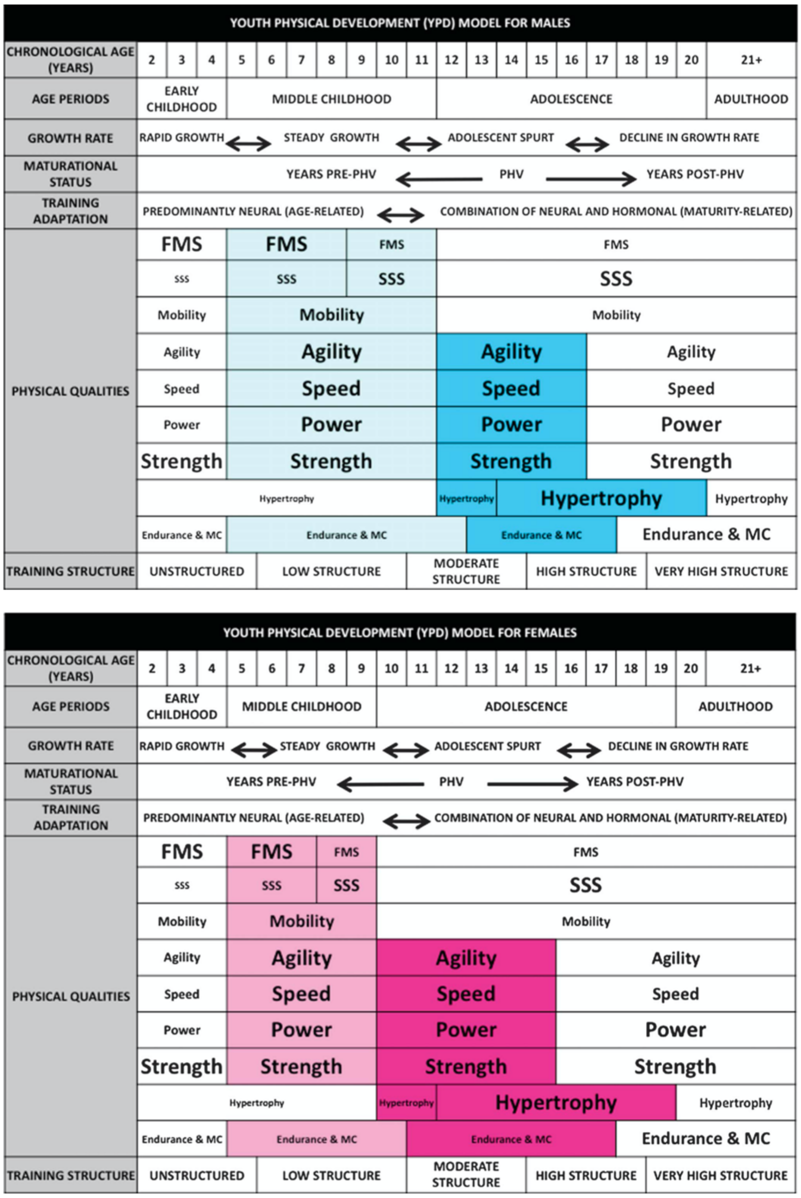

Figure 2:1 The Youth Physical Development Model, Lloyd and Oliver (2012): Font size refers to importance; light pink boxes refer to preadolescent periods of adaptation, dark pink boxes refer to adolescent periods of adaptation. FMS = fundamental movement skills; MC = metabolic conditioning; PHV = peak height velocity; SSS = sport-specific skills; YPD = youth physical development.

2:2:2 Movement Skill Competency

The fundamental movement period ends when the child's FMS successfully become context-specific movements (Clark 2005). The context-specific period, thought to begin around the age of seven when children show significant cognitive development, is a transition from fundamental movement skills to the skilful period (Clark 2005). Once mastered, movement in the skilful period is performed with consistency and efficiency both physiologically and psychologically (Clark 2005). The importance of exposing children to a wide variety of movement experiences during this time has been noted by Baker *et al* (2003). This is supported by Abernethy *et al* (2005), who suggest a wide range of physical activities should be available to children, particularly activities that involve whole-body movements which encourage the child to move through different planes of movement and recruit large muscles groups, in order to allow for movement skills to be learned, developed and transferred.

The process of a child developing these skills throughout childhood contributes to a child's physical literacy (Whitehead 2013). For a child to become physically literate, FMS must be adequately learnt to develop a good level of movement skill competency. The physically literate child will then be able to effectively utilise a wide range of movement skills dependent on the environment they are in (Whitehead 2013). In addition to physical movement ability, physically literate children also have a greater knowledge and understanding of physical activity including its importance and benefits (Sport England 2020b). These physically literate children, who demonstrate greater movement competency, are more likely to engage in higher levels of physical activity compared to children with less proficient movement skills (Castelli *et al* 2015).

2:2:3 Foundational Movement Skills

It has recently been suggested by Hulteen *et al* (2018) that the term fundamental movement skill is too narrow and does not include all of the skills that may help to promote physical activity engagement throughout the life course. Instead, Hulteen and colleagues (2018) introduce the concept of foundational movement skills and position this as an umbrella term that better reflects the wide variety of skills an individual should develop competency in. Foundational movement skills can be defined as goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active and can be developed to enhance physical activity participation and promote health across the lifespan (Hulteen *et al* 2018). Hulteen *et al* (2018) suggest foundational skills can be advanced or adapted for more context-specifc applications across the lifespan, which help to promote long-term engagement in physical activity.

2:2:4 Determinants of Movement Skill Competency

2:2:4:a Perceived Movement Skill Competence

Perceived movement skill competence, defined as an individual's perception of their actual movement skill competency, is a developmental concept that changes across time (Harter *et al* 2006). From age seven, and with newly developed cognitive abilities, children's perceived competence accurately reflects their actual competency (Harter 2006). Perceived competence is an important determinant of a child's behaviours and actions (Deci and Ryan 2012). Children with high perceived competence often have higher self-esteem, exert more effort, and select challenging tasks (Weiss and Amorose 2005). Consequently, it has been suggested that children with good movement skills have high perceived competence, view tasks as less difficult and will frequently attempt them (Deci and Ruan 2012). On the other hand, children with poor movement skills have lower perceived competence, and are less likely to engage in physically demanding activities (McCullough *et al* 2009).

Jekauc *et al* (2017) suggests that the relationship between physical activity, movement ability and perceived movement skill competency is circular in that well-developed movement skills lead to good performance and positive feedback, which are related to positive emotions and motivation to perform physical activity (Wienke and Jekauc 2016; Jekauc 2015). Perceived movement skill competence is therefore an important mediating variable that influences the relationships between movement skill development and physical activity engagement over time (Stodden *et al* 2008). The lack of longitudinal research in this area presents an interesting conundrum which raises the question as to whether interventions should either aim to improve actual movement skill competency, treating improved self-perception and increased engagement as secondary outcomes, or instead treat self-efficacy as the primary outcome, with increased engagement and improved actual movement skill competencies as secondaries. Investigations over a longitudinal period are warranted to explore how these variables influence one another further.

2:2:4:b Enjoyment

Previous research has identified enjoyment as being a key determinant of physical activity engagement (Gao et al 2012, Hagberg et al 2009, Cariney et al 2012). Physical activity enjoyment, a psychological experience characterised by fun and pleasure, can be influenced by intensity, how a child perceived success and failure, as well as emotional state (Gao et al 2012, Smith and St Pierre 2009). Researchers have emphasised the importance of enjoyment by suggesting it should be treated as a primary outcome when designing physical activity programmes for children (McKenzie *et al* 2004; Webber *et al* 2008). To date, research on enjoyment has predominantly investigated the impact is has on physical activity engagement or alternatively how enjoyment interacts with self-efficacy. The work of Jakauc *et al (*2017), for example, suggests that children who have poorly developed movement skills may perform poorly and experience negative emotions as a result, which can disengage children from participation due to lack of enjoyment. Given the associations between enjoyment a physical activity, it must be considered that enjoyment may influence movement skill competency too.

2:2:4:c Strength

It has previously been suggested that muscular strength is critical for the successful development of movement competency (Behringer *et al* 2011). More recently this has been supported by The United Kingdom's Strength and Condition Association (UKSCA) position statement on youth resistance training, which suggests that strength training may have a positive impact on movement skill (Lloyd *et al* 2014). Studies have identified positive impacts of strength training on indicators of movement skill such as squatting (Lloyd *et al* 2016), jumping (Alberga *et al* 2015) and throwing (Hummami *et al* 2017). However, there is often an over reliance on using resistance machines to develop strength that are not commonly available in primary school settings (Grainger *et al* 2020).

Grainger *et al* (2020) studied the effect on strength training on movement skill in 72 children aged between 10-11. Movement ability was measured using the Canadian agility and movement skills assessment (CAMSA), with strength being measured using a dynamometer for upper body and countermovement jump for lower body. Their findings suggest that children who completed bi-weekly sessions of strength training displayed improved movement skill and strength 4 weeks later. In 2019, Pichardo *et al* demonstrated that movement skill competency, measured using the RTSB was associated with isometric-mid thigh pull force in 108 adolescent boys aged 13-14 years. Boys with low strength scores were nearly eight times more likely to score poorly in the RTSB compared with their peers who demonstrated high levels of strength (Pichardo *et al* 2019). Given the small, same-sex sample of participants included in the research, future research exploring the relationship between strength and movement skill competency is warranted.

2:2:4:d Socio-Economic Status

Socio-economic status has been identified as a determinant of physical activity that predisposes, enables or reinforces physical activity behaviour (Inchley *et al* 2005; Hardey *et al* 2012). Despite this, there is a lack of research that aims to investigate how socio-economic status and deprivation may impact movement skill competency of primary school aged children in England. In the United Kingdom the socio-economic status of a child is frequently calculated using the Indices of Multiple Deprivation, each postcode is assigned a number which is calculated using data from household income, employment, health and disability, education, and the living environment (Noble et al 2007). Research from Australia suggests that children who are classified as being of a low socio-economic status have a greater chance of experiencing delays to their movement skill development (Hardy *et al* 2012). Furthermore, children from deprived areas are considered to have limited access to safe outdoor play areas and lack of opportunities to engage in activities that help to promote and develop movement skill competency (Goodway and Smith 2005; Goodway *et al* 2010).

In the United Kingdom, research exploring the relationship between socio-economic status and movement skill competency has predominantly focused on pre-school aged children (Foulkes *et al* 2015, Eyre *et al* 2015, Roscoe *et al* 2019). However, a study conducted by Morley *et al* (2015) concluded that out of 369 children (176 females, 193 males, aged 5.96 ± 0.57 years), participants from high and middle socioeconomic backgrounds scored an average of 34.8 ± 13.8 and 32.7 ± 10.5 respectively using the Bruininks-Oseretsky Test of Motor Proficiency, compared with their peers from low socioeconomic backgrounds who scored an average of 26.2 ± 8.2 ($p=<.001$, ES = 0.16). The results of this study, in addition to the lack of research investigating this relationship in primary-school aged children in England, provide a strong rationale for future research in this area.

2:2:5 Measurement of Movement Skills

Research exploring children's movement skills has traditionally focused on product-oriented assessments which measure outcome of performance, such as distanced jumped or total amount of objects successfully caught (Collins et al 2019; True et al 2017). More recently, there has been a distinct move towards process-orientated assessments. Movement skill competency screens assess the qualitative aspects of movement, examining an individual's movement pattern and the ability to move effectively, therefore making them a process-oriented assessment (True et al 2017). Existing movement screens for children, such as the Test of Gross Motor Development-2 (TGMD-2) are focused on measuring fundamental movement skills such as running, jumping, and throwing (Cools et al 2011; Ulrich 2000). However, in order to assess and develop more complex movements, developed within the context-specific and period, screens that go beyond the traditional FMS exercises are required (Pullen et al 2021).

The Functional Movement Screen (FMS) developed by Cook et al (2006) comprises seven movements ranging from a deep squat to an active straight leg raise. The FMS screen gives a score of 0-3 for each exercise, if the participant scores a 3 on the first repetition, they do not have to complete anymore which means the researcher is unable to determine if the participant moves well consistently. The Athletic Ability Assessment (AAA), introduced by McKeown et al (2014) is a movement screen designed to assess movement ability in athletes alongside performance. The screen aimed to determine the ability of athletes but has since been adapted as the Fundamental Gross Athletic Movement Assessment for use in youth populations. A key strength of this adapted screen is that the scoring criteria recognises the importance of movement variability using a grading system, positioning it as a more suitable screen to use with younger and untrain populations (Pullen et al 2021). The Resistance Training Skill Battey (RTSB) is a movement screen specifically designed for use in a school setting (Lubans et al 2014). The screen is comprised of six movements that involve bilateral, unilateral, pushing and pulling. The RTSB has been adapted for use in young populations, with researchers reporting good inter-rater and intra-rater reliability (Bebich-Philip et al 2016).

The Athletic Introductory Movement Screen (AIMS) is the most recent screen to emerge in the literature and consists of four exercises which involve lower body bilateral and unilateral, upper body push, anti-rotation, and core bracing (Rogers et al 2019). The importance of including stability skills within movement screens has been highlighted by Rudd et al (2015), who suggest that children’s stability should be assessed and developed alongside the other key movement skill competencies. AIMS adapts the performance criteria used in the AAA (McKeown et al 2014) and some of the movements from the RTSB (Lubans et al 2014). The screen is one of the only process-orientated measurements to assess participants across multiple repetitions, capturing movement from both the frontal and sagittal view, which allows the researcher to assess consistency. The adaptations from the RTSB and AAA allows for the AIMS to be quicker and easier to implement with large cohorts of children due to the number of exercises included and the limited equipment needed.

2:3 Sedentary Behaviour

2:3:1 Definition, Guidelines and Prevalence

Sedentary behaviour can be defined as behaviour that occurs when an individual is engaging in an activity that requires minimal movement and energy expenditure (Department of Health 2010). Sedentary behaviour is characterized by long periods of time spent sitting down and can include activities such as television viewing, computer use, mobile phone use and gaming, and is quantified as any activity that equates to <1.5 METs (Pate et al 2011; Shakir et al 2018). It is important to note that sedentary behaviour should not be defined as failure to be physically active, as an individual can be highly sedentary but still meet physical activity recommendations (Pate *et al* 2011). Therefore, it is important to recognise sedentary behaviour as a distinct construct from physical activity with its own independent links to health outcomes.

Research has established associations between increased time spent in sedentary behaviours and the increase prevalence of childhood obesity (Trioano *et al* 2008; Rey-Lopez et al 2008). Self-reported and objectively measured indicators of sedentary behaviour consistently show that sedentary behaviour is high among children and increases with age (Pate *et al* 2011; Carson et al 2016). Research from the British Heart Foundation (2017) indicates that boys and girls in England are spending 4.2 hours and 3.3 hours, respectively, in sedentary behaviours per day. It has been suggested by Pate *et al* (2011) that the availability of electronic forms of entertainment such as television, the internet and mobile phones have negatively impacted sedentary behaviour patterns.

Being sedentary for more than two hours a day has been consistently associated with unfavourable body weight, decreased fitness, low self-esteem and decreased academic achievement (Tremblay *et al* 2011). Furthermore, research has identified sedentary behaviour as being associated with an increased risk of cardio-metabolic disease, all-cause mortality and multiple physiological and psychological problems independent of physical activity levels (Treuth *et al* 2009; Owen *et al* 2009; Katzmarzyk *et al* 2009). As a result of this, Trembley *et al* (2012) highlights the importance of attempting to both increase physical activity whilst decreasing sedentary behaviour.

2:4 School Settings and Classroom Environments

2:4:1 Physical Activity within School Settings

The World Health Organisation (2012) identify schools as primary sites for health interventions due to their ability to reach the vast majority of school aged children. On average, children spend 30 hours per week in school, positioning the school environment as a feasible setting for delivering movement and physical activity interventions (Public Health England 2020). However, primary school children spend the majority of their school day being sedentary (Abbott *et al* 2013). In 2019, the United Kingdom's Ministry of Education suggested that primary schools should be providing their pupils with 30 minutes of physical activity per day in addition to breaktime and lunchtime. Didactic teaching, the one-way transfer of information with minimal feedback, is frequently used throughout primary school classrooms in England (Harris 2019). The choice to use such methods is strongly influenced by both traditional expectations and a culture of performativity within primary schools (Hall *et al* 2009). Such teaching methods, commonly used to help students learn and recall knowledge, often involve large periods of time being seated and inactive (Nettlefold *et al* 2011).

In addition to sedentary teaching practices, opportunities for physical activity outside of the classroom, such as breaktimes and physical education, have decreased as a result of increased focus on academic performance (Hardman and Green 2011). This is worrying given the growing body of evidence that suggests sedentary behaviour can pose detrimental risks to children's health, independent of physical activity levels (Biddle *et al* 2004; Santos *et al* 2013; Coombs and Stamatakis 2015). Moreover, increased levels of physical activity during the school day have been associated with improved cognitive function (Watson *et al* 2017; Donnelly *et al* 2016), increased time-on-task behaviour (Mahar *et al* 2006; Grieci *et al* 2009) and overall academic achievement (Singh and Uijtdewilligen 2012; Daly-Smith 2018).

2:4:2 Classroom Based Physical Activity Interventions

In order to tackle the issue at hand, interventions are being designed and implemented to reduce sedentary behaviour and increase physical activity within primary school classrooms. Watson *et al* (2017) identify three different types of classroom based physical activity interventions: (1) activity breaks, (2) curriculum-focused activity breaks and (3) physically active lessons. Activity breaks involve breaking up a lesson with short bouts of activity, not related to the subject being taught (see Ma *et al* 2015; Mead *et al* 2016; Schmidt *et al* 2016). Curriculum-focussed active breaks comprise of the same structure, but the activity is related to the subject being taught (see Goh *et al* 2016; Carlson *et al* 2015; Howie *et al* 2015). Finally, physically active lessons integrate movement into the teaching and learning process itself (see McCrady-Spitzer *et al* 2015; Riley *et al* 2016; Beck *et al* 2016).

Whilst all three types of intervention aim to improve physical activity and introduce movement into the classroom, they differ in approach and can therefore offer different benefits. For example, Quarmby *et al* (2018) note that physically active lessons encourage a paradigm shift in teaching practices, emphasising a more constructionist, problem-based learning approach in which teachers facilitate learning through physical activity. This type of paradigm shift is supported by O'Riordan (2016), who notes the current education system positions students as passive recipients instead of active agents in their own learning, thus failing to facilitate the social construction of knowledge. Daly-Smith *et al* (2018) identified teachers' perceptions of how parents expect their child to be taught during lessons as a barrier to implementing physically active lessons. The same study identified further barriers to implementation such as teachers being unable to assess or monitor what the children had learnt during the physically active lesson, as well as concerns regarding adding extra work to an already busy schedule (Daly-Smith *et al* 2018).

An alternative to physically active learning can be found through physically active breaks. Physically active breaks can either be directly related to the content being taught or completely unrelated. The daily mile, an idea which was introduced by a headteacher in

Scotland, is a recent example of a non-curriculum related physically active break which encourages all primary school children to walk or run a mile at some point throughout the school day. Teachers are encouraged to take their children outside for 15 minutes of physical activity a day, with those who run for the full 15 minutes likely to have completed a mile. In order to understand teacher's perceived barriers and facilitators to implementing the daily mile, Malden and Doi (2019) conducted semi-structured interviews with 13 teachers who were currently implementing the daily mile. Their results indicated that whilst teachers were positive about the effects the daily mile had on their children's fitness levels, barriers to implementation such as weather and time constraints prevented them from completing the daily mile every day. Furthermore, the majority of participants noted that getting the children ready to go outside was time consuming and reduced the amount of time they could spend teaching other subjects on the curriculum (Malden and Doi 2019). A recent study by Marchant et al (2020) noted that whilst teaching staff generally perceived the daily mile as a positive intervention, children often got bored quickly and wanted more variety. A review conducted by Fairhurst et al (2017) concluded that:

"Whilst measures to increase physical activity should be encouraged, initiatives should seek to make activity fun, engaging for all, varied, and should improve physical literacy through developing skill, co-ordination and confidence. Where additional time is made available, structured play is therefore preferable to the Daily Mile in increasing levels of physical activity in primary school children." p84.

It may therefore be the case that physically active breaks inside the classroom overcome the pedagogical barriers faced by physically active lessons and the practical barriers faced by physically active breaks outside of the classroom.

2:5 Behaviour Change

2:5:1 Defining Behaviour

Although research has identified negative physical and psychological health consequences associated with low levels of physical activity, there is strong evidence to suggest even a small change in behaviour can have a substantial effect on population health outcomes (National Institute for Health and Clinical Excellence 2010). Therefore, understanding the behaviour and the context in which it occurs is essential for developing effective evidence-based health behaviour change. However, in order to do so, behaviour itself needs defining. As a result of a multidisciplinary consensus study of theories of behaviour change, Hobbs *et al* (2011) defined behaviours as being anything an individual does in response to internal or external events, they are physical events that occur in the body and are controlled by the brain. Expanding on this, it has been suggested that actions can be overt such as motor or verbal and are measured objectively, or covert such as physiological responses which are often collected using subjective methods (Davis *et al* 2011).

2:5:2 Behaviour Change Interventions

Behaviour change interventions are fundamental in the efforts to improve public health, given that behaviour change is often dependent on the implementation of evidence-based practice. Behaviour change interventions can be defined as coordinated sets of activities designed to change specific behaviour patterns (Davis *et al* 2014). Despite this, interventions are often based on implicit common-sense models of behaviour (Cameron *et al* 2020). Even when intervention models are used together, they exclude potentially important variables as a result of not accounting for a full range of possible influences. For example, the Health Belief Model is composed of four main perceived components, susceptibility, severity, benefits, and barriers. An individual is likely to change their health behaviour if they perceive the threat of severity and susceptibility to be high enough, along with the benefits of changing to the health behaviour being worthwhile (Janz and Becker

1984). However, this is critiqued by West and Brown (2014) for failing to address the important roles of habit, self-control, impulsivity, and associative learning. This is problematic given that habits, for example, are highly prevalent and structure most of our everyday life (Wood *et al* 2014), particularly when focusing on physical activity (Rebar 2016).

2:5:3 The UK National Institute for Health and Clinical Excellence (NICE): Public Health Guidance of Behaviour Change

In 2008, the National Institute for Health and Care Excellence (NICE) identified evidence-based principles of behaviour change. Within the guidelines, it was noted that three specific recommendations were highly relevant to those interested in understanding and promoting individual level behaviour change. Those recommendations included (1) education and training, (2) psychological targets to be considered when designing individual-level interventions and (3) the importance of planning intervention evaluations such that they contribute to the understanding of causal processes underlying effectiveness (Abraham *et al* 2008).

In addition to the guidelines a set of core competencies were put forward, suggesting that any researcher attempting to design and implement a behaviour change intervention should be able to:

- Critically evaluate the evidence for different approaches to behaviour change
- Design, implement and evaluate valid and reliable interventions working in partnership with members of the target population and those with local knowledge, taking account of the social, environmental, and economic context of behaviours
- Identify and use appropriate outcome measures to assess changes in behaviour and employ a range of behaviour change methods and approaches, according to the best available evidence

The NICE guidelines finish with recommendation for future behaviour change research, which firstly suggest that evaluation of behaviour change interventions should be reported in detail and in a standardised manner. Secondly, the guidance recommends that research should collect adequate baseline data and post-intervention data of both behavioural and health outcomes. Finally, there is emphasis placed on cost effectiveness and external validity, suggesting that interventions should be designed to be easy to implement and sustainable in routine practice as failure to do so can result in a lack of adoption and effectiveness.

2:5:4 An Introduction to the Behaviour Change Wheel

The Behaviour Change Wheel (BCW) emerged as a result of a systematic review that analysed behavioural theories and intervention frameworks in relation to a usefulness criterion (Mitchie *et al* 2015). This analysis was the first of its kind to develop a new framework constructed from existing frameworks in an explicit attempt to overcome their previously noted limitations. A total of 19 frameworks were identified, however no single framework covered a full range of intervention functions or UK policies, with only a minority being linked to a model of behaviour change and/or meeting the usefulness criterion (Mitchie *et al* 2015). As result, the BCW has established itself as important tool for the rigorous development of interventions (Gould *et al* 2017). Interventions aimed at mental health (Murphy *et al* 2014), hearing aid use (Barker *et al* 2016), smoking cessation (Fulton *et al* 2016; Tombor *et al* 2016) and physical activity (Cane *et al* 2012; Westland *et al* 2017) have used the BCW to systematically develop complex behaviour change strategies.

2:5:5 COM-B Model

The COM-B model developed by Mitchie *et al* (2011) is a behaviour system comprising of four components that interact with one another (see Figure 2:2) that sits at the centre of the BCW. The model offers a framework for mapping and understanding multiple factors that shape behaviour change, which in this case involves teachers integrating physically active movement breaks into the classroom (Mitchie *et al* 2011). The COM-B model offers a starting point to planning and designing interventions by encouraging researchers to analyse the current behaviour as well as barriers and facilitators to adopting a new behaviour by considering capability, motivation, and opportunity. The single-headed and double-headed arrows represent the possible influence between components in the system. For example, opportunity can influence motivation which can then influence behaviour.

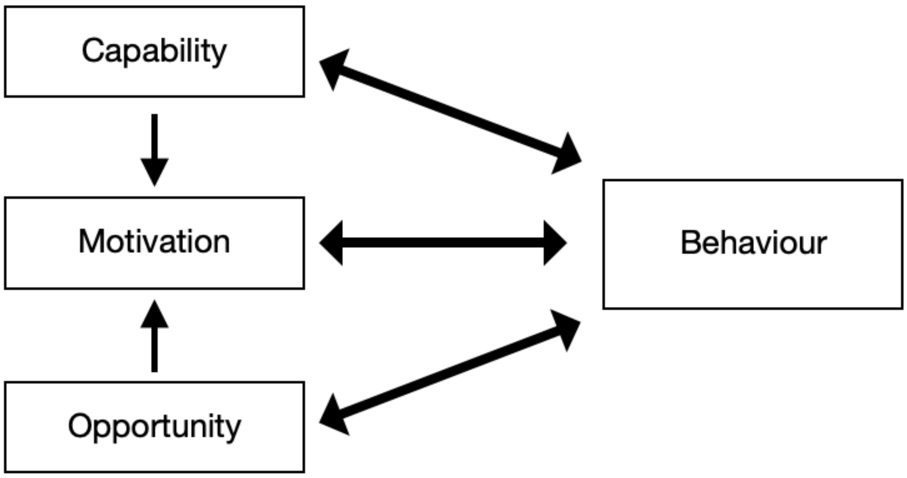

Figure 2:2 The COM-B Model, adapted from Mitchie *et al* (2011).

2:5:5a Capability (Psychological and Physical)

Capability is defined as "the individual's psychological and physical capacity to engage in the activity concerned, it includes having the necessary knowledge and skills" (Mitchie *et al* 2011, p.6). Capability is broken down into psychological capability, which relates to the ability to engage in the necessary thought processes such as comprehension and reasoning. Physical capability relates to physical skill, strength and/or stamina.

2:5:5b Motivation (Reflective and Automatic)

Motivation is defined as "all those brain processes that energise and direct behaviour, not just goals and conscious decision. It includes habitual processes, emotional responding, as well as analytical decision-making" (Mitchie *et al* 2011, p.6). Within motivation there are both reflective processes, which refer to evaluation and planning, and automatic processes which arise from associative learning and/or innate dispositions (Fishbein *et al* 2001).

2:5:5c Opportunity (Physical and Social)

Opportunity is defined as “all the factors that lie outside the individual that make the behaviour possible or prompt it” (Mitchie *et al* 2011, p.6). Opportunity can be distinguished between physical opportunities afforded by the environment, and social opportunities afforded by the cultural environment that dictates the way in which we think about things.

2:5:6 The Practical Application of BCW and COM-B

The creators of the BCW, Mitchie *et al* (2015), provide three comprehensive stages of intervention design each with their own set of steps guided by worksheets. Stage 1 is designed to help the researcher understand the behaviour by defining the problem, selecting, and specifying the target behaviour and identifying specifically what needs to change. Stage 2 involves exploring intervention options by evaluating intervention functions using an APEASE criteria (see Table 2:1). Finally, stage 3 encourages the researcher to identify behaviour change techniques to use within their chosen intervention functions.

Table 2:1 The APEASE criteria, taken from Mitchie *et al* (2011)

Criterion	Description
Affordability	How far can it be afforded when delivered at the scale intended?
Practicability	Can it be implemented as designed within the intended context, material, and human resources?
Effectiveness and Cost-effectiveness	How effective and cost-effective is it in achieving desired objectives in the target population?

Acceptability	How far is it acceptable to all key stakeholders?
Side-Effects/Safety	How far does it lead to unintended adverse or beneficial outcomes?
Equity	How far does it increase or decrease differences between advantaged and disadvantaged sectors of society?

The COM-B model addresses some gaps in existing behaviour change theories, such as those identified within the Theory of Planned Behaviour by including components that address habit, self-control, and impulsivity. The model includes both automatic and analytical processes within 'motivation' whilst 'opportunity' includes all factors external to an individual that either make the behaviour possible or prompt it. Finally, 'capability' includes all factors internal to an individual that contribute to their ability to perform a behaviour (Pinder *et al* 2018). A study conducted by Howlett *et al* (2019) examined the constructs of capability, opportunity, and motivation from the COM-B model and their predictive validity on moderate-to-vigorous physical activity. Using a prospective survey design, 186 healthy adults completed questionnaire measures representing the BCW and COM-B framework, before completing measures representing physical activity levels one-week later. The results suggested that psychological capability and reflective motivation were the two stronger predictors of physical activity amongst participants, and the COM-B model is useful for predicting physical activity (Howlett *et al* 2019).

2:6 Process Evaluations

2:6:1 Translating Research into Practice

The gap between development of effective interventions and the wide-scale adoption of these interventions in real-world settings has been reported since the early 2000's (Durlak and DuPre 2008; Glasgow and Emmons 2007). Research has been critiqued for failing to report details on context, in addition to clarity of implementation making it difficult for interventions to be replicated (Durlak and DuPre 2008). Implementation has been defined as a "specific set of activities designed to put into practice an activity or programme of known dimensions" (Fixsen *et al* 2005, p. 5). This encompasses all aspects of the process of intervention delivery including the extent to which an intervention and its elements are implemented as planned, how much of the intervention is delivered or received, how responsive participants were to the intervention and changes made to the intervention during implementation that enhance its fit within the setting it is being delivered in (Durlak and DuPre 2008; Naylor *et al* 2015). It has been argued by Durlak and DuPre (2008) that in order to bridge the gap between developed and adoption of effective physical activity interventions on a scale broad enough to promote large scale health changes, there is a critical need to understand factors related to intervention implementation. Understanding these factors within school-based settings is often more challenging due to the notion of schools and the education system itself sitting within a constantly changing broader context (Butler *et al* 2010; Newland *et al* 2013).

Given what is currently know about the low childhood physical activity rates levels in the UK, the need to bridge the gap is urgent. Naylor and McKay (2008) argue that effective physical activity interventions, delivered in settings where children learn, are an important part of the solution. In addition to having the potential to improve multiple health outcomes, there are also many direct benefits to the learner and learning environment such as improved classroom management (Mahar *et al* 2006) enhanced cognitive function (Donnelly *et al* 2011) and improved self-concept (Strong *et al* 2005). In addition to this, multiple systematic reviews demonstrate the efficacy of school-based approaches

(Dobbines *et al* 2013; Love *et al* 2018; Lai *et al* 2014). However, a systematic review conducted by Naylor *et al* (2015) identified an urgent need for more school-based physical activity studies that assess implementation through comprehensive process evaluation.

It is clear from the evidence reviewed so far that there is a cause-and-effect relationship between physical activity interventions and levels of childhood physical activity. Despite this, there is a distinct lack of research that addresses the translatability of the research into health promotion practice or its impact on public health (McGoey *et al* 2015). It has been argued that existing research and subsequent reviews have focused on the internal validity of childhood physical activity interventions, thus neglecting issues related to external validity (McGoey *et al* 2015). This is problematic given that the translation from research to practice presents a variety of barriers for both researchers and practitioners to consider, particularly where the school and classroom environments are concerned (Austin *et al* 2011).

In 2008, the Medical Research Council identified the need for guidance on process evaluations, recognising their importance for assessing fidelity, quality of implementation and identifying contextual factors associated with variation in outcomes (Criag *et al* 2008). As noted by Ciseell and Steckler (2004), an intervention may have limited effects due to weaknesses in design or because it was not properly implemented. On the other hand, positive outcomes can sometimes be achieved despite an intervention not being implemented as intended (Moore *et al* 2013). Therefore, process evaluations aim to capture details on whether the intervention was implemented as intended and the quantity of intervention implemented. In addition to what was delivered, process evaluations identify how the intervention was delivered (Carroll *et al* 2007). This provides policy makers and practitioners with vital information about how the intervention might be replicated, as well as providing general knowledge on how to implement a complex intervention within a specific setting. As Oldenburg *et al* stated in 1999, pp123:

> *"The benefit of any health intervention is determined not only by its efficacy and effectiveness, but also by the extent to which it is appropriately adopted and implemented"*

2:6:2 The RE-AIM Framework

The RE-AIM framework developed by Glasgow *et al* (1999) is a health promotion evaluation framework that enables complex settings-based interventions, such as those in school settings, to be comprehensively evaluated. As a result of this, the framework is frequently used to evaluate primary school physical activity interventions (Jenkinson *et al* 2012; Austin *et al* 2011; Collard *et al* 2010; De Meij *et al* 2008). The framework highlights the importance of both internal and external validity within translational research (Ory *et al* 2007). Importantly, the framework recognises that a behavioural change approach may work in theory, but it is necessary to understand how that approach will work in different populations and settings. In 2012, Kessler *et al* re-emphasised the importance of addressing all five components of the RE-AIM framework (reach, efficacy, adoption, implementation, and maintenance) in order to be maximally informative.

2:6:3 Interventions Aiming to Improve FMS, evaluated using RE-AIM Framework

2:6:3:1 Key Findings

The search for relevant literature was conducted using multiple electronic journal databases: PubMed, Scopus, Cochrane Reviews, Science-Direct and ProQuest. The search was limited to peer-reviewed academic journal articles published between 2001 and 2021. Search terms used included 'physical activity', 'fundamental movement skills', 'motor skills', 'movement skill', 'movement skill competency', 'intervention', 'randomised control trial', 'programmes', 'children', 'childhood', 'youth', and 'primary school'. Eligible studies were those that included: (1) the implementation of a fundamental movement or motor skill intervention; (2) a measure of movement skill competency; (3) children aged between 7-11.

Studies were excluded if they: (1) only described an intervention with no outcome data; (2) were not written in English; (3) were cross-sectional in nature; (4) didn't include a control group. To ensure only high-quality studies were reviewed, the 'Quality Assessment of Controlled Intervention Studies' (NIH) was used to evaluate the methodological quality of each study. Each study was given a score according to an adapted criterion of 8 items. The criteria assessed factors such validity and reliability of measures, adherence and reporting of actual probability/significance values, see Appendix 1.

All 16 studies evaluated concluded that at least one measurable foundational movement skill had improved significantly as a result of the physical activity intervention, see Table 2:2. Six out of the 16 studies measured physical activity as a secondary outcome variable. Four studies (Morano *et al* 2013; Van Beurden *et al* 2003; Salmon *et al*; Boyle-Homes *et al* 2009) reported that physical activity had significantly increased, whilst both studies conducted by Cliff *et al* (2007; 2010) reported neither an increase nor decrease of physical activity. Out of the seven studies that measured changes to BMI and/or body weight, six reported significant decreases (Korsten-Reck *et al* 2007; Morano *et al* 2013; Sola *et al* 2010; Steinberg *et al* 2013; Salmon *et al* 2008; Sollherhead *et al* 2006) whilst one did not (Cliff *et al* 2004). It is important to note that the interventions measuring BMI/bodyweight stated that reducing this outcome variable was one of the specific aims of the intervention itself. Finally, five interventions measured psychological outcomes, all of which reported significant improvements to at least one or more. These findings would therefore suggest that interventions aiming to improve fundamental movement skills and movement skill competency are successful at doing so. Furthermore, they have the potential to improve other health outcomes such as reducing in BMI/bodyweight, improved physical activity, and improved psychological health.

Table 2:2 Intervention Results

Method						Outcomes			
Author	**Sample**	**Intervention**	**Exercise Content**	**Control Group**	**Measure of FMS/MS**	**Movement Skills Improved?**	**Physical Activity Improved?**	**Decreased BMI or Body Weight?**	**Improved Psychological Outcomes?**
Van Beurden *et al* (2003) Australia	• N = 1045 • 7-10yrs • Boys and girls	• 1 year • 1 hour • 1x/week • Lead by PE teachers • Conducted during PE lessons • Follow Up: Unclear	Fundamental movement skills: vertical jump, leap, sprint run, kick, catch, throw and balance Whole-school approach. Online website for teachers and parents	9 intervention schools, 9 control schools (received no additional information)	NSW DET (FMS): Balance, sprint run, vertical jump, kick, hop, catch, throw and slide	**Yes** Highly significant improvement for all skills combined (p=.0001).	**Yes** Significant increase in PA compared to control schools (p=.008).	N/M	N/M
Sollerhead *et al* (2006) Sweden	• N = 132 • 9-12yrs • Boys and girls • NW • Mean BMI = 86	• Unclear • 40 minutes • 4x/week • Lead by PE teachers • Conducted during PE lessons • Follow Up: 3 years	Variety of indoor and outdoor exercises were encouraged. Overweight children were offered an additional lesson per week.	Received no intervention	EUROFIT testing battery (sit ups, broad jumps, sit and reach, handgrip test), plus rope skipping and ball bouncing.	**Yes** Significant differences in motor skills between experimental group (0.57) compared with control group (-0.65) (p=<.01).	N/M	**Yes** Changes in BMI were significantly better in the experimental group (-0.32) compared to control group (0.25) (p=<.03).	N/M

Cliff *et al* (2007) Australia	• N = 13 • 8-12yrs • OW/OB • BMI: 24.81±3.1 kg/m² • Boys and girls	• 10 weeks • 2 hours • 1x/week • Lead by PE teachers • Conducted at after school club • Follow up: 9 months	Locomotor Skills: Run, gallop. hop, leap, horizontal jump, slide Object Control: Ball strike, dribble, catch, kick, overhand throw, underhand roll	None	TGMD-2 (locomotor skills and objective control)	**Yes** Pre: 65.9±5.1 Post: 85.3±10.9 Follow-Up: 78.5±16.3 (p=<.001)	**No**	**No**	**Yes** Pre: 102.2±14 Post: 115.1±16.2 Follow-Up: 111.2±17.6 (p=<.002)
Korsten-Reck *et al* (2007) Germany	• N = 49 • 8-12yrs • OB • BMI: 90-97th percentile • Boys and girls	• 8 months • 1 hour • 3x/week • Lead by: NR • Conducted at community sports Hall • Follow Up: NR	Moderate to vigorous endurance training and motor skills: Focused on coordination, flexibility, performance and strength Dietary/behavioural education & parental activities/homework	None	AST: Speed, aerobic capacity, strength and coordination (20m sprint, push up, ball throw, one leg balance)	**Yes** Push up, sprint and throw significantly improved (p=.0001). Single leg balance *did not.*	N/M	**Yes** Significant decrease in fat mass from 47.5% to 43.8% (p=<.0001).	N/M
Salmon *et al* (2008) Australia	• N = 268 • 8-10yrs • NW • BMI: avg 3.4 boys, 2.6 girls	• 1 year • 1 hour • 1x/week • Lead by PE teachers • Conducted during PE lessons • Follow Up: 12 months	Game based physical activity, aiming to develop fundamental movement skills. Inside and outside environment. Implemented behavioural change approaches to physical activity	Received behavioural intervention, or FMS and behavioural intervention, or no intervention	FMS: A manual for classroom teachers (overhand throw, strike, kick, sprint run, jump)	**Yes** Girls improved their FMS significantly (.78) (p=.001). No significant difference for boys.	**Yes** Children in FMS group spent 7.8min per day more in MVPA than control (p=.01).	**Yes** Intervention group decreased BMI units by -1.88 on average (p=.01).	**Yes** Children in FMS group reported higher average enjoyment scores (+.18) than control group (p=.01).

Foweather *et al* (2008) United Kingdom	• N = 34 • 8-9yrs • Boys and girls	• 9 weeks • 1 hour, • 2x/week • Lead by sport coaches • Conducted at after school club • Follow Up: NR	Gamed based physical activity. Fundamental movement skills: vertical jump, leap, sprint run, kick, catch, throw and balance	Received no additional information	Vertical jump, leap, sprint run, kick, catch, throw and static balance	**Yes** Balance Pre: 36.8 Post: 89.5 (P=.005).	N/M	N/M	N/M
Akbari *et al* (2009) Iran	• N = 40 • 7-9yrs • Boys	• 8 weeks • 1 hour • 3x/week • Follow up: NR	Sessions included a warm up, a selection of exercises follow by a cool down. No further information.	Received no intervention	TGMD-2 (locomotor skills and objective control)	**Yes** Participants in the experimental group improved overall fundamental movement development by a mean of 17.2 (p=<.001) compared to control group.	N/M	N/M	N/M

Boyle-Homes *et al* (2009)	• N = 1464 • 9-11yrs • Boys and girls	• 1 school year • 30 minutes • 2x/week • Lead by PE teachers • Conducted during PE lessons • Follow Up: 1 year	Specialised PE programme to develop knowledge, motor skills and behaviours associated with an active lifestyle.	Received no intervention	Rubric created by researchers. Measured locomotor skills, posture and object control.	**Yes** Experimental group demonstrated greater motor skill ability in striking (4.02) and lifting and carrying (0.90) compared to the control group (p=<.001).	**Yes** Exprimental group reported greater total minutes of PA per day (169) compared to control (150). (p<.04).	N/R	**Yes** Experimental group reported higher self-efficacy scores (3.50) than comparison group (3.41) (p=<.01).
Cliff *et al* (2010) Australia	• N = 109 • 5-9yrs • OB • BMI z-score: 2.8±3.7 • Boys and girls	• 10 weeks + 3 month maintenance • 2 hours • 1x/week • Lead by PE teachers • Conducted at after school club • Follow up: 12 months	Locomotor Skills: Run, gallop. hop, leap, horizontal jump, slide Object Control: Ball strike, dribble, catch, kick, overhand throw, underhand roll Parental activities/homework	Received dietary program or received dietary and PA intervention	TGMD-2 (locomotor skills and objective control)	**Yes** Significant treatment effects of +11-13% in motor skill gains (p=.0001).	**No**	N/R	**Yes** Significant improvements at 6 months (+.21) and 12 months (=+.21) (p=<.0001).

Sola *et al* (2010) Norway	• N = 62 • 6-12yrs • OB • BMI: >30kg/m^2 • Boys and girls	• 40 weeks • 20 weeks 2 hours 2x/week • 20 weeks 1 hours, 2x/week • Lead by sports coaches • Conducted: Unclear • Follow Up: 12 months	Indoor and outside physical activity: Speed, agility, coordination, balance and strength	None	Test created by Fjortoft *et al* (20m run, shuttle run, broad jump, one leg jump, ball throw, climb)	**Yes** Significant improvements in broad jump (p=.07), climb (p=.001), agility run (p=.0001).	N/M	**Yes** Pre: 25.6±29.5 Post: 23.8-29.4 (p=<.0001).	N/M
Bakhtiari *et al* (2011) Iran	• N = 40 • 8-9yrs • Girls	• 8 weeks • 45 minutes • 3x/week • Follow up: NR	Sessions included a warm up, a selection of exercises follow by a cool down. No further information.	Received no intervention	TGMD-2 (locomotor skills and objective control)	**Yes** Significant differences between control/ experimental group. For locomotor skills (8.433) manipulation skills (10.951) and overall motor development (13.203) (p=<.05).	N/M	N/M	N/M

Ericsson *et al* (2011) Sweden	• N = 263 • 7-15yrs • Boys and girls	• 9 years • 45 minutes • 5x/week • Lead by PE teachers and sports coaches • Conducted in PE lessons and sports clubs • Follow up: 9 years	Encouraged to practice fundamental movement skills. Teachers, parents and sports coaches advised to encourage participation. Aim to help children feel motivated and to enjoy activity.	Received no intervention	MUGI checklist (balance, coordination and hand-eye coordination)	**Yes** Experimental group improved motor skills after 1 year (51% good motor skills to 73% with good motor skills).	N/R	N/M	N/M
Mitchell *et al* (2011) New Zealand	• N = 598 • 1-8yrs • Boys and girls	• Unclear length, frequency and duration • Lead by research assistants and teachers • Conducted during PE lessons • Follow Up: NR	Research assistants working with teachers to up skill them in teaching fundamental movement skills (kicking, catching, throwing). Encouraged children to identify specific movements they wanted to improve on.	None	TGMD-2 (locomotor skills and objective control)	**Yes** All skills measured significantly improved ($p=<.001$). Kicking, throwing and striking saw the biggest improvement (49.8%, 63.5% and 76.3% retrospectively).	N/M	N/M	N/M

Morano *et al* (2013) Italy	• N = 41 • 8-10yrs • OB • BMI: >95th percentile • Boys and girls	• 8 months • 2 hours • 2-3x/week • Lead by specialist PE instructors • Conducted at university sports hall • Follow Up: NR	FMS, muscle strength, power, aerobic fitness, speed and flexibility. Behavioural information session with parents 30min, 1x/week	None	TGMD-2 (locomotor skills and objective control), squat jump and sprint ability	**Yes** Boys Pre:67.82±11.31 Post: 76.55±15.73 Girls Pre: 66.05±14.66 Post: 79.47±12.74 (p=<.0001).	**Yes** Boys Pre: 2.15±0.51 Post: 2.48±0.69 Girls Pre: 2.15±0.40 Post: 2.49±0.49 (p=<.0001).	**Yes** Boys Pre: 2.2±0.36 Post: 2.19+0.36 Girls Pre: 2.00±0.31 Post: 1.93±0.34 (p=<.0001).	**Yes** Boys Pre: 17.77±3.05 Post: 18.86±2.82 Girls Pre: 16.63±2.59 Post: 18.31±2.94 (p=<.0001).
Steinberg *et al* (2013) Israel	• N = 29 • 6-14yrs • OB • BMI: 96.9%±2.3 • Boys and girls	• 6 months • 1 hour • 2x/week • Lead by youth coaches • Conducted at community sports hall • Follow Up: NR	Game based physical activity: Muscle strengthening exercises, balance, agility, coordination and aerobic endurance. Encouraged to participate in additional exercise	None	Postugraphic assessment: Stability index, weight distribution and falling index	**Yes** Stability improved (p=.05), falling index improved (p=.05).	N/M	**Yes** Boys Pre: 98.1±1.0 Post: 94.9±3.0 Girls Pre: 97.5±2.3 Post: 94.3±7.6 (p=<.05).	N/M
Beck *et al* (2016) Denmark	• N = 165 • 7-8yrs • Boys and girls • NW • BMI: 15.8 - 16.5 (weight/height[2]	• 6 weeks • 1 hour • 3x/week • Lead by teachers • Conducted during maths lessons • Follow Up: 8 weeks	Research assistants conducted 3 workshops with teachers to instruct them how to incorporate motor skills during maths lessons. Whole body movements such as	Received no intervention	Co-ordination wall: children instructed to match certain movements with numbers on the wall. Time taken to complete the	**Yes** Time taken to complete task reduced from 20.0 ±0.7 to 17.9±.07 and was sustained t follow up 14.7±.08 (p=<.05).	N/M	N/M	N/M

	skipping, crawling, throwing, balancing.	activity was recorded.	

2:6:3:2 Reach

Reach refers to the representativeness of the school and the settings or individual's willingness to participate in the study. Understanding how far an intervention reaches is vital given the increasing health inequalities across the UK. The majority of studies recruited participants through approaching schools, although the selection criteria was often unclear or not reported. Mitchell *et al* (2011) conducted a needs analysis to identify schools requiring additional help with teaching movement skills, although no further detail of the needs analysis was given. Understanding the characteristics of those who did not participate is important due to health interventions often failing to help those most in need, a concept known as the 'inverse care law' (Hart 1971). Consequently, despite aiming to narrow health inequalities, interventions can sometimes widen existing inequalities further (White *et al* 2009). Unfortunately, as with most research, there was a lack of data available about the schools and families who did not participate. All studies reported sample sizes, which ranged from 13 to 1464 with a median of 738. Conducting interventions in a school setting with both healthy weight and overweight/obese children therefore seems appropriate to increase the interventions reach through ease of access and lowered risk of stigmatisation.

2:6:3:3 Efficacy

Efficacy considers the effectiveness of the intervention at influencing primary outcome changes, as well as assessing whether positive or negative outcomes were experienced by individuals or within the school setting. Additionally, there is emphasis placed on taking a participant-centred quality of life perspective, an important consideration for any health intervention. For example, the intervention conducted by Sola *et al* (2010) reported that a number of participants dropped out of the study because they felt stigmatised by being involved, thus suggesting an inclusive approach to childhood obesity interventions, such as using body neutral language and positive communication to all pupils, is necessary (Pop 2014).

Five out of the sixteen studies aimed to improve a psychological outcome (Cliff *et al* 2007; Cliff *et al* 2010; Salmon *et al* 2008; Morano *et al* 2012). The psychological outcomes included enjoyment of physical activity, self-efficacy, perceived physical ability and perceived athletic competency. All five interventions reported significant improvements, finding positive associations between perceived physical abilities and movement skill and/or FMS competency. This supports the growing body of research that suggests individuals who perceive themselves to be competent at physical activity are more likely to report higher levels of physical activity engagement (Cliff *et al* 2010; Stodden *et al* 2008).

The intervention conducted by Ericsson *et al* (2011) asked participants which movements they would like to learn and which movements they would like to get better at. A similar aim was emphasised by Morano *et al* (2012) who encouraged a non-competitive environment in order to improve perceived athletic abilities and develop a positive attitude towards physical activity. The process of encouraging children to identify skills they need to learn helps to empower and engage children in the learning process, attributes which have been associated with improved learning experience and outcomes (Babbie and Moulten 2007).

Whilst all interventions reported at least one improvement in FMS or movement skill competency, it is important to consider how much of the improvement was a direct result of the intervention training. Controlling for potential confounding variables increases the chances of determining causality between exposure and outcome. For example, Cliff *et al* (2010) measured and controlled for levels of physical activity outside of the intervention using accelerometers. Ericsson *et al* (2011) notes that children's general development will often naturally improve FMS and movement skill competency to some degree. Controlling and adjusting for improvement effects as a result of maturation is a suitable way to account for this potential confounding variable.

Furthermore, it is also important to consider the variability in measures used to assess movement. Lack of heterogeneity between interventions aiming to improve both physical activity and movement skill has been highlighted by Daly-Smith *et al* (2018) who notes this makes it difficult to draw definite conclusions when reviewing the literature. The lack of a gold-standard tool to measure movement skill, in addition to the use of various process-orientated measures, such as the Gross Motor Development (TGMD) and product-orientated measures has been highlighted by Duncan *et al* (2020).

2:6:3:4 Adoption

Adoption refers to the acceptance of the intervention within the organisation and examination of factors that influenced that decision and is usually assessed by direct observation or surveys. It is viewed as good practice to report intervention location, characteristics, level of expertise of individuals who delivered the intervention and inclusion/exclusion criteria. Identifying who did not take part in an intervention is often just as important as understanding who did, as often the data can be affected by respondent biases. Therefore, understanding potential barriers to adoption is necessary in order to inform future research. For example, many studies require the availability of school sports facilities to use during the intervention, such as the study conducted by Foweather *et al* (2008), this may create a barrier to participation if the school don't have the correct facilities, or if the researchers are unable to access them. The majority of interventions (n=9) were delivered by PE teachers, although their qualifications or specialisations were not reported. A small number of interventions (n=4) were delivered by sport and/or youth coaches. One study, conducted by Van Beurden *et al* (2003) recruited school principals, teachers, parents, and health workers to deliver the intervention. This type of whole-school approach was used to enable a multi-component intervention that encouraged greater adoption by ensuring all stakeholders had an active role in the implementation and delivery (Van Beurden *et al* 2003)

2:6:3:5 Implementation

Implementation refers to the extent to which the participants completed and made use of the various components of the intervention including barriers and facilitators to implementation. Implementation often interacts with efficacy, with the belief that efficacy x implementation = effectiveness. The most commonly reported implementation element was intervention duration and frequency. Whilst nearly all studies reported duration, only one study reported actual intervention delivery time. Sollerhead *et al* (2006) noted that every session was guaranteed to last 40 minutes, with time to change and shower not being included. Implementation of an intervention can be explored in more detail using process evaluations.

Understanding study feasibility is another important element to the implementation process. The study conducted by Morano *et al* (2013) involved 9 specialist instructors delivering sessions three times a week, each two hours long. Whilst the intervention produced a significant change in both movement skill development and perceived physical abilities, it could be argued that recreating such conditions may not be feasible. Primary schools seem to be the most appropriate, and therefore frequently targeted, settings for MC/FMS interventions. PE lessons are often used to implement interventions, however as Sollerhead *et al* (2006) suggests, attempting to increase the frequency and duration of PE lessons conflicts with allocated time for other academic subjects. Foweather *et al* (2008) note that researchers should attempt to offer opportunities for FMS/MC development external to PE lessons alone. The study conducted by Beck *et al* (2016) negotiated these constraints well, by integrating their FMS/MC intervention during lesson time. They suggest:

"Teachers and researchers should consider integrating MC activity in learning activities relevant to the academic curriculum as a promising way to engage children, improve MC and improve academic achievement" pp12.

Physically active learning and active breaks have been utilised extensively by physical activity interventions, producing feasible positive outcomes for physical activity, weight/BMI and academic achievement (Watson *et al* 2017; Lander *et al* 2016; Khamablia *et al* 2012).

2:6:3:6 Maintenance

Lastly, maintenance refers to the extent to which schools and leaders maintained, continued, or planned to continue with the intervention. A small number of studies reported attrition rates. Ericsson *et al* (2011) and Boyle-Holmes *et al* (2009) reported a 10% and 18% attrition rate respectively, both noting participant relocation as the cause. Steinberg *et al* (2013) reported a 20% dropout rate, noting transportation issues to the training centre as the main reason. The highest attrition rate of 43.5% was reported by Sola *et al* (2010) who included overweight and obese participants only. Reasons for dropout included lack of support from parents, problems with transport to the training facility and experiencing feelings of stigmatisation for taking part in the intervention. Interventions conducted in schools tended to have a lower attrition rate, such as that conducted by Sollerhead *et al* (2006) who reported a 1% drop out rate.

At the individual level, follow up data is necessary in order to understand if changes have been maintained. Of equal importance are setting level measures designed to understand whether an intervention has been established in an institution's everyday routine. Eight studies reported follow-up data, ranging from 8 weeks (Beck *et al* 2016) to 9 years (Ericsson *et al* 2011). The most common follow-up period was between 9 and 12 months. Eight studies did not report any follow-up data which is problematic given the aim of each health intervention is to implement behaviour change over a longitudinal period of time. Consequently, without such follow-up information it is difficult to draw conclusions on whether an intervention has successfully done so or not (Van Beaurden *et al* 2003).

Two studies (Cliff *et al* 2010; Sola *et al* 2010) included a maintenance phase within their intervention. Including a maintenance phase helps to understand long-term behaviour change at both the individual and settings level whilst often improving sustainability (Glasgow *et al* 2004). Cliff *et al* (2010) included movement skill booster sessions, skill revision and student/facilitator feedback during the maintenance phase. By including a maintenance phase there is greater chance that both participants and practitioners will continue with their new behaviour (Schwarzer *et al* 2007). Interventions that prove to effective longitudinally are arguably the most appropriate for widespread scalability and translation (Lai *et al* 2014).

It is important to note the chasm between MC/FMS research and real-world settings. Ericcson *et al* (2011) note that teachers require more knowledge and training on MC/FMS interventions in order to help improve their efficacy and maintenance. This is supported by the work of Mitchell *et al* (2011) who notes that providing training and feedback to teachers improved motivation, sustainability, and engagement amongst teachers. A systematic review conducted by Lander *et al* (2016) concludes:

"It is clear that whilst teachers are capable of making substantial improvements in student outcomes in PA and FMS… teacher training component of school-based PA and/or FMS interventions is not only under-reported but is understudied, and, perhaps as a result, the value of teacher training is not widely understood" pp 135.

Consequently, future research should strive to bridge the gap between research and practice by upskilling teachers and encouraging sustainable behaviour changes.

2:6:3j Conclusions and Recommendations from Reviewed Studies

Randomised control trials exploring the associations between childhood obesity, physical activity, self-perception, and movement skill competency are limited. Despite this, this review of the small number of studies that have been conducted indicate that movement skill competency interventions can have a positive impact on physical activity levels, movement skill proficiency, perceived competency and in some cases body fat and/or BMI. A similar finding was noted by Han *et al* (2018) who explored interventions aiming to improve FMS/MC in overweight/obese children. They conclude:

"Developing effective intervention programs that specifically target FMS and MC could help break the vicious cycle of obesity and reduce the prevalence of comorbidities" pp101. An earlier review, conducted by Morgan *et al* (2016) drew similar conclusions, suggesting school and community-based programs that develop FMS significantly improve children's FMS abilities. These findings have been supported further by a number of systematic reviews (Cattuzzo *et al* 2016; Lai *et al* 2013; Logan *et al* 2011; Lubans *et al* 2011).

The evidence provided suggests that that school-based interventions, delivered by both teachers and practitioners, prove to be successful in improving either physical activity or movement skill competency or in some cases both. The average sample size of the studies included was 272, with interventions lasting for an average of 20 weeks. These findings help to indicate that researcher should aim to recruit a larger sample size if possible, to help increase the generalisability of findings. The reviewed studies provided good evidence that improving psychological outcomes, such as enjoyment and self-perceived ability, alongside physical outcomes was possible (Cliff *et al* 2007; Cliff *et al* 2010; Salmon *et al* 2008; Morano *et al* 2012). Seven studies implemented the intervention during PE lessons but as Sollerhead *et al* (2006) argues, attempting to increase the frequency or duration of PE lessons in schools across England is not feasible due to a demanding academic based curriculum. Foweather *et al* (2008) concluded their study by suggesting that researchers should attempt to offer opportunity for movement that may help to develop movement skill competency external to PE lessons. If possible, the intervention should therefore take place outside of PE lessons and provide children an opportunity to increase their movement throughout the school day.

The findings of the intervention studies outlined in Section 2:6 have helped to inform the direction of thesis and guide the development of the subsequent intervention by emphasising the importance of evaluation. In order for policy makers, practitioners or future researchers to understand how an intervention might be replicated, or how outcomes may be reproduced, it is important for intervention studies to report on efficacy, adoption, implementation and maintenance (Moore *et al* 2015). An intervention may have limited efficacy because of its design, or because it was not implemented correctly (Steckler *et al* 2002). Therefore, in order draw conclusions about which elements of an intervention works, an evaluation of how it was delivered and received is required. The high variability of design features, such as intervention delivery, duration, frequency, intensity, and outcome measures identified within this review make this type of evaluation critical.

Chapter 3

The relationship between childhood physical activity, movement skill competency, self-perception, strength, and enjoyment in 7–11-year-olds

Presented at The British Association of Sport and Exercise Sciences (BASES) Conference 2019 - The relationship between childhood physical activity, movement skill competency and strength: what are we going to do about it? Cline, A., De Filippo, R., Knox, G., De Martin Silva, L. and Draper, S.

Presented at The International Society for Physical Activity and Health (ISPAH) 2021 - The relationship between childhood physical activity, movement skill competency and strength in 7–11-year-olds. Cline, A., De Filippo, R., Knox, G., De Martin Silva, L. and Draper, S.

3:1 Rationale

The association between movement ability, health and well-being, physical activity and strength has received developing interest over recent decades (Lubans *et al* 2010; Okley *et al* 2001; Stodden *et al* 2008). Foundational movement skills are considered the building blocks to proficient movement ability (Clarke 2005) and there is agreement that movement skill competency should be a consistent and on-going part of a child's life (Lloyd and Oliver 2012). The Youth Physical Development Model developed by Lloyd and Oliver (2012), as noted in Section 2:2:1, depict the importance of movement throughout childhood. In addition to movement ability, research suggests that strength development is also something that should be targeted and developed during childhood (Behringer *et al* 2011; Faigenbaum *et al* 2010; Granacher *et al* 2011). Importantly, it has been suggested that muscular strength is critical for the successful development of movement competency (Behringer *et al* 2011). The United Kingdom's Strength and Condition Association (UKSCA) position statement on youth resistance training supports this, suggesting that strength training may have a positive impact on movement skill (Lloyd *et al* 2014).

Studies exploring the interaction between strength and movement ability in children are limited. Teeple *et al* (1975) reported that muscular strength, measured using vertical jumps and standing broad jumps, could account for up to 70% of the variability in movement skills in boys aged between 7-12 years. Given the age of the study and development of measurements, such as force platforms and dynamometry, a more up to date exploration of the relationship between strength, physical activity and movement skill is warranted. Gomes *et al* (2016) noted that since the relationships among physical activity and muscular strength have not been extensively explored in previous research, and due to the fact that physical activity and physical fitness levels in youth have declined over the past decades, it is important to explore this possible interaction further.

More recent studies have identified positive impacts of strength training on indicators of movement skill such as squatting (Lloyd *et al* 2016), jumping (Alberga *et al* 2015) and throwing (Hummami *et al* 2017). However, there is often an over reliance on using resistance machines to develop strength that are not commonly available in primary school settings (Grainger *et al* 2020). Gomes *et al* (2016) collected strength data from 378 children aged between 9 and 11 years using a dynamometer, whilst physical activity data was collected using accelerometers. The study explored how strength mediated the effects of low physical activity levels on metabolic profiles. The results suggested muscular strength played a relevant role in attenuating the effects of low physical activity levels on metabolic risk, as children with higher levels of muscular strength showed lower metabolic risk scores than their peers with lower muscular strength (Gomes *et al* 2016). The study didn't, however, explore the direct relationship between strength and physical activity.

More recently, Grainger *et al* (2020) studied the effect on strength training on movement skill in 72 children aged between 10-11. Movement ability was measured using the Canadian agility and movement skills assessment (CAMSA), with strength being measured using a dynamometer for upper body and countermovement jump for lower body. Their findings suggest that children who completed bi-weekly sessions of strength training displayed improved movement skill and strength 4 weeks later. In 2019, Pichardo et al demonstrated that movement skill competency, measured using the RTSB was associated with isometric-mid thigh pull force in 108 adolescent boys aged 13-14 years. Boys with low strength scores were nearly eight times more likely to score poorly in the RTSB compared with their peers who demonstrated high levels of strength.

In addition to physical measures, such as strength, physical activity and movement skill, perceived movement skill competency is also thought to play a key role in a child's development (Harter 1984). Originally introduced by Harter in 1984, perceived movement skill competency is associated with the number of times a child is willing to attempt something, in addition to persistence with a task (Harter and Pike 1984). It has since been argued that during early childhood, increased perceived movement skill competency may be valuable to drive acquisition of movement skill ability and physical activity levels due to children showing persistence and engagement with activities that require practice and skill (Stodden *et al* 2008). Jekauc *et al* (2017) suggests that this relationship between physical activity, movement ability and perceived movement skill competency is circular in that well-developed movement skills lead to good performance and positive feedback, which are related to positive emotions and motivation to perform physical activity (Wienke and Jekauc 2016; Jekauc 2015). Consequently, a positive self-concept develops. On the other hand, poorly developed movement skills lead to poor performance and negative emotions, which can disengage children from participation (Jekauc *et al* 2017).

As described in Section 2:1:1, in England 44% of children aged between 5 and 18 are meeting the recommended physical activity guidelines, with physical activity decreasing significantly at key stage two (Sport England 2021). Childhood physical activity levels vary considerably depending on region. According to the Health Survey for England Report, the number of children meeting the recommended amount of physical activity in Gloucestershire has risen from 18% in 2018, to 48% in 2019, before falling in line with the national average of 44% in 2020. The change in questionnaire design and sample from Gloucestershire used warrants further exploration. Therefore, further investigations into physical activity, movement skill competency, enjoyment, self-perception, strength and the associations between these variables is required to help understand what is happening from a county perspective.

When this thesis was designed, in 2018, Sport England completed their Health Survey for England and reported that in the Gloucestershire, 18% of children were active for 60 minutes or more every day. In 2019, Sport England reported that this figure had increased, suggesting that 48% of children in Gloucestershire reported being active for 60 minutes or more a day. In the most recent report, published in 2020, the figure has decreased to 44% which is in line with the national average. The questionnaire had not been used in previous literature and was designed specifically for use within the Health Survey for England. Accelerometer data from 92 children was used to validate the questionnaire, with findings suggesting evidence of under and over measurement of physical activity. In 2019, the questionnaire changed from asking children if they were active for ‘at least’ 60 minutes a day, to if they were active for ‘an average’ of 60 minutes per day. In 2018, the survey included 2331 children from Gloucestershire, but in 2019 and 2020 this decreased, and the study included 1995 and 1552 participants respectively. Each year a different number of children from each district are included in the sample, which means participation varies, for example in 2018 768 children from Cheltenham were included, but in 2020 there were 76 participants from the district included. Both the sample of participants included and subtle change in questionnaire warrant further investigation into childhood physical activity levels in Gloucestershire.

3:1:1 Aims

The aim of the present study was to establish the movement skill competency of Gloucestershire's primary school aged children, aged between 7-11 years old, whilst exploring possible associations between physical activity levels, movement skill competency, physical activity enjoyment, self-perception, and strength.

3: Methods

3:2:1 Participants

A total of 700 key stage 2 children from 10 Gloucestershire primary schools (boys (n=320), girls (n=380) (mean $\pm SD$) (9.2 $\pm$ 1 years) participated in the study. In order to be able to promote generalisability of results, the inclusion criteria were as wide as possible. All children aged between 7-11 years who were healthy and free of disease were able to participate.

3:2:2 Participant Recruitment

Upon approval from the university's ethic's board, all primary schools in Gloucestershire (n=231) were sent an email inviting them to take part in the research. The email highlighted the importance of childhood physical activity and movement skills, whilst briefly outlining how the research would be conducted should the headteacher decide to participate (see Appendix 2). In total, 231 schools were contacted, with 15 replying and expressing interest. The researched visited each school to meet with the headteacher and explain how the data collection would be conducted and answer any questions. Of the 15, two schools expressed concern that they would be unable to return a high number of parental consent forms and decided not to participate. A further 2 schools agreed to take part but did not have any parental consent forms returned so could not participate. The remaining 11 schools who took part were required to provide written consent from each headteacher, written consent from each parent and written assent from each child (See Appendices 3 to 8). Throughout the study, children were reminded that they did not have to take part and that they could decide to withdraw up until data analysis had started without consequence. Over the duration of the study, the researcher visited the 11 schools each afternoon to collect the necessary data.

All schools were located within the county of Gloucestershire, which has a total of 6 districts. The study included at least one school from each district. Six schools were classified as rural, with rural being defined as settlements below 10,000 people or in the open countryside. Two schools were semi-rural and a further three were inner city. The two largest schools, with 482 and 416 pupils were both inner city primary schools. Ten schools fell within 50% of the least deprived neighbourhoods in the country, with one school falling within 50% of the most deprived neighbourhoods in the country. All but one school were rated as good by Ofsted, one school was rated as outstanding.

3:2:3 Study Design

The study presented was a cross-sectional design. The data was collected over a period of three months from May to July. At the start of the day, participants were asked to complete physical activity, physical activity enjoyment and self-perception questionnaires. Children then completed a standardised RAMP warm up (Jefferys *et al.*, 2007) which involved the children completing 60s of jogging around the school hall to help raise their muscle temperature, before doing a 20 walking lunges to help mobilise their lower bodies, finishing with 10-star jumps to help prepare them for the explosive movement of a mid-thigh pull. They were then asked to complete a movement screen and strength test. From start to finish, it took each participant an average of an hour to complete all measurements.

3:2:4 Measurements

3:2:4:1 Physical Activity Engagement

Pupils first completed a physical activity questionnaire (PAQ-C), validated by Kolwalski *et al* (2004), to measure the children's self-reported physical activity levels (see Appendix 9). The questionnaire took between 15 and 20 minutes to complete. Questions aimed to collect information on physical activity throughout the school day, at break times and lunch times, as well as how many sports the participants played and how much screen time they had during weekdays and weekends. The responses were recorded using either a likert scale or multiple-choice style answers, an average was then calculated to form the final score.

3:2:4:2 Physical Activity Enjoyment

Pupils completed a 9-item physical activity enjoyment questionnaire (PACES) (see Appendix 10). The questionnaire asks children to consider 9 statements in relation to physical activity, such as 'I enjoy it' and 'I feel bored'. Children then use a likert scale to rate the statement based on their opinion with 1 being 'strongly disagree' and 10 being 'strongly agree'. The physical activity enjoyment questionnaire has been found as both a valid and reliable measurement tool when used with children aged between 7-11 (Moore *et al* 2009; Roman *et al* 2014).

3:2:4:3 Self-Perception

Children completed the self-perception profile for children (SPPC) (see Appendix 11). The SPPC is a measure designed to collect data on children's perceived athletic competence, physical appearance, and their self-worth. The questionnaire consists of structured alternative statements which give two opposite descriptions. For example, 'some children do very well at all kinds of sports' but 'other children do not feel that they are very good when it comes to sports'. Children are asked to decide which part of the statement is true for them, before deciding if it is 'really true' or 'sort of true' for them. It has been suggested that this structure decreases the tendency for children to give socially desirable answers (Harter, 1982). Interestingly, whilst the questionnaire has been used in multiple papers aiming to explore the relationship between perceived movement skill competency and actual movement skill competency (Vedul *et al* 2011; De Meester *et al* 2016; Lalor *et al* 2016) the feedback from teachers in the current study was that the younger children (aged between 7-9) found it difficult to interpret and answer the questions without support from teaching staff.

3:2:4:4 Movement Skill Competency

The Athletic Introductory Movement Screen (AIMS) was administered according to procedures previously published (Rogers *et al.*, 2019). This assessment tool was deemed appropriate for testing preadolescents movement skill competency in Gloucestershire primary school pupils given that is draws largely from the resistance training skills battery which has been proven as both valid and reliable when used in children aged between 5 and 16 (Bebich-Phillip 2016; Bennett *et al* 2017; Furzer *et al* 2018). The AIMS-4 tasks were performed in the following order: overhead squat with a dowel, half knelling push ups, alternative lunges and lastly straight-arm prone brace with alternative hand touches to the opposite shoulder (two per shoulder). To standardise the technical instructions across a large sample, the participants observed a pre-recorded video demonstration before completing each exercise. Following the first viewing, pupils were allowed to practice the movement, before being showed the video again. Following familiarisation (1-2 minutes per movement), pupils performed two sets of four repetitions per movement. Only questions related to the assessment protocol, such as the number of repetitions were answered during the assessment, no skill-related feedback was given by the researcher (Bebich-Philip *et al.*, 2016).

The first set of four repetitions were recorded by an iPad (iPad Air, Apple, California, US) in the frontal plane, which was positioned two meters away from the pupil. Once, the four repetitions were performed the pupil was repositioned in front of the same iPad, to perform the second set of four repetitions in the sagittal plane. All recordings were examined after the assessment day by the researcher, with support from an additional assessor. Both the researcher and assessor paused, re-watched, and slowed footage down to obtain the most accurate score. Before independent assessments began, the researcher and assessor viewed samples of movement competency videos to discuss and establish agreed scoring system in relation to the performance criteria of the four tasks. Please see in the Appendix 12 for the scoring rubric, developed by Rogers *et al* 2019. Each participant was scored via video independently, before scores were reviewed and discrepancies addressed, each participant could score anywhere between 16 and 48. Discrepancies were rectified by reviewing the recording whilst providing a verbal justification for each score, the researcher and assessor then discussed their rationale before agreeing on a final score. Inter-rater and intra-reliability data is presented in Section 3:2:5. When testing large cohorts of ten pupils per group, the familiarising and assessment of the AIMS-4 movement took approximately 50 minutes, while the examination of the four movement tasks and scoring required ten minutes per pupil.

3:2:4:5 Isometric Strength

Isometric strength was assessed during an isometric mid-thigh pull testing, using a portable force platform sampling at 1000 Hz (FP8 Force Platform, HUR Labs, California, US). Research exploring isometric mid-thigh pull in children is in its early stages with emerging research suggesting it is a reliable and safe method for evaluation peak force in children aged between 6-17 years (Moeskops *et al* 2018; Pichardo 2019). This is important, given that the test has been significantly correlated to vertical jump performance, sprint speed, agility, weightlifting movements and 1RM squat and deadlift in adults (Juneja *et al* 2010; Thomas *et al* 2015; Haff *et al* 2005; De Witt *et al* 2018). For the isometric mid-thigh pull, pupils obtained a knee angle of approximately 130-145 degrees (Haff *et al*., 1997; Beckham *et al*., 2013; Haff *et al*., 2015) and hip angle of approximately 140-145 degrees (Haff *et al*., 1997; Haff *et al*., 2015; Beckham *et al*., 2018), however pupils used a self-selected grip and foot position. An immovable, steel bar was positioned at mid-thigh, to mimic the position achieved at the initiation of the second pull of the clean (Haff *et al*., 2015), using a portable squat rack. After the pupil was positioned as previously described, two submaximal isometric mid-thigh pulls warm-up trials were performed, one at 50% and one at 75% of the pupils perceived maximum effort separated by one minute of rest (Haff *et al*.,1997; Comfort *et al*., 2015).

Pupils performed three maximal isometric mid-thigh pull and were instructed to 'pull as hard and as fast as possible', while 'pushing against the ground' before the test was performed

(Haff *et al.*, 1997; Stone *et al.*, 2003; Haff *et al.*, 2015). Before each pull, the pupil was asked to apply the minimum amount of pre-tension required to remove slack from the bar (Beckham *et al.*, 2013; Haff *et al.*, 2015). Once comfortable and ready, pupils were counted from '3,2,1, pull' performing a maximal isometric effort for five seconds. All pupils were given strong verbal encouragement during each trial by being told to 'pull, pull, pull, pull' for the duration of the five seconds (Halperin *et al.*, 2016). No further instructions were given, to standardise the test amongst participants. Two minutes of rest were given between the maximal effort pulls. Repeated trials occurred if their differences were greater than 250N during trails, the best recorded peak force was analysed.

3:2:5 Data Analysis

The data was analysed using SPSS (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp). All data were first tested for normality using the Kolmogorov-Smirnov test. Data were found to not be normally distributed and so non-parametric tests were used to analyse the data; data are therefore presented as median (IQR). The effects of gender were calculated using Mann-Whitney U. The effects of year groups were calculated using Kruskall-Wallis. Where significant effects were found, post-hoc tests between pairs were calculated using Bonferroni correction Mann-Whitney U tests. Spearman's rho correlation was used to explore possible correlations between variables, correlations of interest are reported in table 5.

To explore the data in greater depth, quartiles for AIMS-4 total score were calculated. The data was split into quartiles, with percentile groups being formulated as noted in table 6. Descriptive statistics were then run on each group to identify the median for each dependant variable, recorded in table 7. Significant differences between each group were identified using a Kruskal-Wallis analysis, noted in table 7 and displayed in figures A-G. Statistical differences between each group have been noted in each column where significant (<0.05). Alpha was set at <0.05. Data outputs from SPSS are included in Appendices 14 to 37.

To evaluate inter and intra-rater reliability, a random sample of 20 participants were assessed and graded blindly by both the researcher and assessor. The researcher then blindly re-graded the same sample of 20 participants 8-weeks later. Inter and intra-rater reliability was assessed using ICC (two-way mixed, absolute agreement). There was excellent reliability between research and assessor for movement skill scoring (0.988 (0.627-0.997)) and for repeated measures of the researcher (ICC (95% CL): 0.985 (0.797-0.996), see Appendix 13.

3:3 Results

Descriptive statistics split by gender are displayed in Table 3:1. The maximum score possible for movement skill competency was 48, there was no significant difference between males and females. There were significant differences found between males and females for strength and physical activity engagement, with males displaying higher scores for both. There were no significant differences between males and females for movement skill competency, self-perception, total amount of sports played and physical activity enjoyment.

Table 3:1 Descriptive statistics [median (IQR)] for each gender together with gender differences

	Female Median (IQR) n	Male Median (IQR) n	P, ES
Force x Bodyweight (N.Kg^{-1})	24.3 (4.3) 374	25.9 (3.8) 314	<.001, 0.200
Total AIMS	23 (5) 380	23 (5) 320	0.187, 0.049
Self-Perception	25 (7) 299	24 (10) 251	0.300, 0.044
Physical Activity Enjoyment	8 (2) 344	8.5 (2) 271	0.002, 0.127
Physical Activity Engagement	3.8 (1.3) 380	4.3 (1.5) 320	<.001, 0.214
Sports Played (Per Week)	3 (2) 380	3 (3) 320	0.778, 0.010
Self-Description	4.2 (1.3) 81	4.5 (1.4) 69	0.240, 0.095

In order to understand physical activity further, and to compare with the Health Survey for England Data, descriptive data for question four 'during the past week, on how many days were you physically active for an average of 60 minutes per day?' is presented in Table 3:2.

Table 3:2 Descriptive statistic [median (IQR)] and differences between gender for number of days spent physically active for an average of 60 minutes.

	Female Median (IQR) n	**Male** Median (IQR) n	**P, ES**
Number of days spent physically active for an average of 60 minutes	3 (1.7) 380	4 (1.9) 320	<.001, 0.400

Total frequencies for all participants are presented in table 3:3.

Table 3:3 Total number of days spent being physically active for an average of 60 minutes

	Number of days spent physically active for an average of 60 minutes							
	0	1	2	3	4	5	6	7
n	65	59	117	149	126	99	46	39

Descriptive statistics split by year group are displayed in Table 3:4. There was a positive significant difference found between years 3 and 4 for force relative to bodyweight. Significant differences were also identified between years 3 and 5, years 3 and 6, and years 4 and 6 when looking at movement score. There were significant differences found between years 4 and 5 and years 4 and 6 when looking at self-perception. Finally, there were significant differences between years 4 and 6, and years 3 and 4 when looking at physical activity engagement. There were no significant differences between year groups when looking at total amount of sports played or physical activity enjoyment.

Table 3:4 Descriptive statistics of Gloucestershire school pupils included in the cross-sectional analysis, split by year group.

	Year 3 Median (IR) n	Year 4 Median (IR) n	Year 5 Median (IR) n	Year 6 Median (IR) n	P
Force x Bodyweight (N.Kg^{-1})	26 (4.3) ^ 168	24.6 (4.3) 249	24.9 (4.7) 139	24.7 (4.9) 132	.045
Total AIMS	22 (4) + - 170	23 (5) - 256	24 (4) 142	25 (5) 132	<.001
Self-Perception	24 (8) 126	23 (12) + - 223	26 (6) 111	26 (6) 90	<.001
Physical Activity Enjoyment	8.2 (2) 168	8.3 (2) 176	8.2 (2) 139	8.1 (2) 132	.422
Physical Activity Engagement	4 (1.3) ^ 170	4.3 (1.6) - 256	4.1 (1.3) 142	3.8 (1.4) 132	.006
Sports Played (Per Week)	3 (2) 170	3 (2) 256	3 (2) 142	3 (2) 132	.848
Self-Description	4.4 (1) 44	3.7 (1.8) 33	4.1 ± (1.4) 31	4.4 (1.2) 42	.023

*Significant difference from Year 3

^ Significant difference from Year 4

+ Significant difference from Year 5

- Significant difference from Year 6

Table 3:5 displays descriptive data for the 11 schools that participated in the study.

Table 3:5 Descriptive Data for Participating Schools

Variable	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10	School 11
County						Gloucestershire					
District	Gloucester	Tewkesbury	Forest of Dean	Gloucester	Cotswolds	Cheltenham	Stroud	Tewkesbury	Stroud	Gloucester	Forest of Dean
Location	Inner City	Semi-Rural	Rural	Rural	Rural	Inner City	Rural	Inner City	Semi-Rural	Rural	Rural
Deprivation Indices	30,776 10% [1]	22,762 40% [1]	17,244 50% [1]	20,299 40% [1]	17,850 50% [1]	13,914 50% [2]	29,997 10% [1]	32,390 10% [1]	23,747 30% [1]	21,211 40% [1]	20,537 40% [1]
Type of School	Maintained	Maintained	Maintained	Maintained	Private	Maintained	Maintained	Maintained	Maintained	Maintained	Maintained
Number of Pupils	482	393	102	37	101	195	173	416	265	124	109
% Pupils Eligible for FSM	6%	15.8%	15.7%	24.3%	0%	16.4%	7.5%	7.9%	6%	11.3%	5.5%
Ofsted Rating	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Outstanding

FSM = Free School Meals, NBH = Neighbourhoods, [1] least deprived NBH in the country, [2] most deprived NBH in the country

Descriptive statistics split by school are displayed in Table 3:6. Strength scores were consistent across the 11 schools, ranging from 23.7 to 26.1(N). Movement skill competency scores were also consistent, ranging from 22 to 25. Self-perception scores were more varied, ranging from 15.3 to 29. Physical activity enjoyment also varied considerably, ranging from 6.5 to 9. Physical activity engagement was more consistent across the 11 schools, ranging from 3.4 to 4.6 Finally, sports played per week were also consistent, with the average amount being either 3 or 4. A spearman's rho correlation identified no significant negative correlation between the school's deprivation indices, the median self-perception score and the median total amount of sports played as displayed in Figures 3:1 and 3:2.

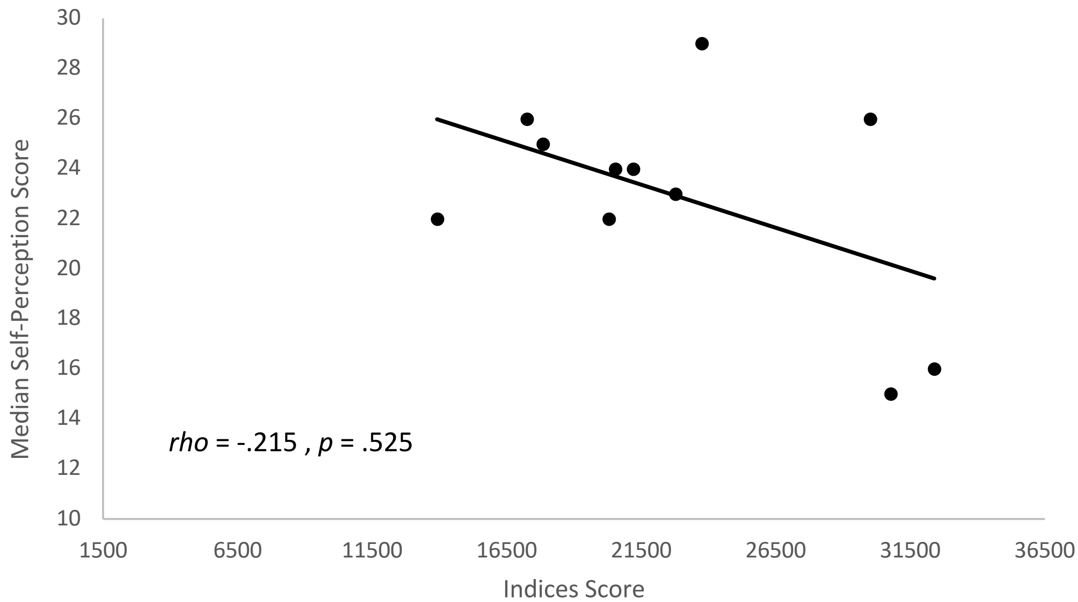

Figure 3:1 Median self-perception score correlated with school's indices score

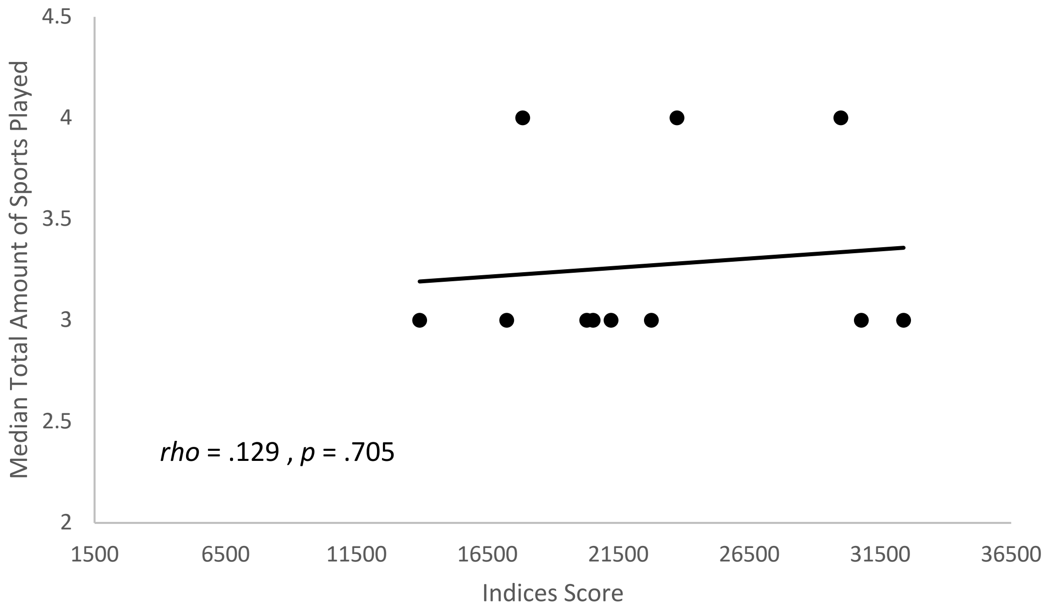

Figure 3:2 Median total amount of sports played correlated with school's indices score

Table 3:6 Showing descriptive statistics [median (IQR) for each school

	School 1 Median (IR) N	School 2 Median (IR) n	School 3 Median (IR) n	School 4 Median (IR) n	School 5 Median (IR) n	School 6 Median (IR) n	School 7 Median (IR) n	School 8 Median (IR) n	School 9 Median (IR) n	School 10 Median (IR) n	School 11 Median (IR) n
Force x Bodyweight ($N.Kg^{-1}$)	24.6 (3.7) 95	26 (4.2) 152	23.9 (5.3) 39	N/A	23.7 (6.7) 19	24.4 (4.9) 27	24.4 (4) 79	25 (4.7) 150	25 (4) 63	25.4 (3.1) 34	26.1 (4.6) 30
Total AIMS	23 (5) 95	22 (5) 152	24 (7) 39	22 (8) 12	25 (10) 19	22 (2) 27	24 (4) 79	24 (5) 150	25 (4) 63	24 (5) 34	22 (7) 30
Self-Perception	15 (2.8) 95	23 (8) 152	26 (7) 39	22 (4.7) 12	25 (8) 19	22 (4) 27	26 (6) 79	16 (1.4) 150	29 (7) 63	24 (9.2) 34	24 (7) 30
PA Enjoyment	7.5 (2) 22	8.5 (1.4) 152	6.5 (3) 39	N/A	8.6 (1) 19	9 (1) 27	8.3 (2) 79	8.1 (2) 150	7.7 (1) 63	7 (3) 34	9 (2) 30
PA Engagement	4.3 ± (1.5) 95	4 (1.5) 152	4 (1.3) 39	3.4 (1.5) 12	4.6 (2) 19	4.8 (1.5) 27	4.3 (1.5) 79	3.9 (1.3) 150	4.3 (1.3) 63	3.8 (1.3) 34	3.4 (1.3) 30
Sports Played (Per Week)	3 (2) 95	3 (2) 152	3 (2) 39	3 (3) 12	4 (5) 29	3 (2) 27	4 (1) 79	3 (2) 150	4 (3) 63	3 (2) 34	3 (3) 30

Correlations between strength, physical activity, enjoyment, self-perception and movement skill competency split by both year group and gender are displayed in Table 3:7. There was a statistically significant positive association found between strength and movement skill competency when analysing all participants. This statistically significant association remained when split by gender and year group. A statistically significant positive association was also identified between movement skill competency and physical activity engagement when all participants were analysed. When analysed by gender, the association remained significant for males, but not for females. There were no statistically associations found when the data was split by year group, apart from Year 6 where there was a statistically significant positive correlation. This trend repeated when looking at the association between movement skill competency and physical activity enjoyment. There was a strong statistically significant positive association found between physical activity engagement and physical activity enjoyment. This association remained significant for both females and males and all of the year groups, apart from Year 3. A strong statistically significant positive association was found between movement skill competency and self-perception when all participants were analysed, this association remained significant for both males and females as well as all year groups. There was a statistically significant association identified between total amount of sports played and movement skill competency when all participants were analysed, this association remained significant for both boys and girls. Year group 4 were the only year group in which the significant association remained, when split by year group. There was a significant association found between strength and physical activity engagement, however when split by gender and year group this association was no longer significant. There was a strong significant association identified between physical activity engagement and total amount of sports played per week, this association remained significant for both males and females, Year 4 and Year 5 but not Years 3 or 4. Finally, a statistically significant positive association was identified between physical activity enjoyment and self-perception. This association remained significant for Year 5, but not for the other year groups or when split by gender.

Table 3:7 Correlation coefficient between strength, physical activity, enjoyment, self-perception and movement skill competency table split by gender and year group

	Force x Bodyweight (N.Kg^{-1}) vs. AIMS Score	AIMS Score vs. PA Engagement	AIMS Score vs. PA Enjoyment	PA Engagement vs. PA Enjoyment	AIMS Score vs. Self-Perception	Sports Played (Per Week) vs. AIMS Score	Force x Bodyweight (N.Kg^{-1}) vs. PA Engagement	PA Engagement vs. Sports Played (Per Week)	PA Enjoyment vs. Self-Perception
	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p	n, *rho*, p
All Cases	688 0.263 <.001	700 0.180 <.001	615 0.172 <.001	615 0.328 <.001	550 0.473 <.001	700 0.215 <.001	688 0.156 <.001	700 0.301 <.001	465 0.164 <.001
Females	374 0.287 <.001	380 0.138 0.007	344 0.134 0.13	344 0.330 <.001	299 0.454 <.001	380 0.226 <.001	374 0.123 .017	380 0.326 <.001	263 0.144 .020
Males	314 0.269 <.001	320 0.260 <.001	271 0.218 <.001	271 0.304 <.001	251 0.479 <.001	320 0.196 <.001	314 0.109 .053	320 0.263 <.001	202 0.190 .007
Year 3	168 0.244 .<001	170 0.163 .034	168 .040 .610	168 0.168 .030	126 0.500 <.001	170 0.135 0.080	168 -0.022 .773	170 0.259 .001	124 0.095 .293
Year 4	249 0.294 <.001	256 0.141 .024	176 0.165 .028	176 0.332 <.001	223 0.433 <.001	256 0.269 <.001	249 0.162 .010	256 0.361 <.001	143 0.151 .072
Year 5	139 0.298 <.001	142 0.126 .136	139 0.192 .023	139 0.344 <.001	111 0.364 <.001	142 0.193 .022	139 0.252 .003	142 0.315 <.001	108 0.345 <.001
Year 6	132 0.336 <.001	132 0.411 <.001	132 0.394 <.001	132 0.496 <.001	90 0.545 <.001	132 0.254 .003	132 0.315 132	132 0.249 .004	90 0.191 .072

Quartile boundaries are displayed in Table 3:8. Children with the highest movement score were in Quartile 1, with children with the lowest movement score in Quartile 4.

Table 3:8 Groupings as a Result of Percentile for 'Total AIMS Score' Boundaries

Aims Percentile	Quartile	n
Score 27+	1st	142
Score 24-26	2nd	194
Score 22-23	3rd	158
Score 16-21	4th	206

Descriptive statistics for each quartile are displayed in Table 3:9. Figures 3:3 to 3:8 aim to explore the differences between each quartile in more detail. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. Figure 3:3 shows the differences between quartiles when looking at strength scores. There was a statistically significant difference between quartile 1 and quartiles 3 and 4. There was also significant differences between quartile 2 and quartile 4, as well as significant differences between quartile 3 and 4.

Table 3:9 Descriptive statistics for differences between 'Total AIMS Score' percentiles

	Median (IQR)				
Variable	**1st Quartile**	**2nd Quartile**	**3rd Quartile**	**4th Quartile**	**P**
Age (Years)	9 (2)	9 (1)	9 (2)	9 (2)	
Force x Bodyweight ($N.Kg^{-1}$)	26.3 (4.3)	25.3 (3.9)	24.7 (5.1)	23.8 (4.4)	<.001
Total AIMS Score	29 (4)	25 (2)	22 (1)	20 (2)	<.001
Self-Perception Score	29 (6)	27 (7)	23 (6)	20 (7)	<.001
Physical Activity Enjoyment	9 (2)	7.8 (2)	8 (2)	7.7 (2)	<.001
Sports Played (Per Week)	4 (2)	3 (2)	3 (2)	3 (2)	<.001
Physical Activity Engagement	4.5 (1.5)	4.1 (1.5)	4 (1.3)	3.8 (1.5)	<.001

Self-Description	5 (9)	4.3 (1.6)	4.1 (1.1)	4 (1.2)	<.001

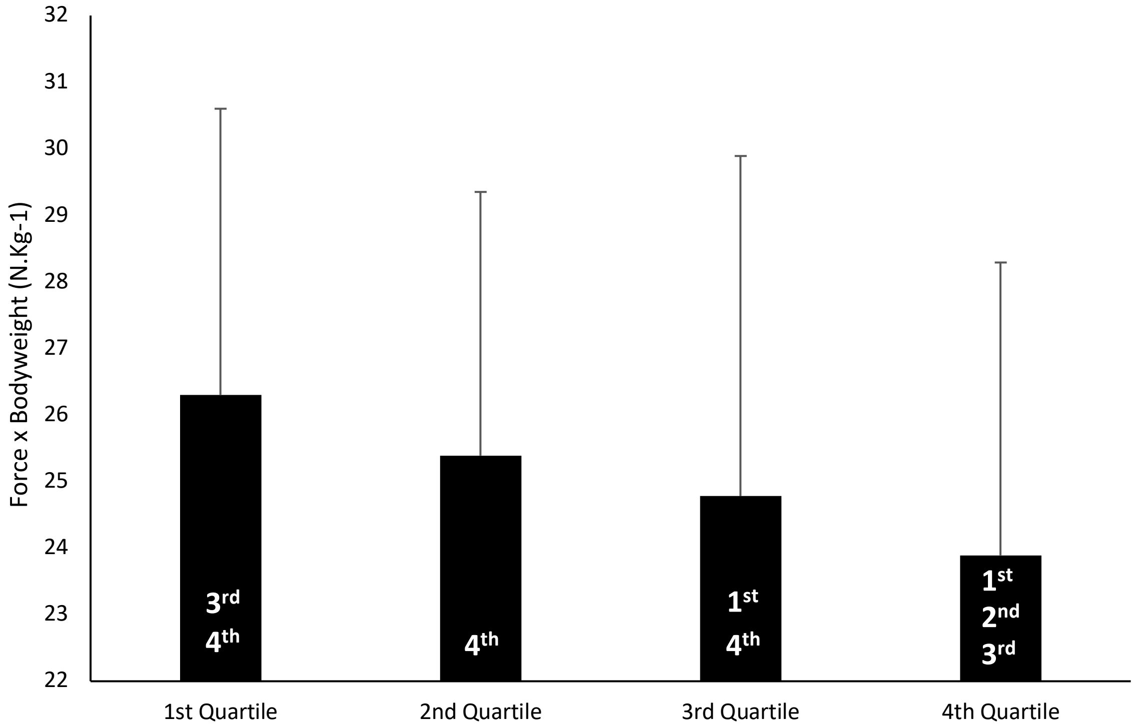

Figure 3:3 Median strength scores for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

Figure 3:4 shows the differences between quartiles when looking at movement skill competency scores. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. There was a statistically significant difference between each quartile, which was to be expected given that the quartiles were calculated using the AIMS scores.

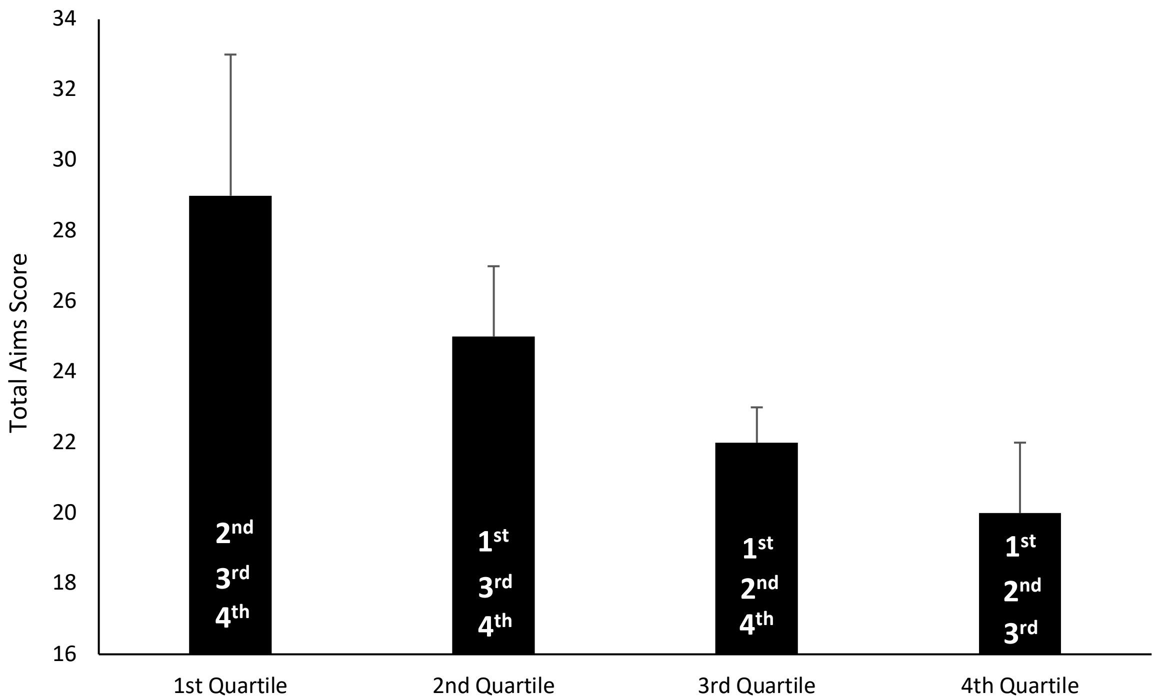

Figure 3:4 Median movement skill competency scores for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

Figure 3:5 shows the differences between quartiles when looking at self-perception scores. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. There was a statistically significant difference between each quartile group, movement scores significantly decrease as the quartiles go down from 1st to 4th.

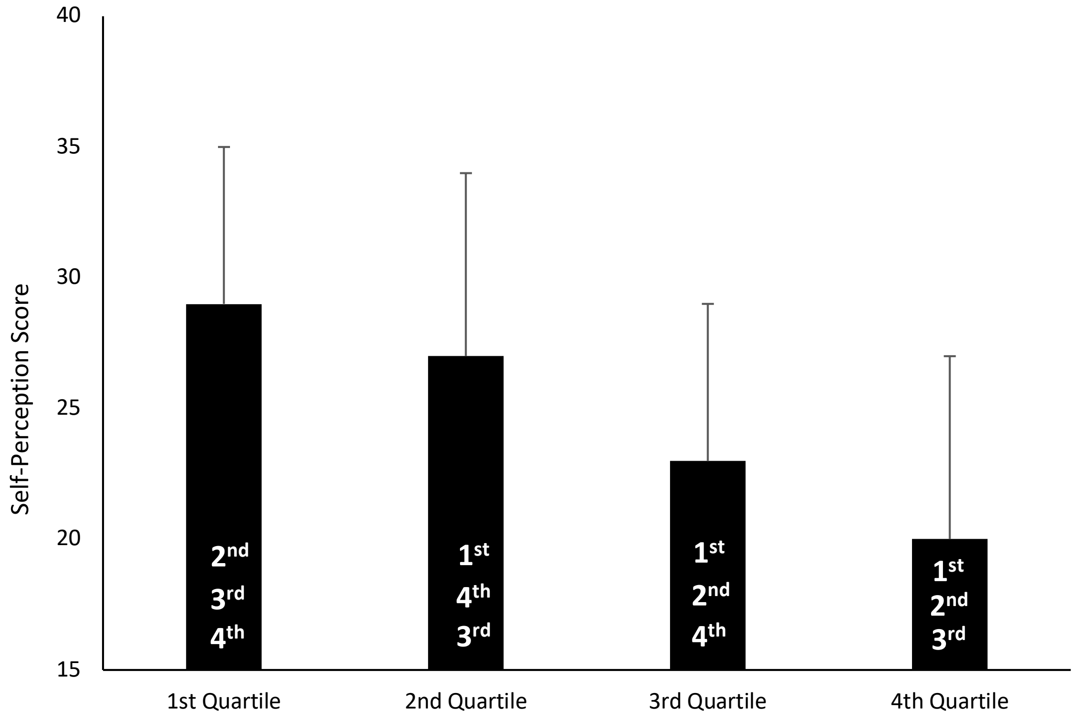

Figure 3:5 Median self-perception scores for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

Figure 3:6 shows the differences between quartiles when looking at physical activity enjoyment scores. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. Those within the first quartile had significantly greater physical activity enjoyment than those in quartiles 2, 3 and 4.

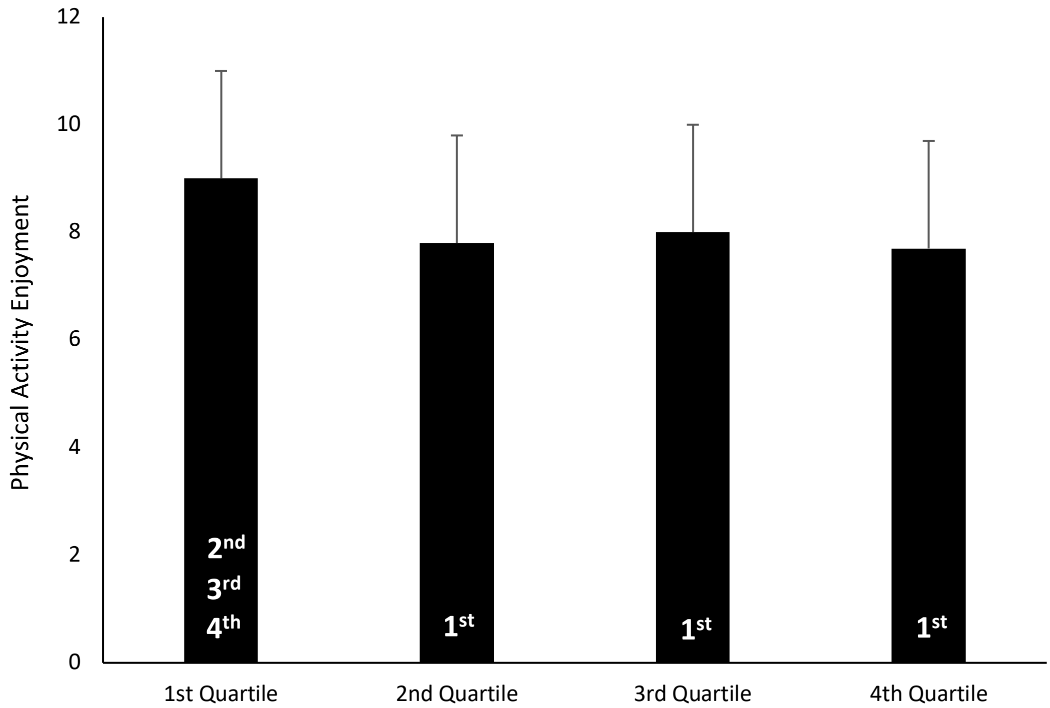

Figure 3:6 Median physical activity enjoyment scores for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

Figure 3:7 shows the differences between quartiles when looking at total amount of sports played per week. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. Here we can see there is a statistically significant difference between quartile 1 and quartiles 2, 3 and 4 indication that those in the first quartile play more sports than those in the 4th quartile.

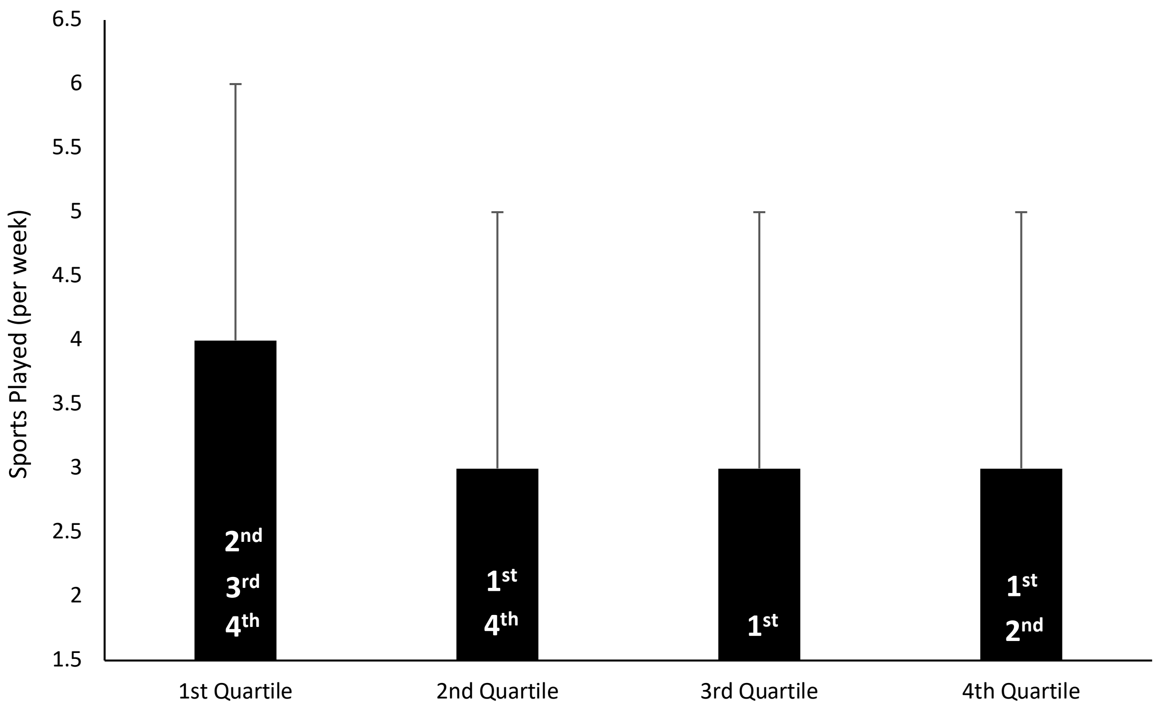

Figure 3:7 Median total amount of sports played for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

Figure 3:8 shows the differences between quartiles when looking at physical activity engagement. Median scores and interquartile ranges are presented, along with statistical differences between quartile groups as indicated by the letters on each bar. Here we can see there is a statistically significant difference between quartiles 1 and quartiles 3 and 4. However there are no other statistical differences.

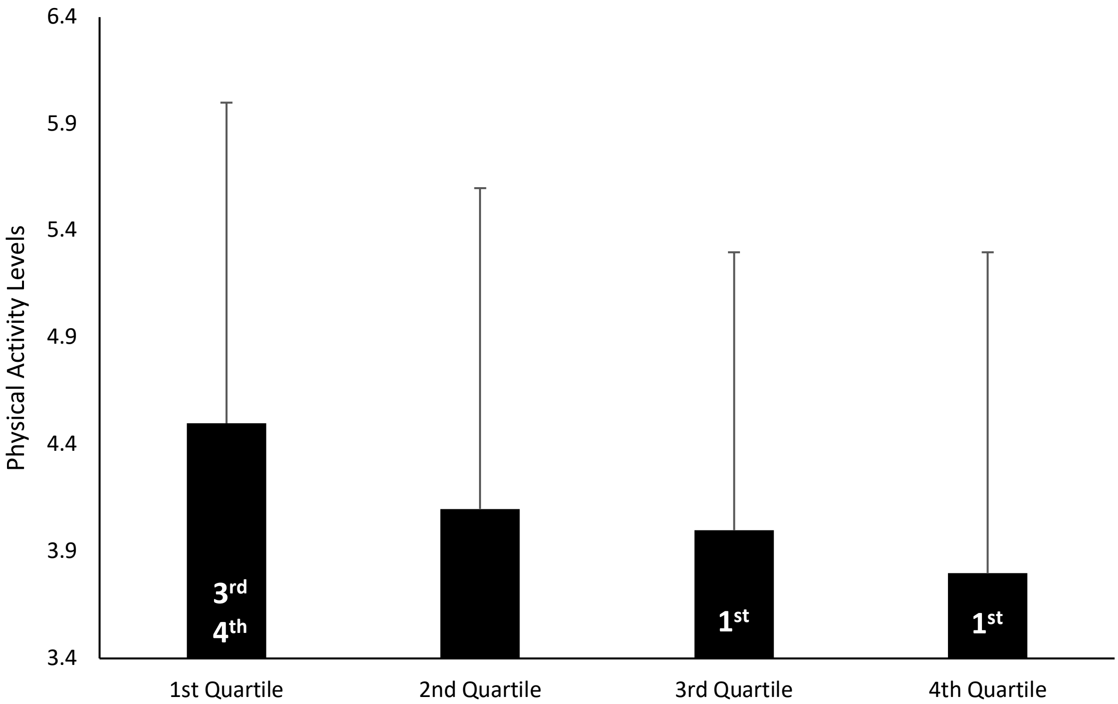

Figure 3:8 Median physical activity scores for each quartile. Error bars represent IQR. Significant differences between quartiles (Bonferroni) are displayed within each column.

3:4 Discussion

3:4:1 Key Findings

The median score for movement skill competency was 24.3 (4.3) and 25.9 (3.8) for girls and boys respectively, with the minimum score being 16 and maximum score 48. A high number of children (n=558) scored between 16 and 26, with fewer students (n=142) soring 27 or above, which suggest movement skill competency scores were low. Boys reported engaging in physical for an average of 60 minutes per day 4 days per week, a statistically significant amount more than girls who reported a median of 3 days. A total of 39 students reported meeting the physical activity guidelines of being physically active for an average of 60 minutes or more, compared to 661 who did not. There were significant differences found between males and females for strength and physical activity engagement. There were no significant differences between males and females for movement skill competency, self-perception, total amount of sports played and physical activity enjoyment. The strongest association identified when looking at both males and females was between self-perceived ability and movement skill competency. There were also significant differences in self-perception scores between each percentile group, meaning as movement scores increased so did self-perception scores. A positive association was identified between movement skill competency and strength, with the strength of the association increasing with age. When looking at the difference between percentiles, children who performed well on the movement screen also returned higher strength scores. Another positive association was identified between movement skill competency and physical activity engagement. Furthermore, children who performed well on the movement screen also reported higher levels of physical activity engagement, however this difference was only apparent between the first, third and fourth quartiles. There was a positive association identified between physical active engagement and physical activity enjoyment. Children in the 1st quartile, those with the highest movement scores, had significantly higher physical activity enjoyment scores compared with their peers in the 2nd, 3rd and 4th quartiles but there were no differences between the lower three quartiles themselves.

3:4:2 Self-Perceived Ability and Movement Skill Competency

There was a positive correlation for both girls and boys between self-perceived ability and movement skill competency, which also had the largest effect size. A number of studies have found self-perceived movement competence as a significant correlate to actual movement skill competence (Babic *et al* 2014). As noted, research has suggested that if a child has a positive self-concept when it comes to their movement skill ability, they are more likely to engage in physical activity (Jekauc *et al* 2017). On the other hand, Stodden (2008) theorised that lower movement competence would result in a negative spiral of physical activity disengagement. This is supported by the present study which identified a statistically significant correlation between physical activity enjoyment and self-perceived ability when looking at all cases (n=465).

When looking at the quartile data, there were significant differences between each quartile. This means children in the 1st quartile, who had the highest quality movement, had significantly higher self-perception scores than children in the 2nd, 3rd and 4th quartile. The significant differences between each quartile when looking at self-perception is interesting as it is the only variable, apart from movement which the quartiles were calculated from, that displays a difference between every quartile. This further supports the notion that perceived movement skill competence is closely related to actual movement skill competence. Barnett *et al* (2017) note, given the consistent positive associations found between perceived and actual movement ability, we now need to develop our understanding of what factors may influence a child's perception of their competence. In time, this will provide key insights in how to design interventions to encourage and develop movement skill competency in children (Barnett *et al* 2017).

3:4:3 Strength and Movement Skill Competency

Importantly, this study is one of the first to use what is considered to be a gold-standard measurement of strength amongst children aged between 7-11 in order to explore the relationship between strength and childhood physical activity (Brady et al 2018; Comfort *et al* 2015; Buckner *et al* 2017; Merrigan *et al* 2021). A positive correlation was identified for both girls and boys between strength and movement skill competency scores. The effect size increased as the children went up in age, starting with Year 3 and increased through to Year 6. As previously noted, the effect size may be increasing with age due to difference in development becoming prominent as children move closer to puberty (Lloyd and Oliver 2012). When looking at the differences between quartiles in relation to strength, children in the 1st quartile (those who had the highest quality movement) had significant differences in strength between the children in the 3rd and 4th quartiles, but not children in the 2nd quartile. Children in the 2nd quartile had significant differences in strength to children in the 4th quartile, but not the 3rd. However, children in the 3rd and 4th quartiles had significant differences to one another in strength scores. The percentile data indicates that those with higher quality movement patterns had higher strength scores than their peers who demonstrated lower movement skill competency.

Research looking into the correlation between strength and movement ability consistently shows a positive correlation with studies emphasising the importance of maintain strength throughout the life course to promote movement ability (Brandon *et al* 2003; Hicks *et al* 2012). Research aiming to understand the relationship between muscular strength and movement skill competency children is still in its early stages, however the findings of this study help to develop this understanding by outlining that associations between strength and movement ability appear to increase in statistical significance as children get older. Children who have strong, well-synchronised trunk muscles can effectively stabilise their core, the ability to do so is result of motor control and muscular capacity of the lower pelvic hip (Kong *et al* 2013). Importantly, a strong and stable spine serves as foundation for all functional movements in addition to postural control and balance. Given these elements all feature within the movement screen used to test the children in this study, it becomes clear why children who performed well on the strength test also displayed higher quality movement patterns. These findings provide a strong rational for movements that encourage postural control and balance, such as the overhead squat and forward lunge, to feature within interventions aiming to improve children's movement skill competency and physical activity levels.

3:4:4 Physical Activity and Movement Skill Competency

The key findings from this study indicated that there was a positive association between movement skill competency and physical activity engagement in the participants tested. To explore the relationship, this study was one of the first to use a new movement screen (AIMS) which has been developed using the good quality scoring criteria of the AAA and some of the movements included within the RTSB. The movement screen is therefore unique in its ability to allow researchers to assess participants movement over multiple repetitions to better understand consistency, whilst including measures of stability and postural control that are easy to implement within a school setting (Rogers et al 2019; Pullen et al 2021). The results are similar to the results noted by Fisher *et al* (2005), who collected physical activity and movement data from 394 boys and girls. Movement was assessed by a single assessor using the Movement Assessment Battery, whilst accelerometers were used to record physical activity. Their results indicated that total physical activity was weakly correlated with movement skill (r = 0.10, p = <.005). A systematic review conducted by Logan *et al* (2015) reviewed 13 studies that explored the relationship between movement competency and physical activity. The evidence suggests there was a range of low to high positive correlations in all the reviewed studies for children aged between 6 and 12 years (r = .24 to .55). Interestingly, in the study presented, the strongest correlation for physical activity and movement occurred when looking at the children in year group 6 (r = .411, p = <.001). As noted by Clarke (2005), as children progress through childhood they will develop their movement abilities at different rates depending on a range of influencing factors such as experiences in and out of school, participation in sport and engagement with physical activity. This could be a possible explanation as to why the correlation is stronger in children aged between 10 and 11.

When split between quartiles, those within the 1st quartile (the children with higher quality movement patterns), only showed a significance difference in physical activity engagement when compared to children in the 3rd quartile and children in the 4th quartile. There were no other differences between quartiles. This suggests children who scored an AIMS score of 27 (1st Quartile) or more, reported a significantly higher level of physical activity per week compared to those who scored 16-23 (3rd and 4th Quartile). However, children who scored 24 (2nd Quartile) or more, reported no additional physical activity in comparison to their peers who scored 27 or more.

In 1980, Seefeldt introduced the hypothetical proficiency barrier model, the concept revolves around the idea that children move from fundamental movement skills to transitional movement skills. Children who are deprived of learning the fundamental movement skills are faced with a proficiency barrier (Seefelft 1980). This concept has been revisited several times since it was introduced. In 2014, Malina revisited the idea of a proficiency barrier and suggested that "there may be a level of movement competence above which a child would be more likely to engage in various physical activities, including sport, and below which a child would be less likely to engage in such activities," (pp 164). More recently, Brian *et al* (2020) have suggested that without adequate practice of movement skill, decline in competence is imminent which consequentially leads to a decline in physical activity. Whilst more research is required to understand this further, the results found in the present study appear to indicate there may be a movement threshold in which children reach whereby they no longer report significant differences in physical activity engagement to their peers.

3:4:5 Physical Activity and Strength

Given the positive associations identified between movement ability and strength, as well as movement ability and physical activity, it was surprising to note a weak positive correlation for girls and no correlation for boys between physical activity engagement and strength. As noted in section 2:2:1, foundational movement skills are considered to be the building blocks for physical activity (Clarke 2005). The findings of this study support this by identifying a stronger association between movement ability and physical activity compared to a weak correlation between strength and physical activity.

This study helps to contribute to the small body of research in this area, highlighting that strength and physical activity are significantly associated with one another, but only weakly, in females aged between 7-11 in Gloucestershire. As with the research exploring the association between strength and movement ability, the research exploring the association between strength and physical activity throughout childhood is sparce. Studies have largely focused on the adolescent period, such as the study conducted by Moliner-Urdiales *et al* (2010). The study involved collecting strength and physical activity data from 363 Spanish adolescents aged between 12 and 17 years. Lower body strength was measured using a variety of jump tests, upper body strength was measured using a handgrip test and physical activity was measured using accelerometers and the results indicated only vigorous physical activity was associated with muscular strength. Further research into the association between strength and physical activity and gender is therefore warranted.

3:4:6 Physical Activity Engagement and Physical Activity Enjoyment

There was a positive correlation for both girls and boys between physical activity engagement and physical activity enjoyment. The strongest correlation appeared when looking at Year 6 children. Further investigation of this correlation through ANOVA identified that children in the 1st quartile (those with the highest quality movement) had higher enjoyment scores than the children in the 2nd, 3rd and 4th quartiles. However, there were no differences between the 2nd, 3rd and 4th quartiles. This suggests that children who scored less than 27+ on the movement screen had no significant differences in their enjoyment scores. Future research may therefore wish to investigate the possibility of a threshold, whereby children who have a certain quality of movement, in this case a score of 27+, are more likely to enjoy physical activity than their peers with poorer movement scores.

Enjoyment, a psychological experience characterised by fun and pleasure, has been associated with higher levels of physical activity engagement (Gao *et al* 2012). Importantly, enjoyment of physical activity has been linked with sustained participation of physical activity throughout the life course (Cairney *et al* 2012, Gao *et al* 2013, Prochaska *et al* 2013). A key concept behind increase enjoyment of physical activity is to allow children to make decisions regarding their own skill development and to focus on personal development rather than competition (Burns *et al* 2017). Interestingly, research has suggested that having fun and experiencing pleasure whilst engaged in an activity may promote perceptions of personal competence which is essential for fostering continued physical activity engagement (Stankov 2012). Furthermore, previous authors help to reiterate the importance of enjoyment by advising to treat it as a primary outcome when designing school-based physical activity programmes, to develop interventions that are able to create sustained behaviour change (McKenzie *et al* 2004; Webber *et al* 2008). The findings of the present study support this, by highlighting the statistically significant association between physical activity enjoyment and physical activity engagement.

3:4:7 Deprivation, Self-Perception and Total Amount of Sports Played

To analyse the effect of deprivation on the dependant variables, the deprivation level using each school's postcode was used. Initially, the spearman's rho correlation identified a significant negative correlation between deprivation, self-perception, and total amount of sports played. When these were plotted on a graph, it was clear that there was little to no meaningful correlation and the analysis was re-run using the median scores for each dependant variable alongside the median score for deprivation indices meaning there were 22 values to analyse in which no significant association was found. A spearman's rho correlation identified no significant negative correlation between each school's deprivation indices, self-perception and total amount of sports played.

Within Gloucestershire, a large majority of pupils travel in and out of the county to attend school each day. Primary and secondary schools which are well-established and known throughout the country are often placed within postcodes that return a low indices of deprivation score. The use of each school's postcode as a measure of deprivation may therefore explain why the findings of this study do not support findings of other research, which have used more accurate measures of deprivation such as walkability, green space, and mapping. When designing the study, the collection of each participants household postcode was intended. However, when attempting to collect this data from parents in addition to parental consent the response was low which resulted in a reduction of questions being asked of parents, including their household postcode.

3:4:8 Limitations/Directions for Future Research

A high number of students received low movement scores, however there is currently very little comparison data available using this movement screen. The lack of consistency between studies when using movement screens to understand movement screen competency has been highlighted by Duncan *et al* (2020). The Athletic Introductory Movement Screen has proved to be a valuable movement screen to use with large cohorts of children. The analysis of inter-rater and intra-rater scoring also demonstrate excellent reliability. Future research may therefore which to collect comparative data from other counties across the UK using the screen, to help develop understanding of movement skill competency in primary school children. Given the clear instructions, scoring criteria and lack of equipment required, future researchers may also be interested to see how feasible it would be for teaching practitioners to make use of the movement screen. If teachers are able to accurately measure movement skill competency at regular intervals throughout the school year, they will be able to identify the needs of their students and subsequently deliver and develop more meaningful movement skill experiences (Longmuir *et al* 2017).

Despite the number of participants of who took part in the study, response rates varied considerably by school and averaged at 55%. It is important to consider the possible effect of responder bias here. Firstly, it could be possible that schools are more likely to participate if they are confident in their provision for physical activity. To overcome this potential limitation, it was made clear to schools that their provision for physical activity was not going to be evaluated or assessed at any point. Secondly, parents who have physically active children may be happier for their child to take part and therefore return the consent form. However, the study was successful at recruiting schools from rural, semi-rural and inner-city localities all of which had a variety of children from different backgrounds and locations.

3:5 Conclusion

The aim of the present study was to establish the movement competency of Gloucestershire's primary school aged children, aged between 7-11 years old, whilst exploring possible associations between physical activity levels, movement skill competency and strength. This study is the first study to explore these variables in Gloucestershire. Movement scores were low, with 558 students scoring between 16-26 out of 48 and 142 students scoring 27 or above. The study addressed previously noted limitations of movement screens and used the Athletic Introductory Movement Screen (AIMS) to establish movement skill competency. The screen is one of the only process-orientated measurements to assess participants across multiple repetitions, capturing movement from both the frontal and sagittal view, which allows the researcher to assess consistency (Rogers et al 2019). Furthermore, this study is one of the first to use what is considered to be a gold-standard measurement of strength amongst children aged between 7-11 in order to explore the relationship between strength and childhood physical activity (Brady et al 2018; Comfort *et al* 2015; Buckner *et al* 2017; Merrigan *et al* 2021). The findings of this study help to contribute to the small body of research aiming to understand childhood strength and movement skill competency by identifying a positive association between the two variables. Furthermore, this study helps to provide an insight into the strength differences between children based on their movement abilities, with children who demonstrate good movement skill also returning high strength scores. This study is also able to add to the literature on childhood physical activity and movement skill competency by identifying positive associations between the two, whilst also identifying positive associations between movement skill, physical activity enjoyment and self-perceived ability. Finally, when looking at the differences between movement percentiles, the findings of this study have highlighted that as movement scores increase, as do physical activity engagement, enjoyment, self-perception scores as well as total amount of sports played. Future interventions aiming to improve movement skill competency and increase physical activity should therefore be encouraged to incorporate activities that aim to improve a wide range of both physical and psychological outcomes.

Chapter 4

Understanding teachers' perceived barriers and facilitators to implementing classroom-based physical activity interventions using the COM-B Model and Behaviour Change Wheel.

Presented at The International Society for Physical Activity and Health (ISPAH) 2021 - Understanding teachers perceived barriers and facilitators to implementing classroom-based physical activity interventions using the COM-B Model and Behaviour Change Wheel. Cline, A., Knox, G., De Martin Silva, L. and Draper, S.

4:1 Introduction

Less than half of children in Gloucestershire are meeting the recommended amount of physical activity per day (Sport England 2021). Out of the 700 children included within the cross-sectional analysis outlined in Section 3:3, 39 (5.9%) reported being physically active for an average of 60 minutes per day or more. The results of the cross-sectional analysis in Section 3:3 also identified that the median score for movement skill competency was 24.3 (4.3) and 25.9 (3.8) for girls and boys respectively, with the minimum score possible being 16 and maximum score possible 48. With 558 students scored between 16-26 and 142 students scoring 27 or above. Importantly, the study has highlighted that as movement scores increase, as do physical activity engagement, enjoyment, self-perception scores as well as total amount of sports played. This highlights the need for future interventions to incorporate activities that aim to improve a wide range of both physical and psychological outcomes.

It has been suggested that interventions aiming to improve physical activity within classrooms are often designed by researchers, who lack the operational knowledge of the school and potential barriers to implementation faced by teachers (Quarmby *et al* 2018). This is problematic given the fact sustained behaviour change is likely to be more successful when a comprehensive understanding of a setting i.e., a school has been established (Mitchie *et al* 2011). As a result, research has begun to explore teachers perceived barriers to increasing physical activity and movement inside the classroom. In 2014, McMullen *et al* conducted semi-structured interviews with 12 American elementary and high school teachers, who identified ease of implementation, children's enjoyment, and classroom behaviour management as important factors to consider when integrating movement into a classroom. In the UK, Gately *et al* (2013) interviewed 8 primary school teachers from 2 schools in Yorkshire and identified additional practical barriers to implementation such as time constraints and demanding workloads. The authors suggest such barriers may therefore be a result of a wider cultural issue in which physical activity remains to be a low priority for primary schools (Gately *et al* 2013).

A more recent study conducted by Quarmby *et al* (2018), involving 31 teachers from 9 different primary schools in Yorkshire, identified several barriers to implementing physical activity interventions in the classroom. Such barriers included teacher's ability and confidence, pupil's behaviour, available space and time, physical resources, school expectations, national curriculum content and challenges related to monitoring performance (Quarmby *et al* 2018). These views are supported by a systematic review of 28 papers conducted by Michael *et al* (2019) who identified institutional and individual barriers to movement integration inside classrooms. The authors suggest that institutional factors including lack of support, resources, time and space had a direct impact on individual factors which included implementation challenges, lack of motivation and lack of training (Dan Michael *et al* 2019). Such findings emphasise the importance of understanding physical, social and psychological barriers when attempting to encourage teachers to increase physical activity and movement inside classrooms (Michael *et al* 2019). The findings of Dan Michael *et al* (2019), which identify the influence of the institution, highlight the need for future research to involve various types of teaching staff rather than just teachers themselves. Furthermore, given that each county across the UK has varying degrees of physical activity prevalence (Venkatraman *et al* 2021), a study local to Gloucestershire is warranted.

Whilst teachers value the importance of childhood physical activity and movement, it is evident that numerous barriers to increasing physical activity inside the classroom exist. Whilst further research aiming to explore these barriers has been recommended, Quarmby *et al* (2019) argues there is a need for future research to explore potential barriers to implementation with teachers who are yet to deliver physically active or movement breaks inside the classroom. Furthermore, they argue that research should include a diverse range of teaching staff, including teaching assistants and members of senior leadership teams, instead of focusing on teachers alone (Quarmby *et al* 2019). As Glasgow *et al* (2004) recommends, teachers should be included in both the design, training and maintenance phase of interventions in order to improve their chances of success. The COM-B model

(Mitchie *et al* 2013) is therefore an appropriate tool to help make sense of the responses from teaching staff, as described in Section 2:5:6.

Capability is defined as “the individual’s psychological and physical capacity to engage in the activity concerned, it includes having the necessary knowledge and skills” (Mitchie *et al* 2011, pp.6). Here, capability is broken down into psychological capability which relates to the ability to engage in the necessary thought processes such as comprehension and reasoning and physical capability, which relates to physical skill, strength and/or stamina.

Opportunity is defined as “all the factors that lie outside the individual that make the behaviour possible or prompt it” (Mitchie *et al* 2011, pp.6). Opportunity can be distinguished between physical opportunities afforded by the environment, and social opportunities afforded by the cultural environment that dictates the way in which we think about things.

Motivation is defined as “all those brain processes that energise and direct behaviour, not just goals and conscious decision. It includes habitual processes, emotional responding, as well as analytical decision-making” (Mitchie *et al* 2011, pp.6). Within motivation there are both reflective processes, which refer to evaluation and planning, and automatic processes which arise from associative learning and/or innate dispositions (Fishbein *et al* 2001). Mitchie (2011) states that for an intervention to be successfully implemented there must be sufficiently strong motivation, ‘individuals must be more highly motivated to do the behaviour are the relevant time than not do the behaviour’ (pp. 59).

4:1:2 Aims

(a) Identify the perceived barriers and facilitators to implementing physically active breaks inside the classroom with primary school teaching staff
(b) Map the facilitators and barriers onto the COM-B model to identify suitable intervention functions

4:2 Methods

4:2:1 Participants

A purposive sampling technique was used to recruit the participants of the study. This involved using the aims of the project to decide what needed to be known before setting out to find participants who were willing to provide the information using their knowledge and experience (Bernard 2017). Purposive sampling is a commonly use recruitment method in qualitative research and allows for the identification and selection of participants, or groups of participants, who are proficient and well-informed with the subject of interest (Creswell and Clark 2017). Importantly, purposive sampling differs from other methods such as random, convenience and snowball sampling because the researcher concentrates on identifying participants with particular experiences and characteristics, such as the ability to articulate, express and reflect, in order to assist with the research (Bernard 2017; Etikan *et al* 2016).

The key gate keepers, head teachers and PE leads, who had previously participated in the study outlined in section 3:1 were contacted via email and a follow up phone call. The researcher explained the purpose of the study and asked if the gatekeeper would pass on the invitation to participate. To be able to take part, participants had to be working with key stage two children within a primary school in Gloucestershire at the time of the study. Importantly, as per recommendation from Quarmby *et al* (2019), those recruited were not already delivering physical activity breaks inside the classroom and could therefore discuss what might prevent them from delivery movement-based interventions in addition to what may enable them to engage with interventions in the future. Twelve members of teaching staff from five Gloucestershire schools volunteered to participate. The five schools were rated as either good or outstanding by Ofsted, but the school size along with the percentage of pupils supported by pupil premium varied. The final sample included teachers, teaching assistants, deputy head teachers and PE leads as displayed in Table 4:1.

Table 4:1 School and Participant Characteristics

School Information							Participant Information			
School	Gender	Age Range	No. of Pupils	No. of Classes	OFSTED Rating	% of Pupils Supported by Pupil Premium	Pseudonym	Gender	Role	No. of Years' Experience
1	Mixed	4-11	182	7	Good	5%	Vicky	Female	Deputy Head Teacher	15
							John	Male	Year 3 Teacher	10
							Emily	Female	Year 4 Teaching Assistant	2
2	Mixed	4-11	265	7	Outstanding	10%	Layla	Female	Year 5 Teacher & PE Lead	12
							Harriet	Female	Year 6 Teaching Assistant	4
3	Mixed	4-11	358	14	Good	20%	Tom	Male	Year 4 Teacher & PE Lead	7
							Chloe	Female	PE Teacher	10
							Alex	Male	Year 5 Teacher	3
4	Mixed	4-11	417	14	Good	11%	Shaun	Male	Year 6 Teacher & PE Lead	8
							Max	Male	Year 3 Teacher	2
5	Mixed	7-11	476	16	Good	15%	Sarah	Female	Year 5 Teacher and PE Lead	14
							Jenny	Female	Year 5 Teacher Assistant & PE Lead	5

4:2:2 Study Design

A total of five focus groups took place, with each focus group having between two and three participants. Each focus group contained teaching practitioners from the same school. A qualitative approach was adopted to explore participants perceived barriers and facilitators to implementing physically active breaks inside the classroom (Brown and Danaher 2019). To allow for an explorative approach, the focus groups followed a semi-structured approach, with the researcher adopting a facilitative approach to discussion (Adams 2015). Semi-structured interviews have been identified as an effective method for allow participants to reveal their perspectives about the phenomemon in question without the research imposing too many predetermined ideas on them (Azungah 2018). To facilitate the conversation, the researcher noted down key words or phrases and asked the group to elaborate in order to help develop the conversation further (Roulston *et al* 2018). Within each focus group the participants often held different roles, meaning it was important to ensure each participant was able to share their perspective on an idea before moving on (Morgan *et al* 2016).

Each participant was provided with an information sheet and were given the chance to ask questions before signing a consent form (see Appendices 38 to 40). Participants were asked if they were happy for the focus groups to be audio recorded to allow for transcription and data analysis to be carried out at a later date. All processes were followed in accordance with the university's ethical board's approval. Each focus group lasted between 40-50 minutes, which is similar to the study conducted by Quarmby et al (2018). The focus groups were conducted within empty classrooms once lessons had finished for the day. The interview questions can be found in Appendix 41.

4:2:3 Data Analysis

Thematic analysis, a method for identifying, analysing, organising, and describing themes, introduced by Braun and Clarke (2013) was used to analyse the data in six phases.

Thematic analysis has been positioned as a suitable systematic and rigorous method for researchers who have complex qualitative data (Riger and Sigurvinsdottir 2016). Importantly, thematic analysis allows for sophisticated analysis of qualitative data to be presented in a way which is accessible to those who aren't part of academic communities (Guest *et al* 2012). This was an important consideration of the project, as it was important for the findings to be accessible for the teaching practitioners it involved (Basit 2010).

Phase 1 and 2: Familiarisation and Initial Coding

The first phase involved becoming familiar with the data. All focus groups were transcribed verbatim, after they had each taken place, before being read multiple times. An 'active' reading approach was adopted, whereby initial meanings, patterns and potential themes were noted down. Phase two involved producing initial codes from the data. Codes identify a part of the data that appear interesting to the researcher, often referred to as the raw data which can later be assessed in a meaningful way (Boyatzis 2009). In this case, coding took a theory-driven approach, in which codes relating to the COM-B model were manually identified and highlighted by the researcher (MacFarlane and O'Reilly-de Brun 2012).

Example:

"I think it's coming up with something that doesn't add too much to an already busy workload, you know I don't want to make their jobs even harder when everyone is pushed for time and feeling pressured about a busy day as it is" – Chloe, Focus Group 3. This raw data was coded as "time" which can be linked to the 'Physical Opportunity' dimension of the COM-B model.

Phase 3, 4 and 5: Searching, Reviewing and Defining Themes:

Once the data had been coded, each code was sorted to form an overarching theme. A theme captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set (Braun and Clarke 2013). Braun and Clarke (2013) recognise that establishing themes requires judgement from the researcher, therefore meaning it is important for the researcher to acknowledge their own theoretical positions and values in relation to the research. A 'keyness' of a theme is not necessarily dependant on quantifiable measures, but in terms of whether it captures something important in relation to the overall research question.

Example:

Physical activity engagement and enjoyment, competition, teacher's confidence, fear, and knowledge were all coded individually and organised into the theme of 'capability'.

Once a set of themes had been identified, the codes within each theme were carefully considered for their coherent pattern. During this refinement, multiple sub-themes were identified. A subtheme, according to Braun and Clarke (2013) is a theme within a theme and can be useful for giving structure to a particularly large and complex theme.

Example:

Within the theme 'capability', teacher's confidence, fear, and knowledge were organised into a sub-theme of 'psychological capability'. Whilst physical activity enjoyment, engagement and competition were organised into a sub-theme of 'physical capability'.

Finally, the thematic map (see Appendix 42) was reviewed to ensure it reflected an accurate representation of the data set as a whole. Once a satisfactory map of the data had been achieved, a detailed analysis of each theme was conducted and written. Braun and Clarke (2013) highlight the importance of identifying a 'story' for each theme, before considering how each story contributes to the broader overall story of the data itself.

Phase 6: Producing the Report

The final phase involved writing up the analysis to communicate a concise and coherent account of the data. Direct quotes from participants were used throughout the text to help ensure transparency (Throne 2000). In addition to the quotes, it was important to demonstrate engagement in the analytic process by referring to the literature when relevant (King 2004). Lorelli *et al* (2017) support this view and suggest the researcher must be able to demonstrate that they have analysed the data in a precise, consistent, and exhaustive manner. This meant the researcher used the data and relevant wider research to support the main points and build to an explanation, something that helps to improve the overall trustworthiness and credibility of the final write up (Straks and Trinidad 2007).

Reliability and validity are frequently discussed in relation to successful quantitative research. However, discussions around credibility, reflexivity, and trustworthiness in relation to qualitative research is widely agreed as being more beneficial (Elo *et al* 2014). Debates on how to ensure rigour in qualitative research have grown in recent years within sport and exercise science, with rigour being embedded in the 'how' and 'why' of the selection of specific frameworks and research design developed by the researcher (Evans *et al* 2021). Purposive sampling, the sampling method used to recruit the participants, has been positioned as a rigorous approach to recruiting participants by Johnson *et al* (2020). Johnson and colleagues (2020) note that purposive sampling reflects the intentional selection of research participants to help optimise data in order to answer the research question at hand. They go onto argue that convenience sampling is the least rigorous approach and may result in lack of credibility and accuracy (Johnson *et al* 2020).

The researcher's positioning has impact over the research and is often dependant on the researcher and participant rapport. Furthermore, the researcher's background affects the way in which they construct the world, makes use of language, asks questions and importantly, how they choose the lends for filtering and making sense of the information gathered from participants (Berger 2015). It therefore must be recognised that the researcher's actions and decisions have inevitably impacted the meaning and context of the participants responses. Ensuring the research reflects on their own experiences, beliefs and interests was essential to helping to ensure rigour throughout the qualitative analysis. To address this the researcher reflected on each interview using a voice note diary. This involved the researcher reflecting back on the interview and exploring comments that came as a surprise and exploring why these were unexpected, did they challenge the researchers' own beliefs for example? The researcher also explored how they felt after each interview, did they feel comfortable because the participant confirmed what the researcher thought to be true from the literature, or did they challenge existing research and therefore cause the researcher to feel uncomfortable or uneasy?

Maintaining rigour throughout data analysis is important in helping to improve the credibility and trustworthiness of the qualitative research. Triangulation is a method whereby a number of researchers, typically three, analyse the data independently before meeting to discuss discrepancies (Campbell *et al* 2013). Due to the nature of the research forming a PhD thesis, it was decided that the researcher would analyse the data alone and then discuss the codes and themes with the supervisory team. This supports the recent narrative provided by Smith and McGannon (2018) who suggest the traditional method of triangulation is unhelpful where qualitative analysis is concerned, suggesting that researchers will naturally disagree to some extent due to having their own identities, backgrounds and experiences. The process of discussing the codes and themes identified by the researcher in an open forum instead encouraged the research to reflect on their choices by providing a verbal justification.

4:3 Findings and Discussion

To meet the aims of the study, the findings have been mapped onto each dimension of the COM-B model and presented as such.

4:3:1 Capability

4:3:1:1 Physical Capability

4:3:1:1:1 Self-Perceived Competence

Participants were more likely to refer to their pupil's physical capability rather than their own. This could be a result of the children being the ones to complete the physical activity breaks, despite teaching staff being the ones implementing and facilitating them. The participants made it clear that they thought the children who were more capable at sports were more likely to engage in physical activity inside the classroom.

> *"I think it goes without saying really that the kids who are good at sports would be happier to do more physical activity inside the classroom, they enjoy being active because they know they can do it you know?"* – Alex, Focus Group 3.

Physical self-concept in relation to physical activity is a well-researched phenomenon. Also known as self-perception, self-concept relates to an individual's perceived physical ability and perceived physical appearance (Shavelson *et al* 1976). Perceived ability, often referred to as perceived competence, is considered to be a central determinant of behaviour (Weiss 2000). Within the context of sport and physical activity, perceived competence is frequently operationalised as an individual's confidence to perform sport and physical activities (Barnett *et al* 2008).

A meta-analysis conducted by Babic *et al* (2014) identified a significant association between children's perceived competence and their engagement in physical activity (r = 0.30, 95% CI 0.24-0.35, $p < 0.0001$). This evidence is supported by the model proposed by Stodden *et al* (2008) who suggest perceived movement competence, actual movement competence, engagement in physical and health related fitness are closely associated with one another (see figure 2).

> *"If they feel like they aren't good at something then they don't engage and they step back"* – Layla, Focus Group 2.

Drawing from previous research, it has been suggested that children who have lower levels of perceived competence are more likely to disengage from physical activity because (a) they understand they are not as competent as their peers, (b) they do not want to publicly display poor low movement skill competency, and (c) they have limited movement skill abilities and will therefore be less motivated to participate in physical activities (Stodden *et al* 2008). It is therefore important for interventions to focus on developing a child's physical capability to improve chances of physical activity engagement.

4:3:1:1:2 Physical Activity Enjoyment

In addition to self-perceived competence, participants suggested that enjoyment of physical activity was likely to affect a child's engagement.

> *"It's clear the children who really enjoy it are the ones who are more likely to be doing it [Layla: Yeah they're always first to volunteer] it sounds obvious but if they like physical activity in the first place it's not hard to get them engaged"* – Harriet, Focus Group 2.

The association between enjoyment, self-perception and physical activity engagement has been explored by Cairney *et al* (2012) who conducted a longitudinal study with 1989 children aged between 9-10. The study identified children who reported higher levels of physical activity enjoyment during physical education (PE) also reported higher levels of perceived competence (Cairney *et al* 2012). Previous studies (Wallhead *et al* 2004; Sallis *et al* 2001) have explored how structured physical activity implemented throughout the school day, such as PE, impact on physical activity engagement. It has been suggested that such activities act as a mechanism to increase self-perceived ability and develop movement skill competencies, therefore making physical activity more enjoyable and accessible.

When discussing how to maintain enjoyment of physical activity, it emerged that children often got bored of physical activities if they found them repetitive or easy, thus meaning they were less likely to engage:

> *"I don't know about you [turning to Tom and Chloe] but my kids get bored of things quickly, if it was a physical activity video or something it would have to keep changing because they would start to get bored [Chloe: Yeah, if it's easy they get bored]* – Alex, Focus Group 2.

Interestingly, this was also apparent for those children who were physically capable.

> "[talking about the daily mile] *It became the daily walk and chat… even the children who were brilliant runners, they were in the minority of children actually doing it properly… so even the really fit sporty children were not taking part as they should have been"* – Vicky, Focus Group 1.

The challenge of both implementing and then sustaining behaviour change is a common issue faced by public health researchers across the world (Abbott *et al* 2013). Multiple school-based physical activity interventions have failed to maintain improvements over a long period of time, with schools often failing to continue to implement the intervention once research teams have left (Masse *et al* 2012).

"You want to keep it interesting so that the kids don't get bored [Tom: Yeah, you don't want it to be a 2 minute wonder] you want to try and keep them engaged over the course of a year" – Chloe, Focus Group 3.

The thrill, excitement and fun of the activity have been rated highly by children as important factors when participating in physical activity (Poulsen and Ziviani 2004). It has been suggested that both researchers and teaching practitioners should carefully consider the mastery climate they are creating within the classroom when integrating movement-based interventions inside the classroom (Han *et al* 2018). First introduced in 1992, Ames defines mastery climate as an instructional approach used within various classroom and physical education settings that provides appropriate success orientated instruction driven through a child's motivation. Importantly, creating the right mastery climate can be an effective instructional approach that promotes positive attitudes and self-perception towards movement whilst keep children motivated and engaged (Robinson 2011). An environment which allows for mastery climate, whilst ensuring activities are both enjoyable and engaging for children, are therefore key when developing interventions aiming to increase childhood physical activity and develop movement skill.

4:3:1:1:3 The Effect of Competition

Finally, participants recognised that for those who lacked the physical capability to engage in sports and physical activities, competition was often likely to disengage them even further:

"I think competition can, well especially for our kids, put them off if they think they aren't very good at something." – Chloe, Focus Group 3.

"Sometimes there are children who do get put off by the competitive nature of an activity. I think it can be a barrier to something children which is a shame" – Harriet, Focus Group 2.

The negative effect competition can have on children's intrinsic motivation to participate in sport has been documented since the mid 1980s (Vallerand *et al* 1986). More recently, research has focused on developing supportive and encouraging environments for children to learn and develop their movement skill competencies instead (Han *et al* 2018). A study conducted by Wadsworth *et al* (2011) identified mastery climates which focused on process-based outcomes were more successful at increasing physical activity engagement compared to product-based climates which focused on performance in 108 key stage 2 children. These findings suggest that it may be preferrable to avoid between-pupil competition where the goal is to develop movement skill competency and encourage engagement in physical activity.

Two participants suggested that introducing competition as a class, or competing against your own personal score would be more beneficial than encouraging children to compete against one another directly:

> *"I think when you do things as a class, like class competitions, that's better than just singling one person out and in some cases, you can make it about team working and working together which is always nice because they really get into that"* – Sarah, Focus Group 5.

This view is supported by Rudisill (2016) who suggests focusing on individual level achievements, or achievements as a group has been associated with increased enjoyment and intrinsic motivation to participate in movement-related activities such as sport and physical activity.

To summarise, participants were more likely to refer to their pupils' physical capability as opposed to their own. It was thought there was a clear relationship between the children who were most physically capable and those who are the most engaged in physical activity. This view is supported by research which suggests there is a significant association between a child's self-perceived ability and their engagement in physical activity (Stodden *et al* 2008). Furthermore, it was thought that physical activity enjoyment mediated this relationship further. Interestingly, despite having the physical capability to participate, engagement and enjoyment of physical activity could be negatively impacted if the children got bored or found the activity to repetitive or easy. Thus, meaning that children's enjoyment of physical activity during lesson time can act as both a barrier and facilitator to adoption. Additionally, it was recognised that some children were disengaged by the competitive nature of some organised physical activities. This therefore raises the importance of future interventions creating a mastery climate in which children feel motivated to learn and develop new movement skills whilst engaging in physical activity (Han *et al* 2018).

4:3:1:2 Psychological Capability

4:3:1:2:1 Teacher's Confidence

Despite being more likely to refer to a child's physical capability, when it came to psychological capability participants were far more likely to reference their own or their colleagues. Across the focus groups, participants identified confidence as both a barrier and facilitator to implementing physical activity breaks inside the classroom. It was apparent that the more confident teachers felt, the more likely they were to implement physical activity breaks.

> *"If they [colleagues] feel a bit more confident with teaching different physical activity tasks they might be more likely to do them [Sarah: Yeah, no one likes teaching things they aren't confident on] more often" – Jenny, Focus Group 5.*

Research regarding classroom-based physical activity has previously identified self-efficacy as a significant barrier to implementation (Parks *et al* 2007; Gibson *et al* 2008; Naylor *et al* 2015). More recently Quarmby *et al* (2019) recognised that teacher's perceived confidence, if low, can create a feeling of reluctance when implementing physically active lessons. Interestingly, confidence was frequently associated with experience. Participants were of the belief that individuals who had a sporting background, or were physically active on a regular basis themselves, were more likely to feel confident delivering physical activity to pupils:

> *"Unless they have a sporting background or tend to do a lot of physical activity, I think there is an element of the unknown that puts people off"* – Tom, Focus Group 3.

This was confirmed by the participants who regularly engaged in physical activity and therefore felt the most confident:

> *"I think it's different for each teacher isn't it because I'd feel really comfortable with that [delivery physical activity inside the classroom] because I've coached sport for years so personally that would be fine for me but not others"* – John, Focus Group 1.

Furthermore, one participant identified that teachers were missing out on the experience to deliver more physical activity because PE lessons were often outsourced to an external company.

> *"A lot of teachers use the opportunity to get some marking done, or just jobs that need doing, because your lesson is essentially being covered. I guess it's different for me because I'm PE lead so I have more of an active role, but a lot of teachers use the time to get stuff done so then if they were asked to take PE themselves, they wouldn't feel as confident compared to say teaching English"* – Tom, Focus Group 3.

A similar issue, dealt in a different way, was raised in Focus Group 2:

> *"We've got external people running our clubs, but they don't teach our PE lessons because it just excludes the teachers completely otherwise and then they feel even less confident because they're almost out of the loop"* – Layla, Focus Group 5.

Outsourcing PE to external companies has become popular within primary schools since the introduction of the Primary PE and Sport Premium in September 2013. Despite spending of the premium being at the discretion of the school leadership team, research into how the money is spent has received relatively little attention. Griggs (2016) carried out an analysis of how 642 primary schools in England were spending their premium, identifying that 77% of schools were spending the majority on external sports coaches. A more recent study conducted by Huddleston and Randall (2018), including 25 primary schools in the Southwest, identified that 21 schools spent the majority of their premium on the use of coaches for physical activity.

Interestingly, even when schools spent their sport funding on upskilling teachers, participants still identified lack of confidence as a key barrier to increasing physical activity throughout the school day:

> *"We get training on sport related exercise but not so much on movement and physical activity... I think people would feel way more involved if they actually felt like they knew what they were looking for and how to help"* – Shaun, Focus Group 4.

It could be argued that this lack of confidence results from the decreasing time spent on PE during teacher training (Morgan and Bourke 2008). Research conducted by Haydn-Davis (2008) identified inadequate time dedicated to the teaching of PE during teacher training, with trainee teachers delivering very few lessons prior to qualifying. According to Bandura's self-efficacy theory, experiences have a direct impact on an individual's beliefs about their capabilities (1997). Therefore, individuals who possess higher levels of self-confidence in their ability would perceive tasks, such as implementing physical activity inside the classroom, as challengers rather than obstacles (Bandura 1997). Given that experience is likely to improve confidence, on-going training, support, and opportunity for reflection should be implemented alongside an intervention in order to address this potential barrier.

4:3:1:2:2 Teacher's Fear

In addition to confidence, participants discussed how fear may impact the implementation of physical activity breaks inside the classroom:

> *"I think it's the getting it wrong isn't it and potentially if you have a child and they do something wrong and they hurt themselves you're in trouble… There is definitely that sort of fear"* – Vicky, Focus Group 1.

A similar discussion occurred in focus group 5, centred around active maths.

> *"It's like with active maths, I think some people were a bit unsure at first [Jenny: scared even] yeah they were concerned about if they could do it, how it would fit in but eventually when they got used to it and more confident, they turn round to me and say it was the best maths lesson they have ever had"* – Sarah, Focus Group 5.

Even when participants felt somewhat confident in identifying children who may need assistance when completing physical activity, upon reflection they began to consider the possibility of getting it wrong:

> *"I could probably watch my kids and spot the ones who may be needed some help but then again I'm not 100 percent sure and I wouldn't want to get it wrong"* – Harriet, Focus Group 2.

Here, fear is directly related to the consequences of incorrectly delivering physical activity. Upon further reflection, Harriet noted that she was concerned for both the consequences it may have on the child's physical health, as well as consequences that may arise from parents should the child injure themselves. This notion is supported by what Barth (2007) terms a 'culture of caution' which refers to a school's desire to avoid taking unnecessary risks. Le Ferve (2014) draws on the nature of risk taking within the school environment, suggesting that teaching is often characterised by the risk of failing to effectively transfer knowledge from pupil to teacher. To achieve behaviour change, the authors argue that teachers should be encouraged to take more calculated risks which can be facilitated through open discussions of potential pros, cons, losses and gains (Le Ferve 2014).

4:3:1:2:3 Teacher's Knowledge

Finally, it appeared that knowledge was something that underpinned both confidence and fear with participants suggesting the provision of knowledge may help to decrease fear whilst increasing confidence which would therefore have a positive impact on psychological capability:

> *"[talking about implementing more physical activity inside the classroom] I think realistically if the staff know what they are supposed to be doing, they know how to do it and they know why they are doing it it's much more likely to actually happen"* – Emily, Focus Group 1

This finding is supported by a scoping review conducted by Nathan *et al* (2018) who identified nine qualitative studies investigating elementary school teacher's perceived barriers and facilitators to the implementation of physical activity re-structuring within American schools. Eighty-eight percent of participants recognised the importance of knowledge as a facilitator to changing physical activity within the school environment (Nathan *et al* 2018). Specifically, participants referred to the importance of knowledge of physical activity and how to effectively deliver physical activity, in addition to knowledge of research that supports the importance of physical activity (Nathan *et al* 2018).

Participants recognised that knowledge regarding the benefits of increasing physical activity throughout the day was regarded as a key facilitator to successful implementation:

> *"I think if staff start to see the benefits or they at least understand the benefit they would get behind it more"* – Chloe, Focus Group 3

Recognising the benefits associated with a change in behaviour is a common feature across multiple behaviour change models such as the theory of planned behaviour change (Azjen 1991), the transtheoretical model (Prochska and Veliver 1997) and more recently the behaviour change wheel (Mitchie *et al* 2011). It is widely accepted within the research that an individual is more likely to be willing to change their behaviour if they understand the physical, psychological, and social benefits of the new behaviour (Mitchie *et al* 2013). Additionally, there is evidence to suggest that sustained behaviour change is more likely to be achieved once the individual sees results, as Chloe suggests. This is supported by Forman *et al* (2008) who noted that interventions within a primary school setting are more likely to be successful if teaching staff could see the beneficial results amongst the children.

Finally, raising knowledge and awareness of other schools who have successfully implemented physical activity inside the classroom was considered to be important:

> *"I think what would help is sharing the research out there. If we could share that I think it would get a lot more people on board because it's saying look this has been done before and these were the outcomes"* – Max, Focus Group 4

This type of modelling is recognised by Mitchie *et al* (2011) as an influential behaviour change technique, thus meaning it has the potential to become a facilitator to implementing physical activity breaks inside the classroom. Research suggests providing an example for people to aspire to or imitate can have a positive effect on behaviour change. Interestingly, whilst the participants noted that this type of modelling could be a facilitator for their colleagues it could also be argued that teachers who encourage participation in physical activity are models for their students too:

> *"I think it's nice for the kids to see us getting into our gym kit… Quite often I get changed and they are like aww are you going to the gym? So, it's nice for them to see us being active which I think helps"* – Harriet, Focus Group 2.

To summarise, participants identified confidence as both a potential barrier and facilitator to implementing physical activity breaks inside the classroom, with the teachers who were more confident in their capabilities being more likely to implement a change. Those who had a sport background or frequently engaged in physical activity were identified as being the most confident, which is consistent with research regarding the association between self-efficacy and experience (Bandura 1977). A lack of experience in delivering both PE and physical activities due to outsourcing PE lessons to external companies was perceived negatively by participants. Fear was also identified as a potential barrier to implementation. Interestingly, despite feeling somewhat confident in delivering physical activity, upon reflection some participants stated they were still afraid of 'getting it wrong'. This aligns with Barth's notion of 'culture of caution' in which schools operate within a risk-adverse climate. Finally, knowledge was thought to underpin both confidence and fear by having the potential to increase confidence whilst reducing fear to have a positive effect on psychological capability. Participants suggested increasing knowledge of the benefits of increased physical activity, as well as providing examples of schools who have implemented similar interventions could act as successful facilitators to behaviour change.

4:3:2 Opportunity

4:3:2:1 Physical Opportunity

4:3:2:1:1 Time

There was an overwhelming agreement from all participants that time was a significant barrier to implementing physically active breaks inside the classroom:

> *"I think time constraints could be an issue, that's an obvious one [Sarah: because it's not like we don't want to do it, we just forget or time runs away with us] it's just trying to fit it in because the kids love being active but us as teachers there are things that need to be finished" – Jenny, Focus Group 5.*

Struggling with finding the time to implement physically active breaks inside the classroom has been identified as a barrier by previous research (McMullen *et al* 2016; Stylianou *et al* 2016; Quarmby *et al* 2018). Currently, in the UK, the primary school curriculum includes 11 different subjects that need to fit into five days of teaching throughout the course of the week with English and Maths taking up the majority of morning teaching time. Therefore, it is understandable that teachers feel pressure when fitting it all in. Throughout the focus groups, the language used to describe the busy timetable was frequently characterised by negativity:

> *"I can see how some teachers who might say [mimics teachers] I'm up to here, I don't want anything else, I don't want anything else to do" – Shaun, Focus Group 4.*

It could be argued that English primary schools have seen an increase in cultures of performativity over the past decade. Troman *et al* (2007) identifies target setting, Ofsted inspections, school league tables, performance management and performance related pay as systems that demand teachers to 'perform' and to be individually accountable. Whilst these measures have been introduced to improve students' achievements, they often have a negative impact on teacher's workload, their professional identities, and their experience of teaching (Jeffrey 2002; Troman *et al* 2007). This is supported by previous research which identifies pressure to perform well in assessments a barrier to increasing physical activity throughout the school day (Gately *et al* 2013).

Participants were quick to identify the time it takes to deliver physical activity, as it often takes longer than expected due to practicalities such as explaining the task to the children, waiting for the children to change into their PE kits, or moving the children from inside the classroom to outside:

> *"You've got to factor in planning time and as well just getting the kids either outside or explaining the task and answering questions, that's going to be way longer than five minutes" – Harriet, Focus Group 2.*

In addition to finding the time to implement physically active breaks, the preparation time required prior to implementation was also identified as a barrier:

> *"And time as well, it already feels like we can't fit everything into the school day as it is. I like the idea of the kids being more active in the classroom but in all honesty, it means I've got find a way to get them more active and that requires more planning which takes up more time"* – Harriet, Focus Group 2.

This barrier has previously been identified by Quarmby *et al* (2018) who explored perceptions to implementing physically active lessons. Despite exploring the physically active breaks, something that arguably requires less planning that a physically active lesson, participants were still quick to consider the impact that extra planning time might have on their workload. A demanding workload coupled with limited time was also frequently identified as a barrier to implementation by participants:

> *"I think people will just be worried about the workload they have and trying to fit something extra in"* – Shaun, Focus Group 5.

A similar point was raised in focus group 5.

> *"I think it's coming up with something that doesn't add too much to an already busy workload, you know I don't want to make their jobs even harder when everyone is pushed for time and feeling pressured about a busy day as it is" – Chloe, Focus Group 3.*

There was notable hesitation and caution in the way participants approached the subject of limited time coupled with a demanding workload. Interestingly this caused a heated debate during focus group 3 between participants who all had different roles within the school:

> *Chloe: I think ten minutes a day*
> *Tom: A week?*
> *Chloe: No, a day*
> *Tom: That's ambitious, nobody is doing that, thinking with my teacher head on*
> *Chloe: I think it needs to be more than ten minutes a day though*
> *Tom: I get that*
> *Chloe: Three blocks of five minutes instead?*
> *Tom: That would be better, I just know how teachers work and if you say ten minutes three times a day, they will just say no I'm not doing that*
> *Alex: I know when I think of my typical day, well it's already busy*
> *Chloe: But my point is that they have to do 30 minutes of physical activity outside of PE, break and lunch*
> *Alex: If you've got an ideal world where we aren't swamped and not drowning because by week 3, we've got a to do list where we need to do this, this, this and this*
> *Chloe: I know we are two extremes aren't we*
> *Alex: I think we need to be realistic about it and put my teacher head on*

Given each participant held a different role within in the school, it is understandable as to why they all had different perspectives and priorities. Conflicting opinions of stakeholders is therefore a key barrier to overcome to ensure successful implementation of physically active breaks. As noted by Quarmby *et al* (2018), ensuring the buy-in of all key stakeholders inside the school is crucial to achieve sustained behaviour change.

4:3:2:1:2 Resources

Participants identified receiving good quality resources as a key facilitator to implementing physically active breaks inside the classroom:

> *"I think teachers like the idea of being given resources, so then we aren't having to design them, that's much simpler for us. Because as soon as you start to ask them to do even more work they are going to switch off because they have enough to do"* – Alex, Focus Group 3.

There was agreement that a good quality resource is something that is fun, simple, quick, and easy to use:

> *"I'm thinking something easy, plug and play, you know like a video clip that the children could follow"* – Tom, Focus Group 3.

Ease of adoption is an important factor for any behaviour change intervention to consider. Given the identified time constraints, it is logical that teachers would prefer resources that require little effort on their behalf. A systematic review conducted by Naylor *et al* (2015) identified quality of resources as the most important facilitator to physical activity intervention implementation. There was also strong emphasis placed on resources being adaptable and flexible depending on class, time, and year group.

"Each class is different, so a sort of plenary would be great, a physical plenary, maybe you have three blocks or choices and then you decide when to implement them throughout your day" – Max, Focus Group 5.

The discussion developed into the idea of resources that were adaptable for each teacher.

"If you have something that is adaptable to each class, I think it would be better received by teachers rather than something quite regimented because I think they would just roll their eyes and not even want to try" – Shaun, Focus Group 5.

Participants shared different ways in which they adapted the physical activity resources that they currently have in schools.

"Yeah, I do mine as an add on, so we have already learnt it and I know they have predominantly got it, but this helps to seal it in and becomes more memorable to them" – Jenny, Focus Group 5.

Being able to adapt an intervention or producing an intervention that is flexible in its approaches created an interesting topic for consideration. On one hand, guidelines suggest that interventions should be delivered with precise consistency to all its participants (Consort Guidelines 2019) with studies failing to do so facing critique (Daly-Smith 2018). On the other hand, it is often the case that 'one size' does not fit all, and the adoption of an intervention often needs to be adapted to fit the participants needs (Glidewell *et al* 2018).

Finally, participants identified poor quality resources as being a barrier to implementation:

"In reality, everyone has drifted away from the Lancashire scheme of work because we couldn't find them, couldn't find them on the server, files wouldn't download because they were too big… you know it's just drifted off" – Shaun, Focus Group 4.

In this case, the participant reemphasises the importance of being able to easily access physical activity resources, something that is an important practical factor to address to avoid resources becoming a barrier to implementation instead of a facilitator.

4:3:2:1:3 Space

Previous research has identified space to be a central barrier when attempted to implement interventions aiming to increase levels of physical activity inside the classroom (Gately *et al* 2013; McMullen *et al* 2014; Quarmby *et al* 2018). Interestingly, space was not mentioned at all during focus groups 3 and 4, with participants in group 2 and 5 recognising their large school grounds as a facilitator to physical activity:

> "*Yeah, we are really lucky to have beautiful grounds [Harriet: yeah definitely have that space is really important] we've got an adventure playground and a track around the field"* – Layla, Focus Group 2.

Despite recognising the benefit of having space outside of the classroom, one participant noted that space inside the school itself acted as a barrier to implementing physical activity inside the classroom:

> *"To be honest we looked at active maths and umm the problem with that is space we've got big classes in small classrooms you know our classes are 35"* – Layla, Focus Group 2.

In addition to classroom size, classroom location was also noted as a potential barrier to implementation:

> *"I'm just thinking of the class below mine, even tucking our chairs in, it makes such a loud noise for them so I'm thinking if we are stomping upstairs, it would create such a racket down here. So, I was thinking especially for space you know with the tables*

if we are trying to do something because we haven't really got loads of room" – Emily, Focus Group 1.

Whilst space outside the classroom is considered to be a facilitator of physical activity, the lack of space inside the classroom can act as a barrier. This study has highlighted that exercises that require little space to complete, as well as little to no equipment to avoid taking up unnecessary space, should be prioritised in order to overcome this potential barrier. esearchers need to take this into consideration when designing the content of a classroom-based physical activity intervention (Martin et al 2018).

To summarise, time was considered a significant barrier to implementing physically active breaks inside the classroom. Preparation time, instruction time and time spent moving the children outside were all noted as factors that would contribute to an already tight schedule. Participants frequently referred to their already busy workload, identifying possible resistance to implementation from their colleagues if they felt increasing physical activity inside the classroom would contribute to an already busy workload. Such findings support those of previous research (McMullen *et al* 2016; Stylianou *et al* 2016; Quarmby *et al* 2018), Research conducted by Troman *et al* (2007) may suggest a culture of performativity inside English primary schools, where significant attention is paid to target setting, league tables and performance related pay, has negatively impacted a teacher's workload as well as their professional identity and experience of teaching. On the other hand, resources were considered to be a facilitator to implementation. With participants suggesting they should be quick, simple, and easy to use. Interestingly, participants recognised the importance of flexibility in the use and adoption of resources which raises an interesting question for researchers who are encouraged to delivery their interventions with consistency. Finally, whilst space outside of the school was considered a facilitator to physical activity in general, the lack of space inside the classroom was considered a barrier. Researchers should therefore focus on physical activity that requires little space and little to no equipment to avoid using unnecessary, and in some cases unavailable, space.

4:3:2:2 Social Opportunity

4:3:2:2:1 Behaviour Management

Throughout the focus groups, there was debate as to whether classroom behaviour management was a barrier or a facilitator to implementing physically active breaks.

> *Max: I don't know what my class is going to be like next year so it might be that we do that, and they go off on one and then it takes 20 minutes to calm down then I'm probably not going to do it again – Focus Group 4.*

> *Shaun: But then I guess they might just need some training, might they? Presumably the first time they do it they might get quite restless but once they are used to it you know doing some work, then doing some exercise, then doing some work, then presumably they'll get used to it and it could work quite well – Focus Group 4.*

This concern is supported in the wider literature that has previously identified pupil behaviour as a barrier to implementation (McMullen *et al* 2014; Quarmby *et al* 2018). Quarmby *et al* (2018) note that ensuring pupils remain seated throughout a lesson helps to ensure a level of classroom control and management, which teachers could be hesitant to disrupt. Some participants reflected these concerns:

> *"To be honest with you, I think you worry about the energy levels going through the roof and you not being able to be get it under control again and if it's that's happening everyday [pause] well, people just aren't going to do it"* – Sarah, Focus Group 5.

Interestingly however, there was agreement that choice over when to implement a physically active break was likely to reduce the chances of behaviour management being a barrier to implementation:

"If you can choose when the kids do it then you can sort of minimise the disruption and use it to your advantage" – Emily, Focus Group 1.

This was reflected in other participants views, who believed that implementing physically active breaks at the right time throughout the day could help to keep their pupils focused:

"I've got some very restless children who benefit from it I think, if I saw I was losing their concentration we could have a blast of exercise and then they would benefit mentally as well as physically too" – Tom, Focus Group 3.

It was evident that teaching staff believed, if implemented effectively, physically active breaks inside the classroom had potential to act as a behaviour management tool as opposed to encouraging poor behaviour from pupils. This is supported by a substantial amount of research that indicates physical activity inside the classroom has the potential to increase time on task behaviour (Mahar *et al* 2006; Grieco *et al* 2009), improve cognitive function (Watson *et al* 2017; Donnelly *et al* 2016) and academic achievement (Singh and Uijtdewilligen 2012; Daly-Smith 2018).

4:3:2:2:1 Whole-School Approach

The importance of all staff members implementing physically active breaks throughout the school day was raised during all five focus groups:

"I think it's something that would need the whole school on-board. You can't just have a few teachers trying to get everyone active, it's got to be everyone" – Shaun, Focus Group 4.

Encouraging a whole-school approach in order to increase levels of physical activity has been widely supported within the literature (Colabianchi *et al* 2015; Naylor 2010; Hunt *et al*

2015). In this case, participants thought that adopting a whole school approach may help to increase adherence:

> *"I think if you made it a whole school approach, you know all in it together and it's just what everybody does. Then you'd be the one left out if you weren't doing it then"* – Jenny, Focus Group 5.

Both Shaun and Jenny's comments identify the importance of encouraging a wider culture change throughout the whole school as opposed to attempting to initiate change within one classroom alone. Culture, defined as a set of key values, beliefs and understanding shared by a group of people, often sets the behavioural norms and standards (Misener 2013). Therefore, when attempting to add a new practice, in this case physically active breaks, it is important that the practice becomes ingrained into the school's organisational culture to create sustained behaviour change, even when the intervention has finished (Fox *et al* 2004).

In addition to helping create sustained behaviour change, one focus group discussed the practical benefits to adopting a whole school approach:

> *"I think the staff have to want to do it, it couldn't be a one-person thing could it? It just couldn't happen practically if it was just one person because everyone already has a lot to do, so you need to share that responsibility out"* – Layla, Focus Group 2.

Interestingly, participants noted that creating a whole school approach could sometimes be difficult due to a difference of priorities:

> *"The problem is, if the staff don't want to do it, they aren't going to be enthusiastic about it with the children. Say you've got history to catch up on, staff who don't want to do extra physical activity will do the history instead"* – Vicky, Focus Group 1.

Participants in focus group 3 identified increasing knowledge and awareness of the benefits of physical activity as a potential method of ensuring all staff were on board:

> *"I think as well, if you present something to the staff, you know... here are the benefits and this is why it's important, this is the reason why we are doing this... it becomes official and the school really do come together and embrace whatever that may be"* – Tom, Focus Group 3.

Finally, the importance of sharing knowledge and ideas with one another was identified as a facilitator for successfully implementing physically active breaks inside the classroom:

> *"I think it's important to share experiences with each other. I don't think I'd like to do it alone if that make sense. You can tell each other what has worked and what hasn't, little tips almost, I guess. I think the hardest thing, like I said, would be choosing what to do and when so you can share your experiences with everyone else"* – Max, Focus Group 4.

To summarise, behaviour management was seen as both a possible facilitator and barrier to implementing physically active breaks inside the classroom. Maintaining classroom control was a cause for concern for some participants which has been reflected in previous literature (Quarmby *et al* 2018). Interestingly, having the ability to choose when to implement physically active breaks was considered by participants as a way in which to manage classroom behaviour more effectively. Participants noted that implementing physically active breaks when children were fidgety or finding it difficult to concentrate could have a beneficial effect on classroom behaviour. To improve adherence, it was noted within all 5 focus groups that a whole-school approach was required. Given that each school has its own cultural organisation which dictates its norms and values, researchers should aim to ingrain physically activity breaks into common everyday practices so they continue longitudinally (Fox *et al* 2004).

4:3:3 Motivation

4:3:3:1 Reflective Motivation

4:3:3:1:1 Choice

All five focus groups discussed the importance of choice as a facilitator to successfully implementing physical activity breaks inside the classroom. Here, John reflected on when he would choose to implement a physical activity break:

> *"I'd be conscious of choosing when to do it. I think you'd have to choose when it would be most appropriate throughout the day, would that be during a transition between lessons or before breaktime"* – John, Focus Group 1.

Allowing individuals to reflect on the potential of their future behaviour is likely to increase chances of adoption. The planning stage is noted as a critical step within multiple behaviour change models. As West (2007) notes, individuals are capable of forming mental representations of future actions alongside a set of starting conditions. Behaviour change is therefore often dependant on whether these mental representations seem desirable and worth committing too.

In addition to pre-planning, participants discussed how teachers could reflect on previous experiences too, suggesting that giving teachers' choice may allow them to reflect on their past experiences to inform and guide their future decisions:

> *"What if it was something that teachers decided? Like we decided when it should be conducted inside the classroom?"* – Max, Focus Group 4.

> *"That sounds lovely, because it would tie in with what other people are doing, their own experiences can come into it then [mimicking teacher] 'oooh that worked quite*

well that time, but no not so well when I did it then' you know?" – Shaun, Focus Group 4.

Drawing from self-determination (Deci and Ryan 2012), which predominantly focuses on the processes in which a person acquires the motivation for behaviour change, it can be argued that reflecting on previous experiences can help to encourage and sustain behaviour change.

Offering an intervention that allowed teachers to make their own choices about implementation was perceived as being well received in comparison to an intervention that was more regimented:

> *"I think it's important to have something that isn't too regimented. Maybe if you can give teachers some choice about when and how they can do it, rather than saying right you have to do it at this time and you have to do it this way [pause] you let them decide when and what is best. There's a huge pressure to fit everything in, whereas giving us choice, we can make it work to fit our plans and it becomes much more doable"* – Layla, Focus Group 2.

Here, it is evident that due to a busy workload, being given the choice as to when to implement a physically active break was likely to be more effective than telling teachers they were to implement a physically active break at a specific time. A similar point was discussed in focus group 3:

> *Chloe: I think if you have options and you give teachers choice, they can decide when works best for them*
> *Tom: Do you mean maybe the daily mile 2 days a week and then the other 3 days something inside the classroom?*
> *Chloe: Yeah exactly, because then you have the choice, and you can make it work for you. If it's raining or depending on your day, surely, you're more likely to do it then*

Tom: Yeah, I agree, I think that would work well because you aren't being told you absolutely have to do something at a specific time [Chloe: exactly] it's down to you instead

Interestingly, Tom and Chloe are discussing the important of choice not only for navigating practicalities such as weather, but also for motivational purposes. A substantial amount of research suggests that an individual is more likely to want to engage in behaviour change if they feel as though it is their choice to do so, rather than having the choice made for them (Ryan *et al* 2009). This degree of perceived autonomy, or internal perceived locus of causality, refers to an individual's willingness to engage in behaviour change and can therefore heavily influence motivation (Ryan and Deci 2000). This is supported further by self-determination theorists, who argue that behaviour change is often facilitated by providing relevant information and meaningful rationale for change whilst avoiding the application of external control and pressures which may detract from a sense of agency or choice (Ryan *et al* 2008). Therefore, it is important that an intervention aiming to implement physically active breaks allows teachers adequate choice, preparation, and reflection time in order to increase levels of adherence.

4:3:3:2 Automatic Motivation

4:3:3:2:1 Competition

Automatic motivation, such as emotional reactions, desires and habits featured significantly less than other elements of the COM-B model. An explanation for this may be that such processes often occur once the behaviour has been adopted. One emerging theme, that could be attributed to automatic motivation, was competition. Whilst individual competition between pupils was seen as a potential barrier to implementation, participants identified that class competitions could be an effective way of increasing motivation to complete more physical activity breaks:

> "*It would be good to compare classes, you know see how everyone has done, that would remind us to do it and help get everyone involved [pause] you know like a class competition"* – Max, Focus Group 4.

Therefore, to successfully navigate the barrier that individual level competition may create, classroom-based physical activity interventions should focus on classroom competitions to help engage pupils whilst providing automatic motivation for teachers.

To summarise, in terms of reflective motivation, all five focus groups identified choice as an important facilitator for effective implementation of physical activity breaks inside the classroom. Firstly, reflecting on the potential of a future behaviour change choice was important for teachers. With participants suggesting the pre-planning of practicalities such as time were necessary in order physical activity breaks to take place. Secondly, participants noted that interventions should aim to give teachers choice rather than be regimented or restrictive. This is supported by research that suggests individuals are far more likely to adopt a behaviour change practice if they feel as though the choice is their own (Deci and Ryan 2012). Supported by self-determination theory, interventions should aim to provide relevant information that is likely to increase motivation upon reflection whilst avoiding the application of external control and pressures which may detract from a sense of agency or choice (Ryan *et al* 2008). Finally, whilst themes relating to automatic motivation featured substantially less, participants identified classroom competition as a potential facilitator to the successful adoption of physical activity breaks inside the classroom.

4:5 Conclusions

Physical activity interventions within the primary school setting are often short lived and fail to create sustained behaviour change. One explanation for this, provided by Quarmby *et al* (2018) is that researchers often lack the operational knowledge of the school, as well as potential barriers to implementation faced by teachers. Therefore, this study has aimed to explore the perceived barriers and facilitators to implementing physically active breaks inside the classroom with primary school teaching staff, before mapping those barriers onto the COM-B model to identify suitable intervention functions. The study differs from previous research that has either drawn from a smaller sample size (McMullen *et al* 2016), focused on teachers who are already implementing physical activity breaks (Gately *et al* 2013), looked at physically active learning as opposed to physical activity breaks throughout the school day (Quarmby *et al* 2018), or focused only on the barriers to implementation as opposed to possible facilitators too (Quarmby *et al* 2018).

A thematic analysis of the data identified codes and themes, which in this case were drawn from the COM-B model developed by Mitchie *et al* (2011) using a deductive approach. When referring to physical capability, participants were more likely to refer to their pupil's physical capability as opposed to their own. A child's self-perceived ability, their actual ability in addition to their level of enjoyment were seen as both barriers and facilitators to implementation dependant on which end of the spectrum the children found themselves. When discussing psychological capability however, participants were more likely to reference their own, suggesting that confidence and fear were potential barriers to implementation. Time and space were considered to be significant barriers to implementation when physical opportunities were discussed, with resources being positioned as a facilitator provided they were of a good quality. Furthermore, classroom behaviour management was viewed as a potential barrier to implementation within social opportunity, whilst adopting a whole-school approach was considered to be a facilitator. Finally, choice was considered to be a key facilitator when discussing reflective motivation, in addition to between classroom competition which was identified as a possible facilitator when discussing automatic motivation.

4:5 Practical Implications

It is clear from the evidence provided that in relation to classroom based physical activity, primary schools are a complex setting in which multiple barriers and facilitators exist. It is therefore important for researchers to work closely with a variety of teaching staff to identify and address these barriers and facilitators to not only successfully implement an intervention, but to make sure that behaviour change is sustained over a longitudinal period of time. Based on the findings identified throughout this study, the following recommendations are suggested for the future design and implementation of physical activity breaks inside the classroom:

- Physical activity breaks should be fun, engaging and challenging for the children involved to avoid boredom or risk losing the 'novelty' factor.

- Where possible, between class competition should be encouraged, whilst individual level competition should be avoided to prevent further disengagement from students who may already feel left out.

- To help develop confidence and reduce fear, teachers should be provided with knowledge on the benefits of physical activity, in addition to sufficient support regarding how to plan and deliver physical activity breaks inside the classroom.

- Given the limited time and workload demands faced by primary school teachers, interventions should aim to introduce physically active breaks that are short, simple and easy to implement throughout the school day.

- Where possible, buy-in from all teaching staff should be encouraged to achieve a whole-school approach that promotes the importance of, whilst allowing time for, physically active breaks inside the classroom.

- Finally, interventions should aim to provide schools with good quality resources that offer some degree of flexibility and choice that allow teachers to remain autonomous over their school day.

Chapter 5

Using the knowledge and experience of primary teaching practitioners to help design a pilot movement-based intervention to implement within Gloucestershire classrooms in accordance with COM-B and Behaviour Change Wheel

5:1 Introduction

The findings outlined in Section 3:4:1 provide evidence that physical activity levels and movement skill competency were low in the participants measured. The subsequent focus groups presented in Section 4:2, conducted with 12 teaching staff from 5 Gloucestershire schools, were able to explore potential barriers and facilitators to implementing physical activity breaks throughout the school day. The results from the study identified multiple barriers to implementation such as time and space constraints, classroom behaviour and lack of knowledge. The study was also able to identify key facilitators such as enjoyment, knowledge and awareness of benefits, good quality resources and freedom of choice. The aim of this chapter was to draw upon the findings in Section 4:3 and explicitly demonstrate how the pilot intervention was designed using the COM-B model.

5:1:1 Aims:

In accordance with the COM-B Model and Behaviour Change Wheel, use teaching practitioner's knowledge and experience to help develop a pilot movement-based intervention to be implemented and evaluated within primary schools in Gloucestershire

5:2 Behaviour Change Wheel

5:2:1 Understanding the problem in behavioural terms

According to Mitchie et al (2013), defining the problem in behavioural terms means being specific about the target behaviour, the target group or population and the behaviour itself by asking:

(a) What is the behaviour?
(b) Where does the behaviour occur?
(c) Who is involved in performing the behaviour?

As outlined in Sections 2:1:5, 2:2:3 and 3:4:1, the behaviour requiring intervention was childhood physical inactivity, sedentary behaviour, and low-quality movement skill competency. Whilst these behaviours occur 24 hours a day, 7 days a week, the intervention was specifically focused on these behaviours during the school day which typically begins at 9am and finishes at 3pm. As identified in chapter 4, the World Health Organisation identify schools as primary sites for health interventions due to their ability to reach the vast majority of school aged youth. Finally, whilst it was children who were performing the behaviour, it was the responsibility of teachers, teaching assistants and headteachers to deliver the intervention that enabled the behaviour change.

5:2:2 Selecting the target behaviour

It is important to acknowledge that behaviours interact within a system. Therefore, when considering which behaviours to change, consideration was given to how behaviours may interact within one another. Mitchie *et al* (2015) encourage thought towards a) how likely it is for a behaviour to change, b) the likely impact if the behaviour were to change, c) how behaviour change may positively or negatively affect other behaviours and d) whether the behaviour change can be feasibly measured (see Appendix 44). For example, encouraging families to be more active throughout the weekend may have a promising impact if the behaviour is adopted, however the likelihood of behaviour changes occurring is low due to a lack of physical opportunity and physical/psychological capability faced by some parents (Shelton *et al* 2011). Furthermore, whilst an increased amount of time spent physically active over the weekend is unlikely to have a negative impact on other behaviours, measuring children's physical activity levels during the weekend poses significant feasibility issues (Freedson *et al* 2012).

Another potential behaviour change intervention may have been implementing a physical activity club before or after school. Measurement feasibility would have been more realistic in an afterschool setting as it allows for greater control. However, a large majority of schools already have sport related afterschool clubs thus decreasing the opportunity to implement additional movement and physical activity.

5:2:3 Specifying the target behaviour

Having selected the target behaviour, it was important to describe the behaviour in appropriate detail and context by asking:

(a) Who needed to perform the behaviour?

In this case, it was primary school children who would be increasing their physical activity levels and reducing their sedentary behaviour throughout the school day in an effort to improve their movement skill competencies. However, it was the teachers, teaching assistants and headteachers who were implementing the intervention and facilitating the behaviour change.

(b) What did they need to do differently in order to achieve the desired change?

Currently children are largely sedentary for the school day (Quarmby *et al* 2018). The Department of Health recommends that schools provide children with up to an addition 30 minutes of physical activity, separate from breaktime and lunchtime (2019). Therefore, teachers were required to implement short physical activity breaks throughout the school day. Given the associations between physical activity and movement skill ability presented in Section 3:4:4, it was important that the breaks included movement competence tasks such as multi-joint movements that manipulate degrees of freedom in the body, as well as a combination or isometric, concentric and eccentric muscle activity that require both inter and intramuscular co-ordination and control (Cattuzzo *et al* 2014). A meta-anlysis conducted by Behringer *et al* (2011) indicated that adequate volume is needed to provide sufficient adaptive stimulus. Despite this, there is no single combination of exercises, sets or repetitions that has proven to optimise training adaptations in children. The importance of exposure to a breadth of movement between the ages of 7-11 is supported by the Youth Development Model (Lloyd *et al* 2016) presented in Section 2:2:1. Multi-faceted programmes that aim to increase muscle strength, improve functional abilities, and enhance movement mechanics appear to be the most effective for developing movement competencies and reducing the risk of injury in children (Myer *et al* 2011).

(c) When did they need to do it?

Physical activity breaks needed to be implemented throughout the school day, with teachers using their own discretion to decide when the breaks should be implemented. As highlighted in Section 4:3:2, providing teachers with choice and flexibility, therefore preserving their autonomy, is a key facilitator to successfully implementing physical activity breaks inside the classroom.

(d) Where did they need to do it?

Physical activity breaks were to be completed inside the classroom. Research conducted by Malden and Doi (2019) identified the weather as a significant barrier to implementing physical activity interventions that required teachers and children to be outside. Furthermore, as noted in Section 4:3:2, teaching practitioners identified lack of time as a barrier to implementation. Therefore, making use of the classroom space and using chairs and tables in new inventive ways to enable physical activity seeks to overcome these previously experienced difficulties.

(e) How often did they need to do it?

Each physical activity break lasted for 5 minutes, and children were asked to complete 3 breaks a day. The use of short bouts of physical activity are recommended within the UK Chief Medical Officers' Physical Activity Guidelines (2019). Interestingly, research by Logan *et al* (2011) suggests more time spent doing physical activity that aims to improve movement skill competency doesn't always result in greater improvements. This may be a result of children plateauing in their competence after critical amount of instruction has been reached (Logan *et al* 2011). Furthermore, the intermittent rather than continuous nature of short movement skill competency tasks is more consistent with how children move and play (Myer *et al* 2011). Improvements to movement skill were noted by Ma *et al* (2014) who implemented 4-minute long 'funtervals' with children aged between 8-11.

(f) With whom did they need to it?

As noted in previous research (Quarmby *et al* 2018) it is important for interventions within school settings to involve all staff members, and not just the teaching staff, to promote and effective institutional approach. Physical activity and movement skill competency interventions led by teachers have been recognised as being both feasible and effective for initiating and sustaining behaviour change (Mitchell *et al* 2013). Furthermore, research has shown that teachers and teaching assistants are capable of delivering physical activity breaks inside the classroom with preserved fidelity and efficiency provided they receive adequate training (Howie *et al* 2014).

5:2:4 Identifying what needs to change

Having specified the target behaviour, the next step was to identify what needed to change. Mitchie *et al* (2011) notes that this refers specifically to what needs to change in the person and/or environment to achieve the desired behaviour change. Drawing from the COM-B model, Mitchie *et al* (2011) suggests that there must be capability, opportunity, and motivation in order for behaviour change to happen, see Table 5:1.

Table 5:1 Identifying what needs to change

Component	What needs to happen for the target behaviour to occur?	Is there a need for change?
Physical Capability Physical skill, strength, or stamina	Children needed to have an adequate level of movement	No. However consideration and alternatives need to be provided for children with movement disabilities
Psychological Capability Knowledge or psychological skills, strength, or stamina	Teachers needed to (a) be aware of the benefits of improving MSC, FMS and increasing physical activity levels whilst reducing sedentary behaviour; (b) be aware of how to implement physical activity safely and effectively inside the classroom; (c) be able to identify children who need extra support	Yes. Additional knowledge: raised awareness and training were necessary for teaching staff. Both teachers and children were required to regulate their newly changed behaviour and record their progress.
Physical Opportunity Opportunity afforded by the environment involving time, resources, locations	Schools and teachers needed to (a) have the time available to do implement physical activity breaks throughout the day; (b) have enough space in the classroom to safely perform physical activity; (c) have the right resources to enable appropriate physical activity to take place	Yes. Time needed to be made available during lessons. Space needed to be correctly used. Teachers needed to be provided with informative resources. Prompts and physical resources were to be provided to act as reminders, as well as to help encourage and keep track of the physical activity breaks
Social Opportunity Opportunity afforded by interpersonal influences, social cues and cultural norms that influence the way we think about things	Schools needed to (a) encourage all staff to take part to help form social bonds; (b) be provided with physical prompts to reduce the chance of teachers forgetting; (c) encourage healthy competition between peers and classes; (d) create a supportive environment in which breaking up sedentary lesson time with physical activity is encouraged	Yes. Encouragement was needed from headteachers and school governors to ensure all teachers take part, and to create a whole-school approach. Physical resources were needed to help prompt teachers and children. Healthy competition between classes was needed,

		which for this study, was in the form of a scoreboard
Reflective Motivation Reflective processes involving plans (self-conscious intentions) and evaluations (beliefs about what is good and bad)	Both teachers and children needed to (a) develop a habit or routine that includes regular physical activity breaks; (b) develop and plan lesson times to allow time for physical activity	Yes. Routines and lesson plans needed to be practiced and established within the classroom. Children and teachers needed to set themselves daily/weekly goals. Teachers needed to feel capable of delivering safe and effective physical activity inside the classroom
Automatic Motivation Automatic processes involving emotional reactions, desires, inhibitions, drive states and reflex responses	Both teachers and children needed to feel as though they want to be more physical active in addition to believing that being physically active more often would be a good thing to do.	No. However, reinforcement of these beliefs through knowledge and awareness would be beneficial. Weekly rewards/incentive schemes for the children would help to increase the motivation to participate in the physically active breaks

5:2:5 Identifying intervention function options

According to Mitchie *et al* (2011) the behavioural diagnosis that has taken place in steps one to four is a crucial stage for designing interventions as it helps to identify potential levers of change. Importantly, the recommendations provided by NICE (2008) can be linked with the identified COM-B components as follows:

Maximise **capability** to regulate own behaviour

1. Develop relevant skills such as monitoring, goal setting and providing feedback
2. Develop specific plans to change

Maximise **opportunity** to support self-regulation

3. Elicit social support
4. Avoid social and other cues for current behaviour
5. Change routine and environment

Increase **motivation** to engage in the desired behaviour

6. Reward change
7. Develop appropriate beliefs (e.g. benefits to changing, confidence to change)
8. Develop positive feelings about change
9. Develop new habits

These principles can also be understood in the general function they serve. Mitchie *et al* (2011) terms these 'intervention functions' which refer to broad categories of means by which an intervention can change behaviour. Any behaviour change strategy may have more than one intervention function. Therefore, when designing an intervention, it is important to start by considering the full range of possible intervention functions. This is often done by using a framework of behaviour change. As noted, many frameworks of behaviour change have been produced, with varying levels of comprehensiveness, coherence, and theoretical base. The Behaviour Change Wheel was based on 19 frameworks, all of which were reviewed and compiled into one over-arching framework which comprised of 9 intervention functions:

1. Education

   Increasing knowledge and/or understanding

2. Persuasion

   Using communication to induce positive or negative feelings or stimulate action

3. Incentivisation

   Creating an expectation of reward

4. Coercion

   Creating an expectation of punishment or cost

5. Training

Imparting skills

6. Restriction

   Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)

7. Environmental Restructuring

   Changing the physical or social context

8. Modelling

   Providing an example for people to aspire to or imitate

9. Enablement

   Increasing means/reducing barriers to increase capability (beyond education and training) or opportunity

Table 5:2 provides a definition of each intervention function in relation to physical activity, before providing a specific example for how the intervention function could be used. Please see Appendix 45 for how each intervention function relates to the COM-B model components. The APEASE criteria as defined in the Behaviour Change Wheel (affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects and safety, equity) were considered to direct the selection of appropriate intervention options, content, and implementation options.

Table 5:2 Identifying and evaluating potential intervention functions using the APEASE criteria

Intervention Function	Definition	Example:	Does the intervention function meet the APEASE* criteria?
Education	Providing teaching staff with information on	School staff needed to understand the health and educational benefits of increasing	Yes

	physical activity and movement skill competency	physically activity and decreasing sedentary behaviour for children during the school day	
Persuasion	Using imagery and/or communication to induce positive feelings about engaging in more physical activity	School staff needed to feel confident that physical activity breaks are beneficial to the children and won't cause too much classroom disruption	Yes
Incentivisation	Implementing prize draws to induce attempts to increase physical activity inside the classroom	Teachers and children had daily and weekly goals to achieve with rewards being made available for classes and individual pupils to help encourage engagement and provide recognition/motivation	Yes
Coercion	Creating an expectation of punishment/cost as a result of not implementing physical activity breaks	Not appropriate	No
Training	Providing teachers with training on how to implement physical activity in the classroom safely	Teachers needed to be able to decide on appropriate times to implement physical activity breaks during the school day so they are both safe and effective for pupils; Teachers will need to feel capable and able of delivering the physical activity breaks	Yes
Restriction	Using restriction/rules to reduce time spent sitting and increase physically activity throughout the day	Not appropriate	No
Environmental Restructuring	Making classrooms movement friendly and introducing physical prompts such as activity trackers and posters with helpful reminders/instructions about physical activity for teachers and children	Teachers needed to learn how to use the space available in the classroom effectively during physically active movement breaks; Physical resources such as incentivisation charts, weekly challenges, posters, and trackers can be added to the classroom to help prompt teachers and children	Yes
Modelling	Using examples of other schools and previous research to demonstrate the benefits of physically breaks during the school day	Examples of previous interventions and research were shared with school staff; Leader boards can be set up within the school so that each classes activity and progress can be seen to help encourage more participation	Yes
Enablement	Ongoing support from the research team, but importantly from school governors and headteachers	A whole-school approach needed to be adopted from the top down so that teachers feel supported and encouraged by all staff members to increase the amount of physical activity children are participating in on a daily basis	Yes

5:2:6 Identifying behaviour change techniques

Behaviour change techniques (BCTs) are observable and replicable components of behaviour change interventions, see Table 5:3. The defining characteristics of a BCT include being observable, replicable, an irreducible component of the intervention and a postulated active ingredient (Mitchie *et al* 2011). The importance of conceptualising and reporting BCTs has been highlighted by Dombrowski *et al* (2012), who suggests it allows future researchers to pick out the 'active ingredients' of a successful intervention. Furthermore, a meta-analysis conducted by Taylor *et al* (2012) found that intervention effect sizes were smaller when BCTs were not reported, suggesting precise specification of BCTs may enhance an intervention.

Table 5:3 Linking intervention functions with COM-B components and assessing potential BCTs using the APEASE framework

Intervention Function	COM-B Component	Most frequently used BCTs*	Does the BCT meet the APEASE framework
Education	Psychological Capability Automatic Motivation	Information about social and environmental consequences	N/A
		Information about health consequences	Yes
		Feedback on behaviour or outcomes of behaviour	Yes
		Prompts/cues	Yes
		Self-monitoring of behaviour and/or behaviour outcomes	Yes
Persuasion	Social Opportunity Automatic Motivation	Credible source	N/A
		Information about social and environmental consequences	N/A
		Information about health consequences	Yes
		Feedback on behaviour or outcomes of behaviour	Yes
		Verbal persuasion of capability	Yes
		Social comparison	Yes

Incentivisation	Reflective Motivation Automatic Motivation	Feedback on behaviour or outcomes of behaviour	Yes
		Monitoring of behaviour by others without evidence of feedback	Yes
		Monitoring outcomes of behaviour by others without evidence of feedback	Yes
		Self-monitoring of behaviour	Yes
		Rewarding completion	Yes
Training	Psychological Capability Physical Capability Automatic Motivation	Demonstration of behaviour	Yes
		Instruction of how to perform behaviour	Yes
		Feedback on behaviour or outcomes of behaviour	Yes
		Self-monitoring of behaviour	Yes
		Behavioural practice/rehearsal	Yes
		Habit formation	Yes
		Graded tasks	Yes
Environmental Restructuring	Physical Opportunity Social Opportunity	Adding objects to the environment	Yes
		Prompts/cues	Yes
		Restructuring the physical or social environment	Yes
Modelling	Social Opportunity Reflective Motivation	Demonstration of the behaviour	Yes
Enablement	Physical Capability Psychological Capability Social Opportunity Environmental Opportunity	Social support	Yes
		Goal setting	Yes
		Problem solving	Yes
		Action planning	Yes
		Self-monitoring	Yes
		Review behavioural goals and/or outcome goals	Yes
		Reduce negative emotion	Yes

*The most frequently used BCTs have been synthesised within the BCT Taxonomy v1 (Mitchie *et al* 2013).

5:2:7 Identifying specific content for the selected behaviour change techniques

Once BCTs have been selected using the BCT Taxonomy v1 (Mitchie 2011) and appraised using the APEASE criteria, specific context for each BCT needs to be identified and reported, see Table 5:4. Given that replication, accumulation, and application of evidence depends on the ability to reliably specify the details of an intervention, it is of critical important that BCTs are reported with clarity. Please also see Appendices 46 and 47.

Table 5:4 Identifying specific content for the selected behaviour change techniques

Behaviour Change Technique	Definition	Specific Example
1. Goals and Planning		
Goal setting (behaviour)	Set or agree on a goal defined in terms of the behaviour to be achieved	Agreed with teaching staff on daily physical activity breaks during lesson time to increase physical activity and reduce sedentary behaviour throughout the school day
Goal setting (outcome)	Set or agree on a goal defined in terms of a positive outcome of wanted behaviour	Agreed with teaching staff that the goal is to complete 3 x 5-minute physical activity breaks (totalling 15 minutes) 3 days a week (on non-PE days)
Problem solving	Analyse, or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators (includes 'Relapse Prevention' and 'Coping Planning'). Note: barrier identification without solutions is not sufficient	Identified possible barriers (previously identified through focus groups) such as time, resources, workload etc. Addressed these concerns and came up with solutions e.g. children not having to change into PE kits, teachers not having to plan specific content for each physical activity break
Action planning	Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration, and intensity). Context may be environmental (physical or social) or internal (physical, emotional or cognitive) (includes 'Implementation Intentions'). Note:	Prompted planning of physical activity breaks throughout the day. Encourage teachers to discuss and make plans for when the physical activity breaks could be appropriate e.g., before assembly or when the children are restless

	evidence of action planning does not necessarily imply goal setting, only code latter if sufficient evidence	
Review behaviour goals	Review behaviour goal(s) jointly with the person and consider modifying goal(s) or behaviour change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first, or no change	Evaluated how well the children and teaching staff adhered to the original goal by collecting weekly information on intervention dose (e.g., how many sessions each classroom completed a week)
Review outcome goals	Review outcome goal(s) jointly with the person and consider modifying goal(s) considering achievement. This may lead to re- setting the same goal, a small change in that goal or setting a new goal instead of, or in addition to the first	Evaluated if the children have better quality movement patterns as a result of the increased physical activity and reduced sedentary behaviour during school time
2. Feedback and Monitoring		
Monitoring of behaviour by others	Observe or record behaviour with the person's knowledge as part of a behaviour change strategy	Researcher observed the physical activity breaks taking place, as well as carrying out weekly visits to monitor number of sessions being carried out
Monitoring of outcome by others	Observe or record outcomes of behaviour with the person's knowledge as part of a behaviour change strategy	Researcher and teaching staff monitored observable changes in children's movement patterns and physical activity levels, but also potential secondary outcomes such as classroom behaviour
Feedback on Behaviour	Monitor and provide informative or evaluative feedback on performance of the behaviour (e.g., form, frequency, duration, intensity)	Teachers provided feedback on the children's behaviour; researcher provided feedback on the teacher's implementation of the physical activity breaks
Feedback on outcome of behaviour	Monitor and provide feedback on the outcome of performance of the behaviour	Researcher shared the results of the intervention with teaching staff once the intervention was complete
Self-monitoring of behaviour	Establish a method for the teacher to monitor and record their behaviour(s) as part of a behaviour change strategy	Children and teaching staff recorded how many physical activity breaks they were completing each week. Children recorded how difficult they are finding the sessions each week using the RPE scale
Self-monitoring of outcomes	Establish a method for the teacher to monitor and record the outcome(s) of	Children and teaching staff recorded how many physical

	their behaviour as part of a behaviour change strategy	activity breaks they were completing each week
3. Social Support		
Social support	Advise on, arrange or provide **social support** (e.g., from friends, relatives, colleagues,' buddies' or staff) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the behaviour. Advise on, arrange, or provide **practical** help (e.g., from friends, relatives, colleagues, 'buddies' or staff) for performance of the behaviour. Advise on, arrange, or provide **emotional** social support (e.g., from friends, relatives, colleagues, 'buddies' or staff) for performance of the behaviour.	Advised teaching staff to support one another and share ideas as to what works and what doesn't when implementing the physical activity breaks. Encouraged senior staff members and/or PE leads to check in with other members of staff. Reassured all teaching staff the researcher can be contacted via email or during the weekly visits if they encounter any problems or need advice
4. Shaping Knowledge		
Instruction on how to perform a behaviour	Advise or agree on how to perform the behaviour (includes 'Skills training')	Conducted training with teachers on how to implement physical activity breaks inside the classroom. E.g., how to introduce, how to coach, how to finish the exercise break and how to return to work
5. Natural Consequences		
Information on health consequences	Provide information (e.g., written, verbal, visual) about health consequences of performing the behaviour	Explained the importance of increasing childhood physical and improving movement patterns, along with the health and educational benefits of reducing sedentary behaviour
6. Comparison of Behaviour		
Demonstration of Behaviour	Provide an observable sample of the performance of the behaviour, directly in person or indirectly e.g., via film, pictures, for the person to aspire to or imitate (includes 'Modelling').	Provided and demonstrate examples of movements/exercises that will be performed inside the classroom to teaching staff
Social Comparison	Draw attention to others' performance to allow comparison with the person's own performance	Showed teachers examples of previous research and other schools who are implementing physical activity breaks. Implement a school leader board that has

		details of how many physical activity breaks each class is completing per week
7. Associations		
Prompts/Cues	Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behaviour. The prompt or cue would normally occur at the time or place of performance	Made use of posters, stickers, activity tracker charts, emails, and weekly school visits to help remind teachers and children to complete the agreed amount of physical activity breaks
8. Repetition and Substitution		
Behavioural practice and/or regulation	Prompt practice or rehearsal of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary, to increase habit and skill	Prompted teachers to practice implementing physical activity breaks at different times of the day so they can figure out which time works best for their class
Habit formation	Prompt rehearsal and repetition of the behaviour in the same context repeatedly so that the context elicits the behaviour	Encouraged teachers to form a habit of including physical activity breaks three times a day, three days a week on a regular basis so it becomes a routine e.g., before assembly, before maths, before English
Graded tasks	Set easy-to-perform tasks, making them increasingly difficult, but achievable, until behaviour is performed	Set each year group weekly challenges which get progressively harder as the weeks progress
9. Comparison of Outcomes		
10. Reward and Threat		
Material incentive/reward	Inform that money, vouchers or other valued objects will be delivered if and only if there has been effort and/or progress in performing the behaviour (includes 'Positive reinforcement'). Arrange for the delivery of money, vouchers, or other valued objects if and only if there *has been* effort and/or progress in performing the behaviour (includes '**Positive reinforcement'**).	Arranged a reward/prize for the class who has done the most amount of movement breaks each term (e.g., extra golden time or a school trip). The specific reward will be specific and therefore be decided by the PE lead and/or head teacher
Social incentive/reward	Arrange verbal or non-verbal reward if and only if there *has been* effort and/or progress in performing the behaviour (includes '**Positive reinforcement**'). Inform that a verbal or non-verbal reward *will be* delivered if and only if there has been effort and/or progress in	Teachers were encouraged to pick a 'most improve mover of the week' the child who has improved the most that week. The child will receive a certificate and their name will be written on a poster for the week. This child can then act as

	performing the behaviour (includes **'Positive reinforcement'**).	that classes champion, reminding the teacher, updating the weekly tracker chart etc
11. Regulation		
Reduce negative emotions	Advise on ways of reducing negative emotions to facilitate performance of the behaviour (includes 'Stress Management')	Provided teachers with reassurance and guidance if children are being noisy/miss-behaving before, during or after a movement break
12. Antecedents		
Restructuring the physical environment	Change, or advise to change the physical environment to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards, and punishments)	Added charts, stickers, posters, weekly challenges to each classroom to act as prompts. Make use of desks/chairs in new ways to make certain exercises easier to do
Restructuring the social environment	Change, or advise to change the social environment to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards, and punishments)	Discussed with school governors and/or headteachers if there is enough time in the school day to allow for an extra 15 minutes of physical and relay the information to the teaching staff
Adding objects to the environment	Add objects to the environment to facilitate performance of the behaviour	Charts, stickers, and posters as previously noted
Body changes	Alter body structure, functioning or support directly to facilitate behaviour change	Encouraged improved movement skills and increased physical activity so children feel competent and are more likely to want to engage in more physical activity as a result (both inside and outside of the classroom)
13. Identity		
Identification as self as role model	Inform that one's own behaviour may be an example to others	Encouraged teachers to be active themselves and sometimes join in with the physical activity breaks
Framing/ Reframing	Suggest the deliberate adoption of a perspective or new perspective on behaviour (e.g., its purpose) in order to change cognitions or emotions about performing the behaviour (includes 'Cognitive structuring')	Proposed that physical activity breaks are not just there to help improve movement patterns and reduce sedentary behaviour but can be used as a behaviour management tool too
14. Scheduled Consequences		
Reward completion	Build up behaviour by arranging reward following final component of the behaviour; gradually add the	Reward small completions at first, such as achieving three breaks in one day, then nine breaks in one

	components of the behaviour that occur earlier in the behavioural sequence (includes 'Backward chaining')	week, then a month and then a term etc
15. Self-Belief		
Verbal persuasion about capability	Tell the person that they can successfully perform the wanted behaviour, arguing against self-doubts, and asserting that they can and will succeed	Reassured teachers that they can implement the movement breaks and asking teachers to reassure the children that they are competent, or will be competent with practice, at the exercises/movements

5:3 The Final Intervention Structure

In summary, both the COM-B model and BCW are well established tools used to help design effective interventions within a wide range of public health fields. Drawing from 19 existing behaviour change frameworks, the BCW encourages researchers to focus on understanding the behaviour, exploring intervention options before identifying behaviour change techniques. As a result, the finalised structure and content of “Busy Brain Breaks” a classroom based physical activity and movement intervention is proposed in Appendix 48.

5:3:1 Materials

5:3:2 Busy Brain Break Videos

The finalised intervention ‘Busy Brain Breaks’ consisted of 5-minute-long videos which included 25 different bodyweight exercises. Each exercise was demonstrated by an individual on screen who completed the exercise for 30 seconds, after which, a new exercise was demonstrated. Each video consisted of 5 different exercises which were then repeated for the remaining 2 and a half minutes. As the individual completed the exercise on screen, coaching cues relevant to that particular exercise would pop up throughout the five minutes. For example, when completing a plank, the coaching cues encouraged children to ‘avoid sticking their bottoms up in the air’ and to ‘squeeze their tummy muscles tightly’. In addition to the cues, music accompanied the video for the 5-minute duration as well as a timer to help indicate the end of each exercise. It was important that the videos were clear and easy for the teachers to deliver given ease of delivery has been highlighted as potential facilitator during the focus group analysis presented in Section 4:3:1. Of equal importance, was that the videos were fun and engaging for children and included a wide variety of sequences and movements to risk losing the ‘novelty factor’, a barrier which was also identified during the focus groups.

The 5-minute long 'Busy Brain Breaks' were to be completed three times a day, three days a week, ideally on the days in which children didn't have PE. However, this was only a provisional structure and teachers were encouraged to adapt it where they felt necessary to help maintain autonomy. Each class received a USB loaded with the videos. It was important that the teachers had easy access to the videos as a previously identified barrier was centred around resources being difficult to access.

5:3:3 Weekly Tracker

In addition to the videos, each class was given a 'Busy Brain Break Weekly Tracker' which consisted of an A3 chart and Velcro stickers (Appendix 49). Teacher's and children were asked to add to the weekly chart each time they completed a Busy Brain Break. This was done for several reasons, firstly it allowed the teacher and pupils to keep track of how many Busy Brain Breaks they had done each week. Secondly, it helped to indicate to the researcher how many Busy Brain Breaks each class had completed each week. Thirdly, it allowed the teacher to distribute responsibility of completing the board to a child which helps to increase engagement.

5:3:4 Most Improved Mover of the Week

Teachers were also encouraged to pick a 'most improved mover of the week' each week (Appendix 50). This child was then seen as the Busy Brain Break champion, they were given the responsibility of the tracker, as well as encouraging their peers and reminding the teacher to complete the necessary amount of Busy Brain Breaks. To avoid creating a greater distance between those most and least competent movers, and thus risk losing motivation or engagement, teachers were specifically encouraged to focus on the child who had improved the most rather than the child who was the best.

5:3:5 Progression/Regression Charts

A chart displaying progressions and regressions for each exercise was given to each class. This was laminated and displayed next to the weekly tracker chart. The reason for this being, each child develops at a different rate, and each will have varying levels of physical activity experience thus meaning some children may need to make the exercise easier, whilst others may need to increase the difficulty to challenge themselves. The chart therefore allowed children to adjust the exercise as they felt necessary, a fundamental concept when attempting to develop a mastery climate (Han et al 2018).

5:3:6 Posters and Leaflets

The school were given posters and leaflets displaying Busy Brain Break reminders that contained the researcher's email address in case teachers, staff or parents had any questions about the intervention (Appendix 52). It was important that intervention resources were of a good quality as this was noted as a possible facilitator by teaching practitioners during the focus groups.

5:3:7 Busy Brain Break Teacher Training

The researcher visited the three intervention schools during their staff meetings to introduce and explain Busy Brain Breaks, hand out resources and answer any questions. Each session lasted for 30 minutes, whilst it would have been beneficial to have had a longer amount of time, each staff meeting had a busy schedule, and the extra time wasn't available. The sessions started with an explanation of movement skill competency and the importance of physical activity, before participants were presented with key findings from the cross-sectional study, outlined in Section 4:4:1. Busy Brain Breaks was then introduced, and an example video was shown. Each resource was introduced and demonstrated before opening the room to questions. Before leaving, each class teacher was handed their Busy Brain Break pack which included:

- USB containing 30 x 5-minute-long videos

- A weekly tracker and Velcro stickers
- A progression/regression chart
- Most improved mover of the week poster and certificates
- An RPE scale, wipe clean register and whiteboard pen
- Busy Brain Break posters and leaflets

Chapter 6

A Process Evaluation of A UK Classroom-Based Physical Activity Intervention—'Busy Brain Breaks'.

Published in Children, Special Issue Physical Activity, Sedentary Behaviour and Health Interventions in Children and Adolescents - Cline, A., Knox, G., De Martin Silva, L. and Draper, S., 2021. A Process Evaluation of A UK Classroom-Based Physical Activity Intervention—'Busy Brain Breaks'. *Children*, *8*(2), p.63.

6:1 Rationale

The World Health Organisation (WHO) identifies schools as primary sites for health interventions due to their ability to reach the vast majority of school-aged youth. On average, school-aged children spend 30 hours per week in school, positioning the school environment as a feasible setting for delivering movement and physical activity interventions. In 2019, the UK Ministry of Education suggested that primary schools should be providing their pupils with 30 min of physical activity per day in addition to breaktime and lunchtime (Department of Education 2019). In addition to sedentary teaching practices, opportunities for physical activity outside of the classroom, such as breaktimes and physical education, have decreased as a result of increased focus on academic performance (Hardman *et al* 2011). Therefore, interventions are being designed and implemented to reduce sedentary behaviour and increase physical activity within primary school classrooms.

Naylor and McKay (2008) argue that effective physical activity interventions, delivered in settings where children learn, are an important part of the solution. In addition to having the potential to improve multiple health outcomes, there are also many direct benefits to the learner and learning environment such as improved classroom management (Mahar *et al* 2006) enhanced cognitive function (Donnelly *et al* 2011) and improved self-concept (Strong *et al* 2005). In addition to this, multiple systematic reviews demonstrate the efficacy of school-based approaches (Dobbines *et al* 2013; Love *et al* 2018; Lai *et al* 2014). However, a systematic review conducted by Naylor *et al* (2015) identified an urgent need for more school-based physical activity studies that assess implementation through comprehensive process evaluation.

The gap between development of effective physical activity interventions and the wide-scale adoption of these interventions in school-based settings has been reported since the early 2000s. Evaluations have been criticised for failing to report details of context, implementation, interventions, adoption, and maintenance. Implementation has been defined as a "specific set of activities designed to put into practice an activity or programme of known dimensions" (Mahar *et al* 2006; Glasgow *et al* 2007). This encompasses all aspects of the process of intervention delivery including the extent to which an intervention and its elements are implemented as planned, how much of the intervention is delivered or received, how responsive participants were to the intervention and changes made to the intervention during implementation that enhance its fit within the setting it is being delivered in (Durlak and Dupre 2008; Naylor *et al* 2015). It has been argued by Durlak and DuPre (2008) that to bridge the gap between developed and adopted effective physical activity interventions on a scale broad enough to promote large-scale health changes, there is a critical need to understand factors related to intervention implementation. Understanding these factors within school-based settings is often more challenging due to the notion of schools and the education system itself sitting within a constantly changing broader context (Fixsen *et al* 2020; Butler *et al* 2010; Newland *et al* 2013). The RE-AIM framework developed by Glasgow *et al* (2007) is a health promotion evaluation framework that enables complex settings-based interventions, such as those in school settings, to be comprehensively evaluated. The framework recognises that an intervention may work in theory, but greater consideration is needed as to how factors such as reach, efficacy, adoption, implementation, and maintenance affect how the intervention may be received in real-world settings (Glasgow *et al* 2007). Using such a framework allows researchers to explore barriers and facilitators to the intervention they are introducing in greater detail.

'Busy Brain Breaks' was an intervention designed to improve movement skill whilst increasing physical activity inside the classroom for children aged between 7 and 11, based on the COM-B model and the behaviour change wheel (Michie *et al* 2015). The behaviour change wheel encourages researchers to think through multiple stages, which encompass various elements, when designing a behaviour change intervention. Some of these stages include understanding the problem in behavioural terms, selecting, and specifying the target behaviour, identifying what needs to change and identifying intervention functions in order to encourage change to happen. At the centre of the behaviour change wheel is the COM-B model, a behaviour system comprising four components that interact with one another—capability, motivation, opportunity, and behaviour (Michie *et al* 2016). Additionally, the intervention was also driven by the experiences and thoughts of current teaching primary school practitioners, whose perceived barriers, and facilitators to implementing physical activity inside the classroom were used to help inform the intervention design, as outlined in section 5:2.

6:1:1 Aims

In accordance with process evaluation frameworks, the aim of this study was to develop and evaluate a pilot movement-based intervention within primary schools in Gloucestershire, considering reach, efficacy, adoption, implementation, and maintenance. The aims are divided into 3 objectives, outlined below:

a) Explore teaching practitioner's adoption and implementation of a pilot intervention aiming to improve key stage two children's movement within the classroom
b) Identify which facilitators and barriers to implementation were experienced whilst exploring solutions used to overcome them
c) Discuss efficacy and maintenance of the intervention in relation to sustained behaviour change

6:2 Methods

6:2:1 Participants

A purposeful sampling method was used to recruit schools to take part in the study (Bernard 2017). The researcher invited the 11 schools that had taken part in the cross-sectional study, described in Section 3:2:1, to participate in the final study via email. Six expressed an interested and were formally invited to take part after the researcher had provided more detail which included outlining the main aims of the study. All six schools accepted, and each head teacher provided written consent. All year groups in Key Stage Two (Year 3, Year 4, Year 5, and Year 6) were invited to participate. Information letters and consent forms were sent home to each parent via the school's administrator. Once written consent had been obtained from parents, written assent was obtained from the children who wanted to participate in the baseline data collection (see Appendix 53 to 59).

Each school was randomly allocated to either the control or intervention arm and baseline data was collected from 747 children from both the control and intervention groups between the months of October and December 2019 (see Tables 6:1 and 6:2).

Table 6:1 Control and Intervention Arm Participant Consent

	School	Year 3		Year 4		Year 5		Year 6	
		No. of Pupils in Year Group	No. of Pupils with Consent	No. of Pupils in Year Group	No. of Pupils with Consent	No. of Pupils in Year Group	No. of Pupils with Consent	No. of Pupils in Year Group	No. of Pupils with Consent
Intervention	A	29	23	29	23	29	25	19	15
	B	60	42	60	46	60	39	59	39
	C	120	76	121	68	120	91	120	66
Control	D	30	15	20	12	30	15	29	6
	E	29	18	27	13	28	20	29	23
	F	51	2	58	11	52	38	38	21

Table 6:2 Control and Intervention School Information

	School A	School B	School C	School D	School E	School F
Location	Rural	Inner City	Inner City	Inner City	Semi-Rural	Semi-Rural
Deprivation Indices	29,997	32,390	30,776	13,914	23,747	22,762
	10% least deprived NBH in the country	10% least deprived NBH in the country	10% least deprived NBH in the country	50% most deprived NBH in the country	30% least deprived NBH in the country	40% least deprived NBH in the country
Type of School	Maintained	Maintained	Maintained	Maintained	Maintained	Maintained

Number of Pupils	173	416	482	195	265	393
% Pupils Eligible for FSM	7.5%	7.9%	6%	16.4%	6%	15.8%
Ofsted Rating	Good	Good	Good	Good	Good	Good

6:2:2 Data Collection

Physical activity engagement, physical activity enjoyment, self-perception and movement skill were collected using the same measurement and protocol as outlined in Section 3:2:4. It was intended for the baseline data, which was collected in December 2019 before the intervention began, to be compared with post-intervention data that was to be collected in July 2020 once the intervention had been implemented for 20-weeks. In addition to baseline measures, RPE score cards were issued to each class in an attempt to measure individual level dose. Dose was to be calculated using the total number of sessions a child had completed multiplied by their RPE average score for the week. Each class was given a wipe-clean register alongside a modified RPE scale suitable for use with children (Appendix 51). The teacher was asked to record how difficult the children had found Busy Brain Breaks at the end of each week to collect individual treatment dose data. Whilst taking an average of how hard the children found all 9 sessions at the end of the week may face critique for accuracy, the possibility of collecting an RPE score after each Busy Brain Break was deemed inappropriate due to feasibility issues such as time and workload for the teaching staff. Class and individual level dose would help to make up the quantitative analysis of the intervention. The quantitative data was to be supported by semi-structured interviews with teachers once the intervention had taken place, in addition to 6 focus groups conducted with a sample of the children who had taken part in the intervention.

6:2:3 Impact of Covid-19 on Data Collection

Baseline data was collected from 553 in December 2019. Teachers received their introduction to the intervention on the 6th, 7th and 8th of January and the intervention was implemented in all three schools on the 13th of January. It was the intention that the intervention would last for a total of 20-weeks. The intervention was in place for 1-weeks before the Covid-19 pandemic forced schools to shut their doors on the Friday the 20th of March. All school-aged children were asked to learn from home, with lessons taking place digitally. This meant the intervention was cut short, meaning no post-intervention data could be collected to compare to the baseline measures.

6:2:4 Amended Data Collection

At the end of March 2020, the researcher approached the teachers from all 28 classes and invited them to take part in a semi-structured interview via mobile phone. The teacher staff expressed they were under a lot of pressure caused by moving their teaching materials online, so it was decided that only one member of teaching staff from each class would take part in the interview. A total of 17 phone interviews were conducted throughout the month of April 2020, see Table 6:4. The interviews ranged from 40 to 55 min in length and were conducted between 9 am and 5 pm, depending on when most convenient for the participant. The interviews were of a semi-structured nature and therefore followed a loose interview guide which was based on reviewed literature and the aims of the study (see Appendix 60). Each interview was recorded using audio recording software so they could be transcribed and analysed after they had taken place. In addition to the semi-structured interviews conducted with teaching staff, each teacher was asked to complete a physical activity enjoyment questionnaire with their class, who were asked as a group to reflect on their experience of 'Busy Brain Breaks' and answer accordingly. The enjoyment questionnaire was presented in the same format as described in Section 3:2:4:2 (Appendix 10).

6:2:5 Data Analysis

The interviews were analysed using thematic analysis (Braun and Clarke 2017). The flexibility of thematic analysis allows for the analyses of participant's experiences in relation to an issue, or the factors and processes that underlie and influence a particular phonemenna, which in this case was 'Busy Brain Breaks' (Ory *et al* 2007; Braun *et al* 2016). The process of analysis followed a similar process as outlined in Section 4:2:2. The interviews were transcribed verbatim before being read multiple times to promote familiarisation. Once this was completed, the researcher began to look for codes within the data (Appendix 61). A total of 15 themes were concluded from the data, with some themes having further subthemes. To conduct a thorough evaluation using the RE-AIM framework (Glasgow *et al* 2007), the codes are presented and analysed according to which domain of the RE-AIM framework they address. Verbatim quotes have been used by participants, who have confirmed the use of those quotes as they are.

The definitions of the five components of the RE-AIM framework are frequently adapted by researchers so that they are suitable for the context in which they are applying them to, see Table 6:3.

Table 6:3 RE-AIM health promotion evaluation framework terminology relevant to the Busy Brain Breaks intervention at both the individual and settings levels, adapted from the definitions provided by Jenkinson *et al* (2012).

Term	Definition/Measurement
Reach	Refers to the representativeness of the school and the individual's willingness to participate in the study.
Efficacy	Considers the effectiveness of the intervention at influencing primary outcome changes, as well as assessing whether positive or negative outcomes were experienced by individuals or within the school setting. This was measured through questionnaires and follow-up interviewers with both teaching staff and pupils.
Adoption	Refers to the school's acceptance of the intervention within the organisation and examination of factors that influenced that decision. This was measured through questionnaires.
Implementation	Refers to the extent to which the participating students and school completed and made use of the various components of the intervention including barriers and facilitators to implementation. This was measured by the level to which the main components, activities and evaluations were completed as intended.

Maintenance	Refers to the extent to which schools and leaders maintained, continued, or planned to continue with the intervention. This was measured through follow-up phone interviews with teaching staff.

6:3 Results

6:3:1 Reach

The study used a purposive sampling method to recruit schools, with schools that had accepted invitiation to be involved in the cross-sectional study, outlined in Section 3:2:1, being invited to participate again (Bernard 2017). The initial recruitment of schools for the cross-sectional study involved the researcher contacting all of Gloucestershire's (n=231) primary schools via email. Fifteen schools replied expressing interest, four schools withdrew due to issues regarding lack of parental consent forms being returned, leaving the 11 schools that took part in the cross-sectional study. The research worked closely with the 11 schools during the cross-sectional data collection and built a good rapport. Given the difficulties experienced in the first round of recruitment, it was agreed to be appropriate to continue working with the schools that were already involved with the research. Of the 11 schools, six had returned a high number of parental consent forms, positioning them as suitable candidates for future research.

Evaluating the reach of a study is to understand how representative the sample is, and therefore how representative the subsequent findings are. At the time of recruitment, there were 47365 pupils enrolled into primary schools across Gloucestershire with 23,682 of these children being in key stage two. Parental consent allowed for 747 children from the control and intervention arms to have their data collected, but a total of 826 took part in the classroom activites as part of the intervention arm with a further 421 children being given access to the intervention materials when the pandemic forced schools to close. These numbers are significantly higher than most school-based interventions aiming to increase physical activity and development movement skill in the United Kingdom (Bryant *et al* 2016; Faghy *et al* 2021; O'Dwyer *et al* 2012).

It must be considered that the schools who accepted the intervention to participate may have been more inclined to do so as they were confident with their physical activity provision. It may also be the case that parents who were confident in their children's physical activity engagement and movement ability may have been happier to provide their child with parental consent in order to take part in the baseline data collection. These children may have therefore been more willing and able to participate compared to their non-active peers.

With regards to the participants that were included in the study, the average deprivation indices of the schools included was 25, 477. Gloucester is positioned as 139th out of the 326 English authorities in the indices of deprivation table that is available nationally, followed by the Forest of Dean (155th), Cheltenham (228th), Tewkesbury (262nd) and the Cotswolds (267th). In general, Gloucestershire is not a very deprived county and an average indices of deprivation score for each of the districts in the county show that even the most deprived districts fall in the miuddle quintile (the middle 20%) for deprivation out of the 326 authorities. All of the six schools included in the control and intervention arms were maintained primary schools, 94% of children in England attend this type of setting and aren't privately educated. The schools included within the study had an average of 320 pupils per school, this is in line with the national average which is 364. Currently, the percentage of pupils eligible for free school meals in England is 17.3%, in the South West it's 14.6%, the schools included in my study had an average of 10%. Finally, all of the schools included in the intervention had been rated as 'good' by Ofsted. The nationally available data suggests that 88% of schools in England have been rated as good by Ofsted, meaning the sample is in line with the national average.

6:3:2 Adoption

When asked to reflect on their initial thoughts, queries or concerns about 'Busy Brain Breaks' before it started, all 17 teachers spoke about concerns revolving around the practicalities of adopting the intervention. These practicalities involved managing an already busy workload, finding the time to do it and finally, being able to make use of the resources. When first introduced, there was apprehension around how much the intervention would impact workload. However, after a week of adopting the intervention, the concerns were no longer an issue.

> *"I was very aware it was one more thing you know every staff meeting we are concentrating on something different we do have a lot on our plates in terms of workload but once we had started it all my concerns melted away because it didn't really require anything from me, it wasn't any extra work to think about"—Participant 2, Teacher of Class 12.*

In addition to workload, time was identified as a potential barrier to adoption and implementation of a classroom-based physical activity intervention. This was noted as a frequent concern amongst teachers when first introduced to Busy Brain Breaks.

> *"First of all, I was thinking how are we going to get through 9 in a week, because I know you said it was 3 a day over 3 days and I was thinking oh okay I'm not sure where that's going to fit in because our curriculum is so tight that was a bit worrying thinking well where is this going to go"—Participant 9, Teacher of Class 9.*

Whilst time and workload were identified by teaching staff as the main concerns of adopting Busy Brain Breaks, these factors did not stop them from adopting the intervention. Frequently, teaching staff spoke about having the approval from management as a key factor that helped to overcome these concerns and thus increase likelihood of adoption.

In addition to having the approval from management, barriers to adoption were frequently overcome by the teaching staff's ability to recognise the benefits of the intervention. This was in part due to the short staff training session delivered by the researcher, but also due to the teaching staff's knowledge of the benefits of children engaging in more physical throughout the school day.

> *"I did think oh my goodness me, because it was three times a day, I just thought oh wow that's three interruptions in the day to do physical activity, but I did whole-heartedly believe in the project and I could see the benefit of the project for the children in terms of getting them more active throughout the day"—Participant 12, Teacher of Class 5.*

Importantly, teacher confidence was identified as a previous barrier to adoption and implementation of physical activity interventions. Therefore, it was a key objective to make sure the resources were informative, thus giving all teachers confidence to adopt the intervention regardless of prior knowledge of ability. Teachers who had identified themselves as being less confident at delivering physical activity or PE lessons noted that they felt confident adopting Busy Brain Breaks due to the resources and in particular the exercise videos.

> *"I liked the idea of Busy Brain Breaks despite my confidence because the videos had pretty much everything we needed, so we were able to use the cues, or to pause the video if we needed to all the content was there for us even down to the adjustments to make it easier or harder so in terms of confidence I didn't ever feel like I wasn't able to deliver it properly or I didn't have enough knowledge"—Participant 11, Teacher of Class 15.*

In addition to recognising the benefits of adopting the intervention, teaching staff recognised how quickly children adopted Busy Brain Breaks and how much they enjoyed it.

"So, the children were very excited they always love physical activity because they love physical activity really, so they were excited to do it"—Participant 12, Teacher of Class 5.

Interestingly, it was suggested that because the children had adopted the intervention so enthusiastically, this increased the teaching staff's adoption and adherence, with children often reminding their teachers to take a 'Busy Brain Break'.

Finally, teachers noted that whilst children were quick to adopt Busy Brain Breaks largely due to enjoyment, the intervention also promoted inclusivity amongst the children who may not usually enjoy PE or other physical activities.

"The fact it was just the five minute they know that actually, even the ones who maybe struggle with the physical aspect of it, they can just appreciate that it is just 5 min not that sort of 15 min to run a mile and thought of a mile to some of them sounds quite far whereas this is just five min"—Participant 13, Teacher of Class 17.

This was supported by several other teachers who noted that the short bouts of 30 seconds per exercise were manageable chunks of time for all children, especially those who usually found physical activity and exercise difficult.

"I think it's a mindset type of thing because they know that it's short and that's the really good thing about HIIT style activities is that they are really short and sharp activities so for the children who are finding difficult know that they only have 30 second of each exercise and actually they only have five min of activity in total."—Participant 9, Class 9.

In addition to the short bouts of exercise, several teachers recognised the benefit of having a diverse range of exercises.

> *"I think the variety of the exercises in Busy Brain Breaks suited all the children for different reasons so some benefited those who had good core strength and others were good at balancing so there was something for everyone and if there was an exercise they weren't too good at it, well it was only 30 seconds and then they would move onto something else."—Participant 11, Class 15.*

6:3:3 Implementation

Out of the 28 classes who took part in the intervention, all 28 teachers adopted the intervention to some extent. The median number of sessions completed over the 10 week period was 76, with 34 being the minimum amount and 113 being the maximum, as displayed in Figure 6:1.

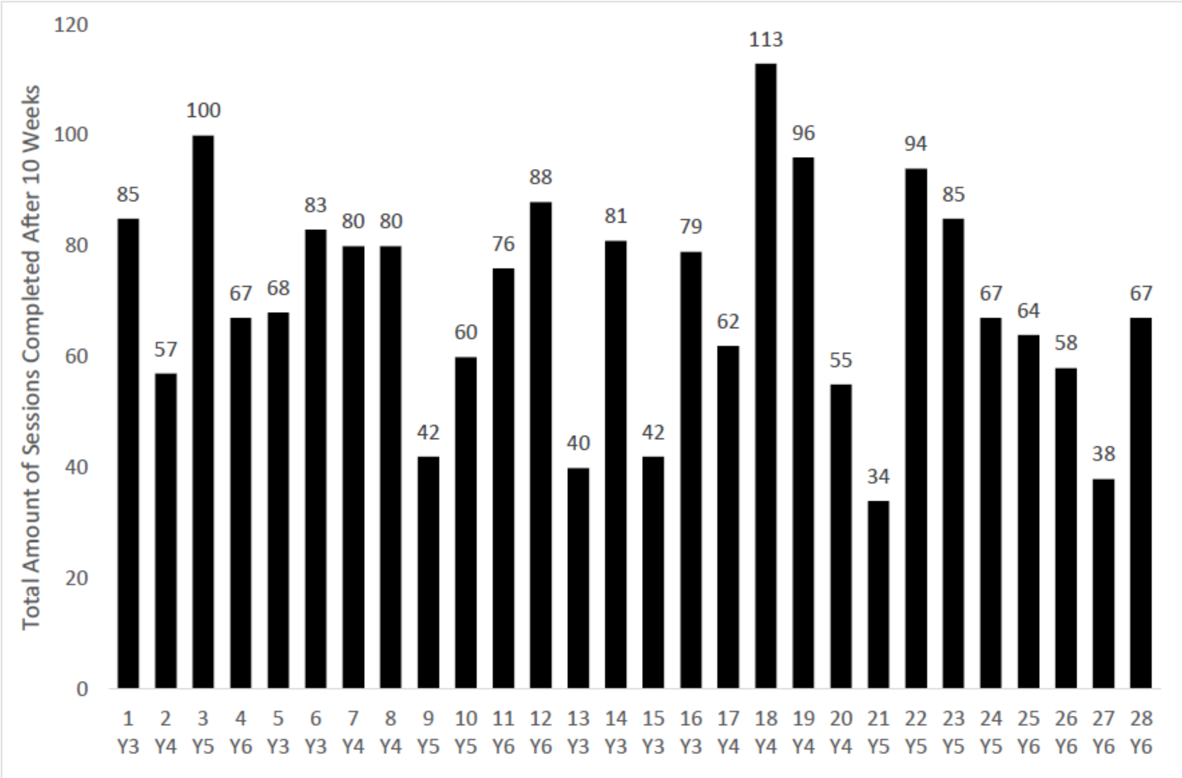

Figure 6:1 Total number of sessions completed by each class, over the 10-week period.

When looking at all three schools together, the average amount of 'Busy Brain Breaks' completed over the 10-week period was 71.29, meaning, on average, each class completed 7 breaks per week. At the lowest end of the scale, the total amount of 'Busy Brain Breaks' completed over the 10-week period was 34, meaning the class was doing an average of 3 breaks per week. At the highest end of the scale, a total amount of 'Busy Brain Breaks' completed over the 10-week period was 113, meaning the class was doing an average of 11 breaks per week. Please see Table 6:4 for a breakdown of how many sessions the 28 classes completed each week.

Table 6:4 Total amount of Busy Brain Breaks completed by each class over 10-week period.

School	**Class**	**Year**	**Interview**	**Participant Number**	**Week / Dose**											**Pupil Enjoyment**
					1	2	3	4	5	6	7	8	9	10	Total Dose	
A	1	Y3	Yes	7	8	9	8	9	7	5	9	11	10	9	85	8.2
	2	Y4	Yes	10	10	6	0	7	6	4	4	6	7	7	57	10
	3	Y5	Yes	4	9	9	9	10	10	9	10	11	12	11	100	10
	4	Y6	No	-	6	9	6	2	6	4	10	7	8	9	67	8.1
B	5	Y3	Yes	12	7	9	6	9	7	5	4	5	7	9	68	7.4
	6	Y3	No	-	8	7	8	6	9	9	9	9	9	9	83	8.5
	7	Y4	Yes	17	8	7	8	8	8	8	8	8	9	8	80	7.2
	8	Y4	No	-	11	8	10	11	8	3	6	7	8	8	80	-
	9	Y5	Yes	9	4	10	5	2	3	0	4	4	5	5	42	8
	10	Y5	Yes	16	7	7	9	7	3	5	5	6	5	6	60	8.5
	11	Y6	Yes	8	6	9	6	9	7	9	8	5	8	9	76	6.3
	12	Y6	Yes	2	9	10	11	10	8	9	9	6	8	8	88	8
C	13	Y3	No	-	3	5	4	4	4	4	4	4	4	4	40	8.1
	14	Y3	No	-	4	4	7	8	11	9	9	10	9	10	81	9
	15	Y3	Yes	11	5	5	4	4	4	4	4	3	5	4	42	7.4
	16	Y3	No	-	8	6	7	8	8	7	9	9	9	8	79	8

17	Y4	Yes	13	5	9	7	7	6	5	6	5	6	6	62	9.6
18	Y4	Yes	5	13	13	11	12	13	9	11	10	11	10	113	7.2
19	Y4	Yes	14	12	9	13	10	10	8	8	9	9	8	96	8
20	Y4	No	-	9	8	5	5	7	3	4	5	5	4	55	7.5
21	Y5	No	-	10	9	8	1	1	1	1	1	1	1	34	-
22	Y5	Yes	6	11	11	10	10	5	10	8	9	10	10	94	8.3
23	Y5	No	-	9	9	9	9	9	8	7	8	8	9	85	9.5
24	Y5	Yes	3	0	6	3	5	10	8	7	9	10	9	67	8.5
25	Y6	Yes	15	3	7	7	6	6	7	7	8	7	6	64	-
26	Y6	Yes	1	5	4	6	6	5	4	8	6	7	7	58	7.8
27	Y6	No	-	7	4	6	3	2	3	3	4	3	3	38	8.1
28	Y6	No	-	7	2	7	7	7	6	8	7	8	8	67	8.6

As noted in Section 2:6:1, a common critique of behaviour change interventions is the lack of understanding as to how the intervention was implemented, and whether changes were made during implementation. Having the ability to adapt an intervention aiming to increase movement inside the classroom was noted as a key facilitator to help teaching staff maintain autonomy in Section 4:3:3. This meant a number of choices regarding implementation were left up to the class teacher.

Time of Implementation

Class teachers were asked to implement three busy brain breaks a day, three days a week, ideally on non-PE days. It was left up to the teachers to decide exactly when they wanted to implement the three breaks throughout those days. Of the 17 teachers interviewed, 15 of them reported that they regularly implemented a Busy Brain Break between lessons, in what they call the transition period.

> *"I focused on transitions between subjects so for example in the morning we did guided reading before English and I was finding that to be a struggle because children would talk and drag their heels so we started to a do Busy Brain Break in between and that meant the children would tidy up a lot quicker, instead of them taking 5 min to tidy up they'd be tidying up in 30 seconds because they'd want to start the video so it was brilliant for the side of things"—Participant 9, Teacher of Class 9.*

In addition to encouraging children to finish tidying up from the previous lesson and get ready for the next, teachers also noted that putting a Busy Brain Break in between a lesson helped them to get the classroom ready for the next lesson too.

"I wanted to make it work for me too, I'd do it between lessons so I could prepare for my next lesson whilst walking around the class and giving me feedback. I'm gathering my bits of paper, or it might be finding something on the internet that I need whilst watching the class and making sure I'm reading out the cues on the board and what not"—Participant 14, Teacher of Class 19.

In addition to having practical benefits, two teachers commented that it was a time efficient way of implementing the breaks.

"It was really easy to put into action because the 5 min, as soon as they knew what they were doing, we might have had a changeover between two lessons and actually we only lost 2 and a half min out each lesson rather than 5 min out of one so yeah we tried to sandwich it between lessons"—Participant 4, Teacher of Class 3.

Frequency of Implementation

Although teachers were asked to implement Busy Brain Breaks three times a day, three days a week, ideally on non-PE days, it was ultimately left up to them as to how they wanted to structure the nine sessions. Whilst some classes stuck to the proposed structure, most teachers adapted the structure to fit in with their weekly schedules.

"So, I probably wouldn't always do the 3, I'd do 2 most of the time and try to do them every day so I'd do 2 one day, then 1 then next day rather than every other day so we were still doing a good amount and that worked with our timetable"—Participant 1, Teacher of Class 26.

Interestingly, 4 teachers noted that implementing Busy Brain Breaks every day, rather than 3 days a week, allowed them to create a routine that was easier to remember and therefore adhere to.

> *"I just thought right if I try and do 2 a day then worse comes to worse we'll end up doing 10 so I found that a lot more manageable because you're not, you're only having to fit in 2 somewhere, but you're thinking every day of doing it, whereas if you're thinking every other day you can easily forget so I actually didn't end up timetabling them because of that reason."—Participant 8, Teacher of Class 11.*

This was supported further by Participant 6, who suggested it also helped to create a routine for the children too.

> *"We began by doing it 3 times a day, 3 days a week, but in the end, I definitely found doing it twice a day everyday was better. Because I really liked to have it on set time each day between lessons because then I got used to it and so did the children. So, I forgot the children would remind me."—Participant 6, Teacher of Class 22.*

Changes Made during Implementation

Finally, teachers were asked whether they had to make any changes to the way Busy Brain Breaks was implemented other than time, frequency, and the role they played. Out of the 17 teachers interviewed, in addition to the 25 responses via questionnaires, 2 teachers reported making changes to the intervention. Participant 3, teacher of class 24 noted that she implemented an additional minute at the end of each Busy Brain Break where the children practiced mindfulness.

"We used mindfulness or a minute of silence at the end of each session before we got back to work. Sometimes we used GoNoodle, which has great breathing/mindfulness videos just to calm the class back down. Or even just to get the class to sit back in their chairs, close their eyes and think about what they can hear, smell, taste etc. I tried to make sure it didn't take up more time"—Participant 3, Teacher of Class 24.

Both Participant 3 and Participant 6, teachers of class 24 and class 22, respectively, reported that during the first week of implementation, they used a PE lesson to take their class through a Busy Brain Breaks video.

"I spent a PE lesson in the first week, I spent a whole PE lesson going through it. I went through with them exactly what they needed to be doing. I said to them, I know those of you who are messing around, it's because you're finding it hard. And a few of them were nodding, and I said, you're just being silly because you don't know how to do it and I get that."—Participant 6, Teacher of Class 22.

Barriers to Implementation

To understand how the intervention was implemented, and in order to help inform future classroom-based interventions, it is important to understand whether there were any factors that acted as barriers to implementation. The most frequently raised barriers were space, time, and classroom behaviour. The most frequently reported barrier to implementation was space, with 15 out of 28 class teachers raising this as an issue either through the questionnaires or during interviews.

"Space was definitely a challenge, but we just had to make sure we were careful, the children had to look for a space and make sure they weren't going to bump into anyone as we did the movements and once they were conscious of that it was absolutely fine"—Participant 6, Teacher of Class 22.

In addition to space, time was also reported by 11 teachers as being a barrier to implementation. Given that time was raised as a potential barrier to adoption and implementation during the focus groups conducted in study two, this was to be expected. Time was most frequently mentioned by the Year 6 class teachers, caused by the busy work schedule because of SATs.

"Time especially I don't know if it's different in year 6 I'm not sure but because we've got so much to fit in in such a short space of time, obviously now we haven't because we have got SATS, but if we had SATs you've got to fit it all in by May so that makes it quite a struggle to fit in all 3 which is why I didn't get to do more Busy Brain Breaks a day"—Participant 1, Teacher of Class 26.

The final challenge, noted by six classroom teachers out of the possible 28, was classroom behaviour. Of the six teachers who identified behaviour as a barrier to implementation, five noted that it only lasted as a barrier for the first two weeks of the intervention. All six teachers noted the importance of identifying and addressing the misbehaviour during Busy Brain Breaks early in the intervention in order to prevent it from affecting further implementation.

"I mean every child is different, the way they react, but yeah nipping it in the bud early was important for me and for them because then they knew what was acceptable and what wasn't"—Participant 7, Teacher of Class 1.

Facilitators to Implementation

Whilst misbehaviour posed a challenge to implementation at the start of the intervention, eight teachers identified being able to use the way they implemented Busy Brain Breaks to help with classroom management. For some teachers, the threat of taking Busy Brain Breaks away helped them to manage classroom behaviour. Others found offering Busy Brain Breaks as reward for completing or finishing a task quickly was beneficial.

> *"I'd say okay you've got twenty min left and we're going to work for 15 min of that but if you finish your work because they can be talkative in the afternoon especially so if you finish your work in the next 15 min then great we can do a Busy Brain Break but if not then we won't be able to do it so yeah from a behaviour management point of view as well it's like that carrot at the end of the stick and it is a big carrot because they really enjoy Busy Brain Breaks"—Participant 13, Teacher of Class 17.*

Good-quality resources were identified as a potential facilitator to both adopting and implementing a classroom-based physical activity intervention during the focus groups conducted during study two. Twenty-two of the 28 class teachers identified the resources as positive influence throughout implementation. Importantly, the instructional cues and practical demonstration of the exercise within the videos allowed teachers to confidently instruct children despite their own physical activity knowledge and ability.

> *"Even if you don't have the knowledge, you've still got the videos on the screen and you know even if you didn't know exactly why they had to be in that position you can still show a child the video and even demonstrate it yourself to help get them into that position"—Participant 8, Teacher of Class 11.*

6:3:4 Efficacy

For this study, efficacy considers how the intervention influenced primary outcome changes, as well as assessing whether positive or negative outcomes were experienced by individuals or within the school setting. This was measured through questionnaires and follow-up interviewers with both teaching staff and pupils. It was intended for this outcome to be measured using the Athlete Introductory Movement Screen (AIMS-4). However, due to the COVID-19 pandemic, it was not possible to collect the post intervention measurements. The successes identified fell into either physical success such as movement ability, or behavioural-educational success such as time-on-task behaviour. It can therefore be argued that the behavioural-educational successes are likely to be higher in validity in comparison to the physical successors as the participants were all primary school practitioners.

Movement Ability

All 17 of the teachers interviewed identified that movement ability had improved as a result of the intervention. The teacher's previous knowledge and experience affected how in depth they were able to discuss these improvements, but despite previous knowledge, all reported observing a noticeable change in the way in which children were performing the exercises. The majority of teachers were able to identify specific exercises that the children improved in. The most frequently mentioned were press ups, deadbugs and planks.

> *"In terms of my opinion of the results, the results are obvious you know when we started maybe two of them could do some half-hearted press-ups whereas more recently the majority of them are doing proper press-ups during the press up bit, or planks were spent with their backsides in air or even lying down by the end lots of them were doing planks for the duration and they actually looked like the ones being done on the video. The deadbugs were all over the place to start but then*

they obviously improved their co-ordination a lot and weren't getting mixed up or confused anymore."—Participant 8, Teacher of Class 11.

Fitness and Physical Activity

Seven teachers identified a positive improvement to the children's fitness levels whilst they were completing Busy Brain Breaks.

"I know definitely at the start they were moaning and they found it hard and they were out of breath and I even had a couple of parents say their kids had aching legs the next day but then over time it definitely got easier and they wouldn't moan and they could do the whole 5 min without needing a rest and they even commented to me about how they were finding it easier too and they weren't having to take as many breaks"—Participant 6, Teacher of Class 22.

In addition to movement ability and fitness levels, eight teachers during interview and three teachers via questionnaire identified the effect that the intervention had on general physical activity levels.

"Definitely and the effect of Busy Brain Break wasn't just specific to when we were doing the actual exercises because the children would talk about it before and after and they'd often go out to break talking about various exercises, I had a small group of children who would come in with different variations on exercises that we had done so I think we had a few different types of lunges and they found different ways to do planks so it helped to encourage more chat about fitness and exercise which was nice"—Participant 9, Teacher of Class 9.

Time-on-Task Behaviour

In addition to physical outcomes, all seventeen teachers noted positive behavioural and educational benefits because of the intervention. The most frequently identified benefit was improved focus, which had a positive impact on time-on-task behaviour.

> *"Oh, it definitely re-focuses them, it kind of draws a line, you draw a line under the activity that they have just done, and they take a big breath and they are ready, they are just more ready to learn."—Participant 14, Teacher of Class 19.*

All 17 teachers recognised that children were required to sustain concentration for long periods of time throughout the school day. It was suggested that being able to stand up and release some energy was the mechanism behind the improved focus and improved time-on-task behaviour.

> *"They're expected to sustain concentration for long periods of time and you know that's difficult and they can maybe do it for 30 min if you're lucky and then they start getting chatty and you can hear the noise level in the room change so being able to give them a chance to get up and get moving really helps them to get rid of that energy and they are able to sit back down and concentrate on their work."—Participant 7, Teacher of Class 1.*

6:3:5 Maintenance

When asked whether they would implement the intervention again next year, sixteen out of the seventeen teachers interviewed reported that they would use Busy Brain Breaks in their classroom again next year. Out of the sixteen teachers who reported that they would deliver the intervention again next year, three teachers noted that they would make some changes to the intervention. The most frequently mentioned change was the frequency of Busy Brain Breaks, with the teachers suggesting they would do fewer breaks each week due to time constraints.

> *"I think probably for me to make it more manageable I'd have to do say like 2 maybe 3 times a week so 6 a week which I think for me is more manageable."—Participant 1, Teacher of Class 26.*

As a result of the COVID-19 pandemic, the Busy Brain Break videos were uploaded to YouTube and each teacher was asked to make their classes aware that they could access the videos at home. As part of the questionnaire sent home to children via their school website, children were asked whether they were doing Busy Brain Breaks at home during the pandemic.

The results indicated that 75.75% of children who completed the questionnaire were doing Busy Brain Breaks at least once a week at home. When separated by school, the average amount of sessions being completed at home differs, with children from school A having a median value of 5 sessions per week, children from school B having a median value of 3 sessions per week and children from school C having a median value of 1 session per week.

6:4 Discussion

By using the RE-AIM framework to conduct a process evaluation, this paper has been able to draw out key barriers and facilitators to a small-scale physical activity intervention implemented across 28 classrooms in Gloucestershire, UK. The key findings indicated that giving teaching staff autonomy over when to implement an intervention within their classrooms was a successful way to overcome time constraints and busy workloads which were both positioned as barriers to adoption and implementation. Children's behaviour acted as both a facilitator and barrier to implementation and maintenance, meaning teaching practitioners should be supported with behaviour management in future interventions. Good quality resources that were easy to use, plus the variety of movements and activates included within the intervention were also key facilitators for both teaching staff and children. Finally, teaching staff (n=17) observed improvements to movement ability and time on task behaviours. The evaluation provides good evidence for the promotion of using teaching practitioner's knowledge and experience to help design school-based movement interventions.

Upon reflection, teaching practitioners made it clear that, prior to implementation, they had concerns revolving around the practicalities of adopting a new intervention. These included managing an already busy workload, finding the time to implement the regular movement breaks as well as being able to make use of the resources. Struggling with finding the time to implement physically active breaks inside the classroom has been identified as a barrier by previous research (McMullen *et al* 2016; Stylianou *et al* 2015; Quarmby *et al* 2018). It could be argued that English primary schools have seen an increase in cultures of performativity over the past decade. Troman *et al* (2007) identifies target setting, Ofsted inspections, school league tables, performance management and performance-related pay as systems that demand teachers to 'perform' and to be individually accountable. Whilst these measures have been introduced to improve students' achievements, they often have a negative impact on teacher's workload, their professional identities, and their experience of teaching (Troman *et al* 2007; Jeffrey 2002). This is supported by previous research which identified pressure to perform well in assessments as a barrier to increasing physical activity throughout the school day (Gately *et al* 2013).

The findings of this evaluation suggest that giving teachers flexibility and autonomy over the way in which they implement an intervention may increase the likelihood of adoption. Introducing an intervention with high-quality resources that are engaging for both teachers and children also acts as a key facilitator to adoption. Ease of adoption is an important factor for any behaviour change intervention to consider. Given the identified time constraints, it is logical that teachers would prefer resources that require little effort on their behalf. A systematic review conducted by Naylor *et al* (2008) identified quality of resources as the most important facilitator to physical activity intervention implementation. Being able to adapt an intervention or producing an intervention that is flexible in its approaches created an interesting topic for consideration. On the one hand, guidelines suggest that interventions should be delivered with precise consistency to all their participants, with studies failing to do so facing critique (Daly-Smith *et al* 2018). On the other hand, it is often the case that 'one size' does not fit all, and the adoption of an intervention often needs to be adapted to fit the participants' needs (Glidewell at al 2018).

As a result of the present study, the intervention was successfully implemented to some extent by all 28 teachers. Interestingly, a recent review conducted by Calvert *et al* (2018) notes that consideration of factors such as organisational climate directed towards teaching practitioners is critical to school-wide implementation of behaviour change interventions. The use of the COM-B model and the behaviour change wheel encourages careful consideration of multiple factors, in this case, both the children's and teacher's capabilities, opportunities and motivations. This may help to explain why the intervention was well received. Time was frequently perceived as a significant barrier to the intervention. However, giving the teachers flexibility to implement the 5-minute videos when they thought most suitable allowed teaching staff to retain their autonomy and make the intervention work with their schedule. Research suggests that an individual is more likely to want to engage in behaviour change if they feel as though it is their choice to do so, rather than having the choice made for them (Ryan *et al* 2009). This degree of perceived autonomy refers to an individual's willingness to engage in behaviour change and can therefore heavily influence motivation (Ryan *et al* 2000). Children's behaviour appears to be both a facilitator and barrier to implementing physical activity interventions within the classroom. Whilst misbehaviour can pose as a barrier, children's enjoyment acts as a key facilitator for teaching practitioners. This concern is supported in the wider literature that has previously identified pupil behaviour as a barrier to implementation (McMullen *et al* 21; Quarmby *et al* 2018) Quarmby *et al* (2018) note that ensuring pupils remain seated throughout a lesson helps to ensure a level of classroom control and management, which teachers could be hesitant to disrupt. Future research should therefore focus on support for teaching practitioners to help manage potential misbehaviour during physical activity interventions, to prevent it from becoming a barrier.

All 17 of the teachers interviewed identified that movement ability had improved because of the intervention 'Busy Brain Breaks', with teachers recognising co-ordination, balance and stability as areas that had improved the most. In addition to movement, seven teachers identified that fitness levels had improved during the intervention, with children having to take fewer and shorter rest breaks during the exercises. This is potentially significant considering low cardiorespiratory and muscular fitness have previously been associated with reduced metabolic health in children and adolescents (Steene-Johannessen *et al* 2009; Artero *et al* 2011). It must be noted, however, that cardiorespiratory and muscular fitness were not assessed directly in the present study and that objective assessment would be required to substantiate the teachers' observations. Considering movement skill competency has previously been linked to cardiorespiratory and muscular fitness (Cattuzzo *et al* 2014), it is possible that the intervention had a positive effect on these health-related factors. Some teachers noted that physical activity outside of the intervention had also been positively impacted, with children talking more frequently about physical activity and practicing the exercises at home. This is perhaps a reflection of increased enjoyment of physical activity, which has recently shown to be an important predictor variable for achieving physical activity guidelines in primary school children (Connolly et a 2020). Authors suggested that enjoyment of physical activity should be an important aspect when designing future interventions, and although enjoyment was not assessed directly in the present study, comments from teachers would appear to support this recommendation.

A limitation of this study is the lack of objective pre/post intervention measurements. It was intended for these outcomes to be measured using the Athlete Introductory Movement Screen (AIMS-4). These objective measurements were to be presented alongside the process evaluation data to help support the interventions effectiveness. However, due to the COVID-19 pandemic, it was not possible to collect the post intervention measurements due to schools being forced to close. To collect efficacy data, teachers were asked about their perceptions of general success as a result of the intervention. It is important to note that findings for efficacy are considerably less valid than they would be if objective measures had been taken.

All 17 teachers interviewed noted that the intervention improved focus, which positively impacted time-on-task behaviour. Teachers also noted that the intervention had a positive impact on peer work, with children frequently giving each other feedback and encouragement. These findings are similar to that of Donnelly and Lambourne (2011) who found a link between physical activity, cognitive function and academic achievement. More recently, a systematic review conducted by Daly-Smith *et al* (2018) identified classroom movement breaks as being successful methods for increasing overall time spent doing physical activity during the school day and for improving classroom behaviour. It has been suggested that giving children a break from concentration and a chance to release their energy is a key mechanism for improved focus Stylianou *et al* 2015). Furthermore, research suggests that making this break an active one has both physical and educational benefits, as identified by Norris *et al* (2019).

Whilst this study was planned to last for 20 weeks to understand how the intervention was implemented over a longer period of the time, the pandemic meant that the intervention lasted for 10 weeks. As Barnett *et al* (2009) note, whilst physical activity interventions that aim to increase levels of physical activity and improve movement skill can be effective, less is known about the longitudinal results. Currently, this study has only reported the teacher's intention to maintain their behaviour change. Therefore, follow-up research in 12 months' time would be advantageous to further understand whether the intervention is able to create sustained behaviour change.

A further limitation of the project is the sampling method used to recruit schools and participants. Given the difficulty with recruitment for the study outlined in 3:1, six of the 11 schools who participated in the cross-sectional research were invited to take part in the second and third study. In addition to recruiting schools, there was further difficulty obtaining parental consent. Despite the number of participants of who took part in the study, response rates varied considerably by school and averaged at 55%. It is important to consider the possible effect of responder bias here. Firstly, it could be possible that schools are more likely to participate if they are confident in their provision for physical activity. To overcome this potential limitation, it was made clear to schools that their provision for physical activity was not going to be evaluated or assessed at any point. Secondly, parents who have physically active children may be happier for their child to take part and therefore return the consent form. However, the study was successful at recruiting schools from rural, semi-rural and inner-city localities all of which had a variety of children from different backgrounds and locations. Despite being well-place to reach a vast majority of school-aged youth, the challenges involved when working with schools have been widely documented and include logistical complications (Jago et al 2011; Mishna et al 2012), parental involvement (Coyne 2010), difficulties with measurement (Lund et al 2012), recruitment (Daley 2013) and time management (Bartlett et al 2017).

With regards to the process evaluation itself, the collection of class-level dose data to support the semi-structured qualitative interviews is a key strength. Collecting information with regards to intervention dose is required in order to understand intervention fidelity. It was intended for the class-level dose data to be compared with baseline and post intervention data in order to explore the possibility of a dose-response relationship in more detail. Future research should strive to collect similar data in order to investigate this in more detail. Furthermore, future researchers may wish to replicate the method used to collect the class-level dose data which involved each class completing their 'weekly tracker' with the research visiting each class to collect the data at the end of the week. This method also helped to improve accountability and could be scaled-up by each class submitting their results to a digital platform instead.

As part of the process evaluation, an attempt was made to collect individual-level dose data in additional to class-level. As described in Section 6:2:2, each class was provided with a wipe clean RPE score card and the children were asked to reflect on their weeks-worth of Busy Brain Break sessions to come up with an average RPE score. Whilst the data was recorded, the researcher had verbal conversations with multiple teachers who suggested the scores recorded by the children were not reliable. The teacher's recalled how they knew the children were finding it difficult, giving examples of children being red in the face and short of breath, but recording low RPE scores which suggested they didn't find it difficult at all. The majority of teachers asked children to call out their RPE scores during the Friday afternoon register and it was suggested that children were giving competitive scores in relation to their peers which often weren't accurate to the children's experience of the intervention. As a result, the individual-level data was not used in the analysis. One classroom teacher asked the children to come up and write down their RPE scores individually, the teacher discussed their scores with them and prompted where necessary with questions such as 'do you remember how you felt whilst you were doing squats?' or 'can you remember feeling out of breath?'. The children in this classroom typically reported higher scores (i.e. they found it more difficult) than their peers in other classes, which may suggest this method of collecting the data may be worth further investigation in future studies.

Finally, the evaluation lacked the comparison data required to adequately address the 'reach' arm of the RE-AIM framework, and instead compared the sample used with national averages. Failing to compare the sample with participants who chose not to participate is a frequent limitation of process evaluations due to the complexities of collecting data on participants who have not consented to be involved in research (Gaglio *et al* 2013). Given the possibility that schools and parents who were happy with their children's physical activity engagement may have been more likely to agree to participate in the study, future research may wish to conduct a qualitative investigation into schools who decline to participate in physical activity research. Future researchers may therefore wish to focus on building a good rapport with key stakeholders (Yancey *et al* 2006) and developing community-based partnerships which promote key school values such as time and workload in order to explore this further Hooven *et al (*2016).

6:5: Practical Implications

In addition to conducting a thorough process evaluation using the RE-AIM framework, it was important to collect what the teachers perceived to be important guidance for successful delivery of the intervention. At the end of each interview, teachers were asked to reflect back on their experience of Busy Brain Breaks and give three top tips for someone who was hoping to successfully implement the intervention inside their classroom in the future. The advice has been summarised below.

- Introduce the children to Busy Brain Breaks by showing them a video first and talking through the benefits of physical activity.
- Set out clear behavioural expectations before implementing Busy Brain Breaks inside the classroom.
- Make sure the children find a space and are aware of who is behind them, to the side and in front of them.
- Ask for quiet voices, or little to no talking when the videos are on in order to help reduce silly behaviour.
- Try to do some of the exercises with the children where possible.

- Be sure to give lots of positive reinforcement to all children, especially the children who find physical activity difficult or don't enjoy it.
- Have a rough idea in your head as to when you plan to implement the Busy Brain Breaks throughout the day.
- Do your best to stick to the schedule in your head and finish/start lessons promptly so you are being time efficient
- Try to keep consistent with the days and times so it becomes part of your class's everyday routine

Chapter 7

Conclusion

7: Conclusion and Recommendations

7:1 Physical activity, strength, movement skill competency, self-perception and enjoyment

The overall aim of the project was to conduct an investigation into the development of children's movement skill competency and physical activity within a primary school setting. The first study outlined in section 3:1 aimed to establish the movement competency of Gloucestershire's primary school aged children, aged between 7-11 years old, whilst exploring possible associations between physical activity levels, movement skill competency and strength. The study was the first study to explore these variables in Gloucestershire, where physical activity had been reported to be in line with the national average (Sport England 2021), and movement proficiency had not been investigated. A total of 39 (5.9%) students reported meeting the physical activity guidelines of being physically active for an average of 60 minutes or more, compared to 661 who did not, with boys reporting a statistically higher amount of physical activity per week compared to their female peers. A high number of students (n= 558) received low movement scores, however there is currently very little comparison data available using this movement screen. The lack of consistency between studies when using movement screens to understand movement screen competency has been highlighted by Duncan *et al* (2020).

The study addressed previously noted limitations of movement screens and used the Athletic Introductory Movement Screen (AIMS) to establish movement skill competency. The screen is one of the only process-orientated measurements to assess participants across multiple repetitions, capturing movement from both the frontal and sagittal view, which allows the researcher to assess consistency (Rogers et al 2019). The adaptations from the RTSB and AAA allows for the AIMS to be quicker and easier to implement with large cohorts of children due to the number of exercises included and the limited equipment needed. The Athletic Introductory Movement Screen has proved to be a valuable movement screen to use with large cohorts of children, with excellent inter-rater and intra-rater reliability. Future research may therefore wish to collect comparative data from other counties across the UK using the screen, to help develop understanding of movement skill competency in primary school children. Given the clear instructions, scoring criteria and lack of equipment required, future researchers may also be interested to see how feasible it would be for teaching practitioners to make use of the movement screen. If teachers are able to accurately measure movement skill competency at regular intervals throughout the school year, they will be able to identify the needs of their students and subsequently deliver and develop more meaningful movement skill experiences (Longmuir *et al* 2017).

The study was one of the first to use what is considered to be a gold-standard measurement of strength amongst both boys and girls aged between 7-11 (Brady et al 2018; Comfort *et al* 2015; Buckner *et al* 2017; Merrigan *et al* 2021). The study expanded on previous research which has typically involved small, same sex samples. The findings of the study identified positive statistically significant associations between movement skill ability and strength, physical activity, physical activity enjoyment, self-perceived ability and total amount of sports played. When looking at the difference between movement percentiles, the study was able to highlight that as movement scores increase, as do physical activity engagement, enjoyment, self-perception scores as well as total amount of sports played. Future interventions aiming to improve movement skill competency and increase physical activity should therefore be encouraged to incorporate activities that aim to improve a wide range of both physical and psychological outcomes.

7:2 Using teaching practitioner's knowledge and experience to help design a movement-based classroom intervention

Both the movement scores and relationships between variables identified in the cross-sectional analysis warranted further investigation through a pilot intervention over a longitudinal period. As previously noted however, movement interventions within the primary school setting are often short lived and fail to create sustained behaviour change. One explanation for this, provided by Quarmby *et al* (2018) is that researchers often lack the operational knowledge of the school, as well as potential barriers to implementation faced by teachers. Therefore, the study presented in Section 4:1 aimed to explore the perceived barriers and facilitators to implementing movement breaks inside the classroom with primary school teaching staff, before mapping those barriers onto the COM-B model to identify suitable functions. The study differed from previous research that had either drawn from a smaller sample size (McMullen *et al* 2016), focused on teachers who are already implementing physical activity breaks (Gately *et al* 2013), looked at physically active learning as opposed to physical activity breaks throughout the school day (Quarmby *et al* 2018), or focused only on the barriers to implementation as opposed to possible facilitators too (Quarmby *et al* 2018).

The findings suggested that a child's self-perceived ability and their actual ability, in addition to their level of enjoyment, were seen as both barriers and facilitators to implementation dependant on which end of the spectrum the children found themselves. When discussing psychological capability however, teaching staff were more likely to reference their own, suggesting that confidence and fear were potential barriers to implementation. Time and space were considered to be significant barriers to implementation when physical opportunities were discussed, with resources being positioned as a facilitator provided they were of a good quality. Furthermore, classroom behaviour management was viewed as a potential barrier to implementation within social opportunity, whilst adopting a whole-school approach was a facilitator. Finally, choice was considered to be a key facilitator when discussing reflective motivation, in addition to between classroom competition which was identified as a possible facilitator when discussing automatic motivation. Based on the findings, the following recommendations were suggested for the future design and implementation of physical activity breaks inside the classroom:

- Physical activity breaks should be fun, engaging and challenging for the children involved to avoid boredom or risk losing the 'novelty' factor

- Where possible, between class competition should be encouraged, whilst individual level competition should be avoided to prevent further disengagement from students who may already feel left out

- To help develop confidence and reduce fear, teachers should be provided with knowledge on the benefits of physical activity, in addition to sufficient support regarding how to plan and deliver physical activity breaks inside the classroom

- Given the limited time and workload demands faced by primary school teachers, interventions should aim to introduce physically active breaks that are short, simple, and easy to implement throughout the school day

- Where possible, buy-in from all teaching staff should be encouraged to achieve a whole-school approach that promotes the importance of, whilst allowing time for, physically active breaks inside the classroom

- Finally, interventions should aim to provide schools with good quality resources that offer some degree of flexibility and choice that allow teachers to remain autonomous over their school day

7:3 Intervention evaluation using the RE-AIM framework

'Busy Brain Breaks' was an intervention designed to improve movement skill whilst increasing physical activity inside the classroom for children aged between 7 and 11, based on the COM-B model and the behaviour change wheel Michie *et al* (2015). Importantly, the intervention was one of the first to be driven by the experiences and thoughts of current teaching primary school practitioners, whose perceived barriers and facilitators to implementing physical activity inside the classroom, as outlined in chapter four, were used to help inform the intervention design. The behaviour change wheel itself encourages researchers to think through multiple stages, which encompass various elements, when designing a behaviour change intervention. The RE-AIM framework, developed by Glasgow *et al* (2007) was used to evaluate the intervention as it progressed to address previous critiques of school-based interventions that have failed to report on factors such as implementation, adoption and maintenance. By using the RE-AIM framework to conduct a process evaluation, the study was able to draw out key barriers and facilitators to a small-scale physical activity intervention implemented across 28 classrooms in Gloucestershire.

The intervention was implemented to some extent within all 28 classrooms. The key findings indicated that giving teaching staff autonomy over when to implement an intervention within their classrooms was a successful way to overcome time constraints and busy workloads which were both positioned as barriers to adoption and implementation. Children's behaviour acted as both a facilitator and barrier to implementation and maintenance, meaning teaching practitioners should be supported with behaviour management in future interventions. Good quality resources that were easy to use, plus the variety of movements and activates included within the intervention were also key facilitators for both teaching staff and children. Finally, teaching staff (n=17) observed improvements to movement ability and time on task behaviours. The evaluation provides good evidence for the promotion of using teaching practitioner's knowledge and experience to help design school-based movement interventions.

In addition to conducting a thorough process evaluation using the RE-AIM framework, it was important to collect what the teachers perceived to be important guidance for successful delivery of the intervention, which may be used to help inform future research aiming to improve physical activity and/or movement skill competency in the classroom. The practical advice has been summarised below.

- Introduce the children to Busy Brain Breaks by showing them a video first and talking through the benefits of physical activity

- Set out clear behavioural expectations before implementing Busy Brain Breaks inside the classroom

- Make sure the children find a space and are aware of who is behind them, to the side and in front of them

- Ask for quiet voices, or little to no talking when the videos are on to help reduce silly behaviour

- Try to do some of the exercises with the children where possible

- Be sure to give lots of positive reinforcement to all children, especially the children who find physical activity difficult or don't enjoy it

- Have a rough idea in your head as to when you plan to implement the Busy Brain Breaks throughout the day

- Do your best to stick to the schedule in your head and finish/start lessons promptly so you are being time efficient

- Try to keep consistent with the days and times so it becomes part of your class's everyday routine

7:4 Conclusion

To conclude, this project has developed the understanding of physical activity and movement skill competency within Gloucestershire's 7–11-year-old children, whilst highlighting associations between movement ability and physical activity levels, physical activity enjoyment, strength, and self-perceived ability. Future research may want to consider comparing these results to other areas across the UK to develop understanding of movement proficiency further. Importantly, this project has highlighted the importance of taking a holistic approach when designing movement-based interventions and future researchers should be encouraged to consider the impact on both physical and psychological health outcomes. Finally, the project presented has demonstrated the benefits of using teaching practitioner's knowledge and experience to help inform the design of a movement-based classroom intervention. This warrants further investigation as to how practitioners from different disciplines, such as healthcare, may be able to inform interventions relevant to their own field.

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Appendix

Contents

Appendix 1: Literature Review Quality Assessment

Author Date	Was the study described as a randomised control trial?	Were participants representative of the entire population from which they were recruited?	Was there high adherence to the intervention?	Was the overall dropout rate lower than 50%?	Were the statistical tests used to assess the main outcomes appropriate?	Were losses of patients to follow-up taken into account?	Were outcomes assessed using valid and reliable measures?	Have actual probability values been reported for main outcomes?	Total Score
Van Beurden *et al* (2003)	Yes	Yes	N/R	N/R	Yes	N/R	Yes	Yes	5/8
Sollerhead *et al* (2006)	Yes	Yes	N/R	N/R	Yes	N/R	Yes	Yes	5/8
Cliff *et al* (2007)	No	Yes	Yes: 95%	Yes: 15%	Yes	Yes	Yes	Yes	7/8
Korsten-Reck *et al* (2007)	No	Yes	N/R	N/R	Yes	N/R	Yes	Yes	4/8
Salmon *et al* (2008)	Yes	Yes	Yes: 88%	Yes: 12%	Yes	Yes	Yes	Yes	8/8
Foweather *et al* (2008)	Yes	Yes	Yes: 85%	N/R	Yes	N/R	Yes	Yes	6/8
Akbari *et al* (2009)	Yes	Yes	NR	NR	Yes	NR	Yes	Yes	5/8
Boyle-Holmes *et al* (2009)	Yes	Yes	Yes (but not reported)	N/R	Yes	Yes	No	Yes	6/8
Cliff *et al* (2010)	Yes	Yes	Yes: 95%	Yes: 5%	Yes	Yes	Yes	Yes	8/8
Sola *et al* (2010)	No	Yes	N/R	Yes: 43.5%	Yes	Yes	Yes	Yes	6/8
Bakhtiari *et al* (2011)	Yes	Yes	NR	NR	Yes	NR	Yes	No	4/8
Ericsson *et al* (2011)	Yes	Yes	Yes:	Yes:	Yes	Yes	No	No	6/8

Mitchell *et al* (2011)	No	Yes	N/R	N/R	Yes	N/R	Yes	Yes	4/8
Morano *et al* (2013)	No	Yes	Yes: 88%	N/R	Yes	N/R	Yes	Yes	5/8
Steinberg *et al* (2013)	No	Yes	N/R	N/R	Yes	N/R	Yes	Yes	4/8
Beck *et al* (2016)	Yes	Yes	Yes: 89%	Yes: 12%	Yes	Yes	No	No	6/8

Appendix 2: Invitation Letter

HARTPURY

Hartpury University
Sport Arena
Gloucestershire
GL193BE

Dear (Head Teacher Name),

My name is Alice and I'm a PhD student studying within Hartpury's university sport arena. We are conducting research on physical activity engagement and movement skill development of primary school aged children in Gloucestershire and surrounding areas. We would like to invite you and your key stage pupils to work with us on the project.

Currently, just 13% of children aged between 7 and 11 in Gloucester are meeting the recommended amount of 60 minutes of moderate to vigorous activity per day. As you are probably aware, physical activity has multiple physical and psychological benefits. Therefore, we are eager to work closely with both schools and pupils to help increase this percentage and improve the chances of children becoming physically active adults.

The project will start by collecting data from your key stage two pupils. The data will be collected by myself and a strength and conditioning MRes student Rebecca, with the occasional help of my supervisor Gareth - we are all DBS checked. In order to collect the data, we will send consent forms home to parents along with a short questionnaire. We will provide the consent forms to you in paper form, with the request that you have them returned and signed before data collection takes place.

The data collection process is flexible and will take one afternoon per 30 students. Over the course of the afternoon, students will be required to leave the classroom in pairs to have the following measurements taken:

- Blood Pressure
- Height/Weight
- Sitting Height
- Waist Circumference
- Movement Skill Competency
- Power/Strength

In addition to this, we will send you two short questionnaires to fill out with your students that will collect information on their physical activity levels and self-perceived physical activity abilities. Both questionnaires together should take no longer than 20 minutes to complete and will be provided to you in paper from prior to our visit to you.

Whilst the overall aim is to collect data in order to build a database of the general health and fitness of children aged between 7-11 in Gloucestershire, Hartpury would like to take this opportunity to educate students in the areas you feel necessary. For example, we could accompany the blood pressure monitoring with an informative session on blood, blood pressure and the role of blood in the body. A similar session could be conducted for physical activity, explaining its benefits and discussing ways to become more active. For the older key stage 2 pupils, we could discuss the information we are collecting and do some data work – whatever you feel is appropriate and/or necessary.

I am happy to discuss the practicalities of this further with you in person, or with the teachers of your key stage two classes should you decide to take part. My number is 07802836291, and my email is alice.cline@hartpury.ac.uk.

I look forward to hearing from you,

Kind Regards,

Alice Cline
BSc (hons), MSc (dist), PhD Candidate
Hartpury University / University of the West of England

Appendix 3: Headteacher Consent Form

HARTPURY

HEADTEACHER CONSENT FORM

Project Title:
What is the state of fitness levels, physical activity and lifestyle in school children aged 7-11 years in Gloucestershire (HARTLINX)

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

Please initial box

I can confirm that I have read and understood the information sheet provided and have had the opportunity to ask questions. ☐

I understand that the children's participation is voluntary and that I am free to withdraw my pupils at any time, without giving any reason, with out their medical care or legal rights being affected. ☐

I understand that sections of the data obtained may be looked at by responsible from Hartpury University. I give permission for these individuals to have access to these records. ☐

I am happy for the data collected in this study to be used in future health related studies where data collected will be linked to health outcomes. ☐

I agree to allow the pupils in my school to take part in the study.

____

Name of School

____/____/____

Date

____

Signature

Appendix 4: Site Permission Form

HARTPURY

Nam: Alice Cline
Email: alice.cline@hartpury.ac.uk

<u>Site permission form:</u>

To whom it may concern,

I __________________________, in my capacity as manager/owner of

____ grant permission for Alice

Cline to conduct research looking at childhood physical activity at my establishment on _______________.

I understand what the project involves and will facilitate work which will be presented as a PhD thesis, with aims to publish in an appropriate journal. I also understand that a paper and electronic copy will be kept at Hartpury University.

Yours sincerely,

Signature of manager/owner____

Location/facility____

Please print name/s: ____

Date: ____

Appendix 5: Parent/Guardian Information Sheet

HARTPURY

PARENT/GUARDIAN INFORMATION SHEET

Project Title:
Get Gloucestershire Going: Improving physical activity and movement skill competency in Gloucestershire's key stage two children. An inquiry, an insight and an intervention.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

1. Invitation Paragraph

The children in your child's school who are aged 7-11 years have been invited to take part in this study. They will be asked to take part in a fitness fun day and to complete a questionnaire. The data we collect from your pupils will help us assess different physical and psychological aspects of children in Gloucestershire.

2. What is the purpose of the study?

The purpose of the study is to determine health, movement performance and lifestyle of children aged 7-11 years in Gloucestershire. The data collected will be used to help children become more healthy and involved in sport in the future.

3. Why have I been chosen?

Your child has been invited to take part in this study because they attend a primary school in Gloucestershire and are aged 7 to 11 years and have been invited to take part in the fitness fun day. During the study if any of the children do not feel happy about anything they are asked to do they can stop at anytime without fear of penalty. If you need any more information about the study then please contact any member of the team on the details written above.

4. What will happen to the children if they take part?

If you allow your child to take part in the study, they will be involved in two fitness fun afternoons. The first will take place in school and will involve and interaction session where they will complete a physical activity questionnaire and a wide range achievement test, before learning about physical activity and it's benefits. They will also have various anthropometric measurements taken including height, weight, blood pressure and waist circumference. All measurements will be taken privately and the children can decide if they do not want to take part. The second session will involve your child attending a fitness fun at Hartpury University. The half day will involve a number of fun activities that will measure the children's strength, speed, object control skills, flexibility and cardiorespiratory endurance. This approach has been followed with around 70000 children in Liverpool since 1996. The activities will be no harder than what a child would do during school PE lessons, with the afternoon being designed as fun experience.

5. What are the possible disadvantages of taking part?
Taking part in the fitness fun day poses no greater risk than a child would face during PE lessons in school. However, in the unlikely event that a child feels unwell, sick, tired, faint or sustains an injury, there will be people monitoring the children during all parts of the fitness fun day; and the children's teachers will remain present at all times. A qualified first aider will always be present at the sports centre during the fitness fun day.

6. What are the possible benefits of taking part?
The fun day will be an active and very enjoyable day for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out their skills, fitness, flexibility related to health and well-being. The final data will be made available to the school for educational and curriculum use.

7. Will my taking part in the study be kept confidential?
All the data we collect from the children will be kept private and confidential, the children's names will be changed to numbers. Any hard copies of the questionnaires and fun day data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team from Hartpury University Centre. The data we collect will be used to assess the health, movement performance and lifestyle of children in Gloucestershire.

8. What if I have any questions?
Questions are encouraged! If you have any questions about what it is written above or anything to do with the study please don't hesitate to contact me or anyone from the research team as detailed above. If after the study you are concerned about how any aspect of the research was conducted please contact Alice Cline (alice.cline@hartpury.ac.uk).

Appendix 6: Parent/Guardian Consent Form

HARTPURY

PARENT/GUARDIAN CONSENT FORM

Project Title:
Get Gloucestershire Going: Improving physical activity and movement skill competency in Gloucestershire's key stage two children. An inquiry, an insight and an intervention.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

	Please initial box
I can confirm that I have read and understood the information sheet provided and have had the opportunity to ask questions.	☐
I understand that my child's participation is voluntary and that I am free to withdraw my child at any time, without giving any reason, with out their medical care or legal rights being affected.	☐
I understand that sections of the data obtained may be looked at by responsible from Hartpury University. I give permission for these individuals to have access to these records.	☐
I am happy for the data collected in this study to be used in future health related studies where data collected will be linked to health outcomes.	☐

I agree to allow my child to take part in the study.

____________________	_____/_____/_____
Name of Child	Date
____________________	____________________
Name of Parent/Guardian	Signature

HARTPURY

PARTICIPANT INFORMATION SHEET

Project Title:
Get Gloucestershire Going: Improving physical activity and movement skill competency in Gloucestershire's key stage two children. An inquiry, an insight and an intervention.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

You have been selected to take part in a Hartpury University Centre study. You have been chosen because you are between the ages of 7 - 11 years old and got to a primary school in Gloucestershire.

In this study you will have the chance to take part a series of fun activities such squats, lunges and press-ups. You will also be asked to have some measurements taken including; weight, height and sitting height. All measures are taken **privately** and no results are shared with the rest of the class.

You will not be forced to take part and can stop at any time without fear of penalty or having to worry about being in trouble.

If you have any questions please ask any of the research team.

Thank you.

Appendix 8: Participant Assent Form

HARTPURY

PARTICIPANT ASSENT FORM (Child)

Project Title:
What is the state of fitness levels, physical activity and lifestyle in school children aged 7-11 years in Gloucestershire.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

I agree to take part in the above study.

______________________________ ________________

Name of Participant Date

Appendix 9: Physical Activity Questionnaire for Children (PAQ-C)

HARTPURY

Physical Activity Questionnaire Name:

1. Circle any sport that you regularly do:

Archery	Badminton	Cricket
Boxing	Bowls	Football
Canoeing	Cheerleading	Hockey
Climbing	Cycling	Netball
Golf	Dance	Basketball
Skateboarding	Gymnastics	Rugby
Sailing	Rowing	Volleyball
Athletics	Martial Arts	Dodgeball
Table tennis	Swimming	Running/cross- county
Tennis	Squash	Other

2. In the last 7 days, what did you do most of the time during **break time?** Tick one box only.

Sat down (talking, reading, working)	
Stood around or walked around	
Ran or played a little bit	
Ran around and played quite a bit	
Ran and played hard most of the time	

3. In the last 7 days, what did you normally do at **lunch** (apart from eating your lunch)? Tick one box only.

Sat down (talking, reading, working)	
Stood around or walked around	
Ran or played a little bit	
Ran around and played quite a bit	
Ran and played hard most of the time	

4. During the **past week**, on how many days were you physically active for an average of at least 60 minutes per day? (activities that increased your heart rate and made you breathe hard). Tick one.

0 days	
1 day	
2 days	
3 days	
4 days	
5 days	
6 days	
7 days	

5. How many days **right after school** were you very active last week? Tick one box only.

None	
1 day after school I was active	
2 days after school I was active	
3 days after school I was active	
4 days after school I was active	
5 days after school I was active	

6. How many **evenings** were you very active last week? Tick one box only.

None	
1 evening I was active	
2 evenings I was active	
3 evenings I was active	
4 evenings I was active	
5 evenings I was active	
6 evenings I was active	
7 evenings I was active	

7. How many times were very active **last weekend?** Tick one box only.

None	
1 time I was active last weekend	
2 times I was active last weekend	
3 times I was active last weekend	
4 times I was active last weekend	
5 or more times I was active last weekend	

8. On a **school day** how many hours of TV do you normally watch? Tick one.

I did not watch TV	

Less than 1 hour	
1 hour	
2 hours	
3 hours	
4 hours	
5 hours or more	

9. On a **weekend day** how many hours of TV do you normally watch? Tick one.

I did not watch TV	
Less than 1 hour	
1 hour	
2 hours	
3 hours	
4 hours	
5 hours or more	

10. In the **last week**, how did you mainly get to school? Tick one.

Walking	
Bicycle, roller-blade, skateboard, scooter	
Bus, train, tram, underground or boat	
Car, motorcycle or moped	
Other:	

Thank you.

Appendix 10: Physical Activity Enjoyment Letter (PACES)

Please rate how you feel about physical activity:

I enjoy it	1	2	3	4	5	6	7	8	9	10	**I hate it**
I feel bored	1	2	3	4	5	6	7	8	9	10	**I feel interested**
I find it pleasurable	1	2	3	4	5	6	7	8	9	10	**I find it unpleasurable**
I am very absorbed in this activity	1	2	3	4	5	6	7	8	9	10	**I am not at all absorbed in this activity**
It's not fun at all	1	2	3	4	5	6	7	8	9	10	**It's a lot of fun**
I find it energising	1	2	3	4	5	6	7	8	9	10	**I find it tiring**
It makes me depressed	1	2	3	4	5 10	6	7	8	9		**It makes me happy**
It's very pleasant	1	2	3	4	5	6	7	8	9	10	**It's very unpleasant**
I feel good physically while doing it	1	2	3	4	5 10	6	7	8	9		**I feel bad physically while doing it**

Appendix 11: Self-Perception Questionnaire

HARTPURY

Name:

Really true for me	**Sort of true for me**				**Sort of true for me**	**Really true for me**
		1. Some children do very well at all kinds of sports	BUT	Other children don't feel that they are very good when it comes to sports		
		2. Some children often forget what they learn	BUT	Other children can remember things easily		
		3. Some children think they can do well at new sports activity, even if they haven't tried it before	BUT	Other children are afraid they might not do well at sports activities they haven't tried before		
		4. Some children wish their body was different	BUT	Some children are happy with their bodies		
		5. In games and sports, some children usually just watch instead of play	BUT	Other children usually play rather than just watch		
		6. Some children don't do well at new outdoor games	BUT	Other children are good at new games right away		
		7. Some children are happy with their height and weight	BUT	Some children wish their height and weight were different		
		8. Some children wish they could be a lot better at sports	BUT	Other children feel they are good enough at sports		
		9. Some children feel like they are better than other children their age at sports	BUT	Other children feel like they can't play as well		

Appendix 12: Scoring Rubric and inclusion rationale for the Athlete Introductory Movement Screen (AIMS-4), adapted from Roggers *et al* (2018).

Movement Task	Criteria	**3 Points** *'Full proficiency and consistency'*	**2 Points** *'Moderare/partial proficiency and/or inconsisten performance'*	**1 Point** *'Poor and/or inconsistent movement ability'*
Overhead Squat Comprehensive assessment of bilateral lower extremity and hip neuromuscular control and range of motion, while simultaneously challenging shoulder mobility and control; highlighting any compensatory patterns, and requiring integrated stability of the core.	Heels [sagittal view]	Heels remain on floor throughout 4 consecutive repetitions	3 appropriate repetitions	2 or less appropriate repetitions
	Depth [sagittal view]	Thighs are at least parallel to the floor at the bottom of the movement throughout 4 consecutive repetitions	3 appropriate repetitions; OR near parallel for all repetitions	2 or less appropriate repetitions
	Bar (dowel) and trunk position [sagittal view]	Maintains bar overhead with appropriate shoulder/ thoracic extension & trunk angle without rotation, throughout 4 consecutive repetitions	3 appropriate repetitions; OR bar position appropriate but minor deviation from appropriate thoracic extension & trunk angle on all repetitions; OR poor bar position but with appropriate thoracic extension and trunk angle on all repetitions	2 or less appropriate repetitions
	Frontal Plane Alignment [front view]	Appropriate alignment, symmetry and control of hip/knee/ankle, including thighs, move symmetrically throughout 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment and/or asymmetry on all repetitions	2 or less appropriate repetitions
	Upper body alignment/control	Head, back and hips are held in a straight line throughout the	3 appropriate repetitions; OR minor misalignment/slight loss of	2 or less appropriate repetitions

	[sagittal view]	movement on 4 consecutive repetitions	control of 1 segment (e.g. head) on all repetitions	
Push-up Assessment of upper body strength, core stability and control including scapular and glenohumeral joint function	**Shoulder position and control** [sagittal view]	Shoulders are away from ears (not shrugged / moved closer to ears during movement) AND elbow positioning is directed slightly anterior, not flaring, in 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment/slight loss of control on all repetitions	2 or less appropriate repetitions
	Hand position [sagittal view]	Hands are placed under the shoulders AND hands not repositioned in any repetitions	Minor miss-positioning of hands relative to shoulders (less than 10 cm); OR 1 repositioning of hands	Poor initial positioning initial OR; 2+ repositioning of hands
	Depth **[front view]**	Body is lowered until elbows at 90 degree angle for 4 consecutive repetitions	3 appropriate repetitions to 90 degrees; OR near 90 degrees on all repetitions (±10 degrees)	2 or less appropriate repetitions
Lunge An integration of unilateral lower extremity and hip mobility, stability/balance and neuromuscular control, with overall truck stability during a functional gate stance	**Turnk control** [sagittal view]	Maintains neutral spine during full movement (out and back), no flexion/extension or rotation for 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment/slight loss of control on all repetitions	2 or less appropriate repetitions
	Depth [sagittal view]	Knee of rear leg lowered with control until almost touching the floor (<10cm) for 4 consecutive repetitions	3 appropriate repetitions; OR Near appropriate depth for all repetitions OR some weight acceptance on knee on 1 rep (i.e. visible touch down)	2 or less appropriate repetitions
	Frontal plane alignment **[front view]**	Appropriate alignment and control of knee/ankle throughout 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment on all repetitions	2 or less appropriate repetitions
	Hip/pelvic control **[front view]**	Appropriate alignment and control of hips with neutral pelvis throughout movement on 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment (end range) on all repetitions	2 or less appropriate repetitions

Front Support Brace & Shoulder Touch Assessing core musculature strength in a brief isometric hold, with the added trunk stability challenge of transiting from 4 to 3 points of ground contact, challenging the athlete's ability to maintain trunk integrity.	**Foot contact** [sagittal view]	Both feet remain on the ground throughout 4 consecutive repetitions, no foot sliding	3 appropriate repetitions (1 foot lift only); OR no repetitions lifted, but feet slide on up to 2 repetitions	2 or less appropriate repetitions (feet lifted in 2 or more AND/OR feet slide in 3 or more)
	Full body align,ent [sagittal view]	Holds the total body plane in straight alignment through legs (knees fully extended), hips, shoulders and head, for 4 consecutive repetitions	3 appropriate repetitions; OR minor misalignment on all repetitions	2 or less appropriate repetitions
	Resist rotation **[both views]**	Minimal rotation of the pelvis / hip complex during all 8 repetitions while changing from 4 to 3 points of contact (approx. 10cm is acceptable)	6 or more appropriate repetitions; OR minor rotation on all repetitions	6 or less appropriate repetitions
	Controlled arm movement **[both views]**	Chest touches performed in controlled manner with arms deliberately returned to floor following chest touch on all 8 repetitions	6 or more appropriate repetitions; OR minor loss of control on all repetitions	6 or less appropriate repetitions

Appendix 13: Inter and Intra Rate Reliability Data

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.976[a]	.457	.995	268.077	19	19	.000
Average Measures	.988[c]	.627	.997	268.077	19	19	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.970[a]	.663	.992	149.783	19	19	.000
Average Measures	.985[c]	.797	.996	149.783	19	19	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Appendix 14: Descriptive Statistics for Year 3

			Statistic	Std. Error
*Force Relative to BW	Mean		25.5307	.25491
	95% Confidence Interval for Mean	Lower Bound	25.0275	
		Upper Bound	26.0340	
	5% Trimmed Mean		25.6113	
	Median		26.0338	
	Variance		10.916	
	Std. Deviation		3.30397	
	Minimum		14.24	
	Maximum		34.89	
	Range		20.65	
	Interquartile Range		4.32	
	Skewness		-.416	.187
	Kurtosis		.526	.373
*Total AIMS Score	Mean		22.71	.264
	95% Confidence Interval for Mean	Lower Bound	22.18	
		Upper Bound	23.23	
	5% Trimmed Mean		22.51	
	Median		22.00	
	Variance		11.842	
	Std. Deviation		3.441	
	Minimum		17	
	Maximum		39	
	Range		22	
	Interquartile Range		4	
	Skewness		1.074	.186
	Kurtosis		2.516	.370

*Total Self Perception	Mean		23.9762	.47025
	95% Confidence Interval for Mean	Lower Bound	23.0455	
		Upper Bound	24.9069	
	5% Trimmed Mean		23.9559	
	Median		24.0000	
	Variance		27.863	
	Std. Deviation		5.27858	
	Minimum		12.00	
	Maximum		36.00	
	Range		24.00	
	Interquartile Range		8.00	
	Skewness		.040	.216
	Kurtosis		-.456	.428
*Total Self Description Score	Mean		4.5262	.12025
	95% Confidence Interval for Mean	Lower Bound	4.2837	
		Upper Bound	4.7687	
	5% Trimmed Mean		4.5404	
	Median		4.4615	
	Variance		.636	
	Std. Deviation		.79768	
	Minimum		2.62	
	Maximum		6.00	
	Range		3.38	
	Interquartile Range		1.00	
	Skewness		-.121	.357
	Kurtosis		-.323	.702

*Total PA Levels Score	Mean		3.9912	.07360
	95% Confidence Interval for Mean	Lower Bound	3.8459	
		Upper Bound	4.1365	
	5% Trimmed Mean		3.9771	
	Median		4.0000	
	Variance		.921	
	Std. Deviation		.95962	
	Minimum		1.67	
	Maximum		6.33	
	Range		4.67	
	Interquartile Range		1.33	
	Skewness		.235	.186
	Kurtosis		-.242	.370
*Total Sports Played	Mean		3.31	.121
	95% Confidence Interval for Mean	Lower Bound	3.07	
		Upper Bound	3.55	
	5% Trimmed Mean		3.25	
	Median		3.00	
	Variance		2.509	
	Std. Deviation		1.584	
	Minimum		1	
	Maximum		8	
	Range		7	
	Interquartile Range		2	
	Skewness		.398	.186
	Kurtosis		-.404	.370

*Total PA Enjoyment Score	Mean		8.07	.119
	95% Confidence Interval for Mean	Lower Bound	7.84	
		Upper Bound	8.31	
	5% Trimmed Mean		8.16	
	Median		8.28	
	Variance		2.367	
	Std. Deviation		1.539	
	Minimum		4	
	Maximum		11	
	Range		7	
	Interquartile Range		2	
	Skewness		-.589	.187
	Kurtosis		-.352	.373

Appendix 15: Descriptive Statistics for Year 4

			Statistic	Std. Error
*Force Relative to BW	Mean		24.6950	.20022
	95% Confidence Interval for Mean	Lower Bound	24.3006	
		Upper Bound	25.0894	
	5% Trimmed Mean		24.7777	
	Median		24.6355	
	Variance		9.982	
	Std. Deviation		3.15949	
	Minimum		13.07	
	Maximum		32.73	
	Range		19.66	
	Interquartile Range		4.30	
	Skewness		-.438	.154
	Kurtosis		.739	.307
*Total AIMS Score	Mean		23.53	.234
	95% Confidence Interval for Mean	Lower Bound	23.07	
		Upper Bound	23.99	
	5% Trimmed Mean		23.35	
	Median		23.00	
	Variance		14.062	
	Std. Deviation		3.750	
	Minimum		16	
	Maximum		35	
	Range		19	
	Interquartile Range		5	
	Skewness		.672	.152
	Kurtosis		.356	.303

*Total PA Levels Score	Mean		4.2733	.06939
	95% Confidence Interval for Mean	Lower Bound	4.1367	
		Upper Bound	4.4100	
	5% Trimmed Mean		4.2843	
	Median		4.3333	
	Variance		1.233	
	Std. Deviation		1.11028	
	Minimum		1.17	
	Maximum		6.33	
	Range		5.17	
	Interquartile Range		1.63	
	Skewness		-.085	.152
	Kurtosis		-.418	.303
*Total Sports Played	Mean		3.26	.109
	95% Confidence Interval for Mean	Lower Bound	3.05	
		Upper Bound	3.48	
	5% Trimmed Mean		3.19	
	Median		3.00	
	Variance		3.041	
	Std. Deviation		1.744	
	Minimum		0	
	Maximum		9	
	Range		9	
	Interquartile Range		2	
	Skewness		.509	.152
	Kurtosis		-.031	.303

*Total Self Perception	Mean		20.3587	.76067
	95% Confidence Interval for Mean	Lower Bound	18.8597	
		Upper Bound	21.8578	
	5% Trimmed Mean		20.6771	
	Median		23.0000	
	Variance		129.033	
	Std. Deviation		11.35926	
	Minimum		.00	
	Maximum		36.00	
	Range		36.00	
	Interquartile Range		12.00	
	Skewness		-.855	.163
	Kurtosis		-.532	.324
*Total Self Description Score	Mean		3.9883	.18997
	95% Confidence Interval for Mean	Lower Bound	3.6014	
		Upper Bound	4.3753	
	5% Trimmed Mean		3.9978	
	Median		3.7692	
	Variance		1.191	
	Std. Deviation		1.09127	
	Minimum		1.23	
	Maximum		6.00	
	Range		4.77	
	Interquartile Range		1.81	
	Skewness		.091	.409
	Kurtosis		-.085	.798

*Total PA Enjoyment Score	Mean		8.10	.099
	95% Confidence Interval for Mean	Lower Bound	7.90	
		Upper Bound	8.29	
	5% Trimmed Mean		8.16	
	Median		8.33	
	Variance		1.721	
	Std. Deviation		1.312	
	Minimum		4	
	Maximum		10	
	Range		6	
	Interquartile Range		2	
	Skewness		-.663	.183
	Kurtosis		.110	.364

Appendix 16: Descriptive Statistics for Year 5

			Statistic	Std. Error
*Force Relative to BW	Mean		24.9732	.29113
	95% Confidence Interval for Mean	Lower Bound	24.3976	
		Upper Bound	25.5489	
	5% Trimmed Mean		24.8877	
	Median		24.9048	
	Variance		11.781	
	Std. Deviation		3.43235	
	Minimum		16.62	
	Maximum		35.47	
	Range		18.85	
	Interquartile Range		4.77	
	Skewness		.286	.206
	Kurtosis		.079	.408
*Total AIMS Score	Mean		24.50	.377
	95% Confidence Interval for Mean	Lower Bound	23.75	
		Upper Bound	25.25	
	5% Trimmed Mean		24.14	
	Median		24.00	
	Variance		20.181	
	Std. Deviation		4.492	
	Minimum		17	
	Maximum		42	
	Range		25	
	Interquartile Range		4	
	Skewness		1.417	.203
	Kurtosis		3.033	.404

*Total Self Perception	Mean		25.9459	.46426
	95% Confidence Interval for Mean	Lower Bound	25.0259	
		Upper Bound	26.8660	
	5% Trimmed Mean		25.9745	
	Median		26.0000	
	Variance		23.924	
	Std. Deviation		4.89125	
	Minimum		15.00	
	Maximum		36.00	
	Range		21.00	
	Interquartile Range		6.00	
	Skewness		-.059	.229
	Kurtosis		-.526	.455
*Total Self Description Score	Mean		4.1811	.16306
	95% Confidence Interval for Mean	Lower Bound	3.8481	
		Upper Bound	4.5142	
	5% Trimmed Mean		4.1809	
	Median		4.1538	
	Variance		.824	
	Std. Deviation		.90790	
	Minimum		2.23	
	Maximum		6.00	
	Range		3.77	
	Interquartile Range		1.46	
	Skewness		.130	.421
	Kurtosis		-.565	.821

*Total PA Levels Score	Mean		4.0141	.08266
	95% Confidence Interval for Mean	Lower Bound	3.8507	
		Upper Bound	4.1775	
	5% Trimmed Mean		4.0168	
	Median		4.1667	
	Variance		.970	
	Std. Deviation		.98501	
	Minimum		1.67	
	Maximum		6.33	
	Range		4.67	
	Interquartile Range		1.33	
	Skewness		-.067	.203
	Kurtosis		-.289	.404
*Total Sports Played	Mean		3.41	.138
	95% Confidence Interval for Mean	Lower Bound	3.14	
		Upper Bound	3.68	
	5% Trimmed Mean		3.34	
	Median		3.00	
	Variance		2.697	
	Std. Deviation		1.642	
	Minimum		0	
	Maximum		8	
	Range		8	
	Interquartile Range		2	
	Skewness		.520	.203
	Kurtosis		-.123	.404

*Total PA Enjoyment Score	Mean		8.06	.115
	95% Confidence Interval for Mean	Lower Bound	7.83	
		Upper Bound	8.29	
	5% Trimmed Mean		8.10	
	Median		8.22	
	Variance		1.840	
	Std. Deviation		1.357	
	Minimum		5	
	Maximum		10	
	Range		5	
	Interquartile Range		2	
	Skewness		-.354	.206
	Kurtosis		-.868	.408

Appendix 17: Descriptive Statistics for Year 6

			Statistic	Std. Error
*Force Relative to BW	Mean		24.8731	.27384
	95% Confidence Interval for Mean	Lower Bound	24.3313	
		Upper Bound	25.4148	
	5% Trimmed Mean		24.8838	
	Median		24.7750	
	Variance		9.898	
	Std. Deviation		3.14616	
	Minimum		18.10	
	Maximum		32.10	
	Range		14.00	
	Interquartile Range		4.93	
	Skewness		.024	.211
	Kurtosis		-.659	.419
*Total AIMS Score	Mean		25.14	.384
	95% Confidence Interval for Mean	Lower Bound	24.38	
		Upper Bound	25.90	
	5% Trimmed Mean		24.84	
	Median		25.00	
	Variance		19.462	
	Std. Deviation		4.412	
	Minimum		18	
	Maximum		39	
	Range		21	
	Interquartile Range		5	
	Skewness		1.006	.211
	Kurtosis		1.433	.419

*Total Self Perception	Mean		26.0222	.49793
	95% Confidence Interval for Mean	Lower Bound	25.0328	
		Upper Bound	27.0116	
	5% Trimmed Mean		26.0370	
	Median		26.0000	
	Variance		22.314	
	Std. Deviation		4.72378	
	Minimum		13.00	
	Maximum		36.00	
	Range		23.00	
	Interquartile Range		6.00	
	Skewness		-.174	.254
	Kurtosis		-.152	.503
*Total Self Description Score	Mean		4.5037	.10698
	95% Confidence Interval for Mean	Lower Bound	4.2876	
		Upper Bound	4.7197	
	5% Trimmed Mean		4.5204	
	Median		4.4615	
	Variance		.481	
	Std. Deviation		.69329	
	Minimum		3.15	
	Maximum		5.54	
	Range		2.38	
	Interquartile Range		1.23	
	Skewness		-.206	.365
	Kurtosis		-.944	.717

*Total PA Levels Score	Mean		3.9293	.08671
	95% Confidence Interval for Mean	Lower Bound	3.7578	
		Upper Bound	4.1008	
	5% Trimmed Mean		3.9293	
	Median		3.8333	
	Variance		.992	
	Std. Deviation		.99620	
	Minimum		1.00	
	Maximum		6.17	
	Range		5.17	
	Interquartile Range		1.46	
	Skewness		-.030	.211
	Kurtosis		-.371	.419
*Total Sports Played	Mean		3.39	.161
	95% Confidence Interval for Mean	Lower Bound	3.07	
		Upper Bound	3.70	
	5% Trimmed Mean		3.25	
	Median		3.00	
	Variance		3.414	
	Std. Deviation		1.848	
	Minimum		1	
	Maximum		10	
	Range		9	
	Interquartile Range		2	
	Skewness		.913	.211
	Kurtosis		1.492	.419

*Total PA Enjoyment Score	Mean		7.79	.139
	95% Confidence Interval for Mean	Lower Bound	7.52	
		Upper Bound	8.07	
	5% Trimmed Mean		7.87	
	Median		8.11	
	Variance		2.540	
	Std. Deviation		1.594	
	Minimum		4	
	Maximum		10	
	Range		6	
	Interquartile Range		2	
	Skewness		-.483	.211
	Kurtosis		-.675	.419

Appendix 18: Descriptive Statistics Females

Descriptives

			Statistic	Std. Error
*Force Relative to BW	Mean		24.3990	.17124
	95% Confidence Interval for Mean	Lower Bound	24.0623	
		Upper Bound	24.7358	
	5% Trimmed Mean		24.4354	
	Median		24.3200	
	Variance		10.967	
	Std. Deviation		3.31165	
	Minimum		13.07	
	Maximum		35.47	
	Range		22.40	
	Interquartile Range		4.35	
	Skewness		-.143	.126
	Kurtosis		.542	.252

Descriptives

			Statistic	Std. Error
*Total AIMS Score	Mean		23.98	.204
	95% Confidence Interval for Mean	Lower Bound	23.58	
		Upper Bound	24.38	
	5% Trimmed Mean		23.70	
	Median		23.50	
	Variance		15.778	
	Std. Deviation		3.972	
	Minimum		16	
	Maximum		42	
	Range		26	
	Interquartile Range		5	
	Skewness		1.266	.125
	Kurtosis		2.808	.250

Descriptives

			Statistic	Std. Error
*Total Self Perception	Mean		23.8829	.44189
	95% Confidence Interval for Mean	Lower Bound	23.0133	
		Upper Bound	24.7526	
	5% Trimmed Mean		24.5734	
	Median		25.0000	
	Variance		58.386	
	Std. Deviation		7.64105	
	Minimum		.00	
	Maximum		36.00	
	Range		36.00	
	Interquartile Range		7.00	
	Skewness		-1.521	.141
	Kurtosis		3.093	.281

Descriptives

			Statistic	Std. Error
*Total Sports Played	Mean		3.29	.085
	95% Confidence Interval for Mean	Lower Bound	3.12	
		Upper Bound	3.45	
	5% Trimmed Mean		3.21	
	Median		3.00	
	Variance		2.759	
	Std. Deviation		1.661	
	Minimum		0	
	Maximum		10	
	Range		10	
	Interquartile Range		2	
	Skewness		.586	.125
	Kurtosis		.786	.250

Descriptives

			Statistic	Std. Error
*Total PA Enjoyment Score	Mean		7.86	.078
	95% Confidence Interval for Mean	Lower Bound	7.71	
		Upper Bound	8.01	
	5% Trimmed Mean		7.92	
	Median		8.00	
	Variance		2.109	
	Std. Deviation		1.452	
	Minimum		4	
	Maximum		11	
	Range		7	
	Interquartile Range		2	
	Skewness		-.421	.131
	Kurtosis		-.544	.262

Descriptives

			Statistic	Std. Error
*Total PA Levels Score	Mean		3.8934	.05002
	95% Confidence Interval for Mean	Lower Bound	3.7951	
		Upper Bound	3.9918	
	5% Trimmed Mean		3.8767	
	Median		3.8333	
	Variance		.951	
	Std. Deviation		.97497	
	Minimum		1.67	
	Maximum		6.33	
	Range		4.67	
	Interquartile Range		1.33	
	Skewness		.247	.125
	Kurtosis		-.286	.250

Descriptives

			Statistic	Std. Error
*Total Self Description Score	Mean		4.2441	.09754
	95% Confidence Interval for Mean	Lower Bound	4.0499	
		Upper Bound	4.4382	
	5% Trimmed Mean		4.2718	
	Median		4.2308	
	Variance		.771	
	Std. Deviation		.87788	
	Minimum		1.23	
	Maximum		5.92	
	Range		4.69	
	Interquartile Range		1.38	
	Skewness		-.368	.267
	Kurtosis		.569	.529

Appendix 19: Descriptive Statistics Males

Descriptives

			Statistic	Std. Error
*Force Relative to BW	Mean		25.6927	.17229
	95% Confidence Interval for Mean	Lower Bound	25.3537	
		Upper Bound	26.0317	
	5% Trimmed Mean		25.7092	
	Median		25.9200	
	Variance		9.321	
	Std. Deviation		3.05299	
	Minimum		17.89	
	Maximum		34.89	
	Range		17.00	
	Interquartile Range		3.87	
	Skewness		-.108	.138
	Kurtosis		-.274	.274

Descriptives

			Statistic	Std. Error
*Total AIMS Score	Mean		23.64	.232
	95% Confidence Interval for Mean	Lower Bound	23.19	
		Upper Bound	24.10	
	5% Trimmed Mean		23.39	
	Median		23.00	
	Variance		17.271	
	Std. Deviation		4.156	
	Minimum		16	
	Maximum		41	
	Range		25	
	Interquartile Range		5	
	Skewness		.944	.136
	Kurtosis		1.377	.272

Descriptives

			Statistic	Std. Error
*Total PA Enjoyment Score	Mean		8.21	.087
	95% Confidence Interval for Mean	Lower Bound	8.04	
		Upper Bound	8.39	
	5% Trimmed Mean		8.31	
	Median		8.56	
	Variance		2.035	
	Std. Deviation		1.426	
	Minimum		4	
	Maximum		10	
	Range		6	
	Interquartile Range		2	
	Skewness		-.755	.148
	Kurtosis		.020	.295

Descriptives

			Statistic	Std. Error
*Total Sports Played	Mean		3.37	.098
	95% Confidence Interval for Mean	Lower Bound	3.18	
		Upper Bound	3.56	
	5% Trimmed Mean		3.28	
	Median		3.00	
	Variance		3.081	
	Std. Deviation		1.755	
	Minimum		0	
	Maximum		9	
	Range		9	
	Interquartile Range		3	
	Skewness		.575	.136
	Kurtosis		-.182	.272

Descriptives

			Statistic	Std. Error
*Total PA Levels Score	Mean		4.3176	.05936
	95% Confidence Interval for Mean	Lower Bound	4.2008	
		Upper Bound	4.4344	
	5% Trimmed Mean		4.3367	
	Median		4.3333	
	Variance		1.128	
	Std. Deviation		1.06194	
	Minimum		1.00	
	Maximum		6.33	
	Range		5.33	
	Interquartile Range		1.50	
	Skewness		-.247	.136
	Kurtosis		-.098	.272

Descriptives

			Statistic	Std. Error
*Total Self Description Score	Mean		4.4314	.10772
	95% Confidence Interval for Mean	Lower Bound	4.2165	
		Upper Bound	4.6464	
	5% Trimmed Mean		4.4313	
	Median		4.5385	
	Variance		.801	
	Std. Deviation		.89476	
	Minimum		2.62	
	Maximum		6.00	
	Range		3.38	
	Interquartile Range		1.46	
	Skewness		-.101	.289
	Kurtosis		-.967	.570

Descriptives

			Statistic	Std. Error
*Total Self Perception	Mean		22.4781	.59889
	95% Confidence Interval for Mean	Lower Bound	21.2986	
		Upper Bound	23.6576	
	5% Trimmed Mean		23.0425	
	Median		24.0000	
	Variance		90.027	
	Std. Deviation		9.48823	
	Minimum		.00	
	Maximum		36.00	
	Range		36.00	
	Interquartile Range		10.00	
	Skewness		-1.235	.154
	Kurtosis		.943	.306

Appendix 20: Differences Between Genders

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of RELATIVE_TO_BW is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
2	The distribution of ** FMS TOTAL ** is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.187	Retain the null hypothesis.
3	The distribution of SELF_PERCEPTION_TOTAL is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.300	Retain the null hypothesis.
4	The distribution of **PHYSICAL ACTIVITY ENJOYMENT SCORE** is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.002	Reject the null hypothesis.
5	The distribution of **TOTAL SPORTS PLAYED** is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.778	Retain the null hypothesis.
6	The distribution of **PHYISCAL ACTIVITY LEVELS SCORE** is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
7	The distribution of SELF_DESCRIPTION_TOTAL is the same across categories of GENDER.	Independent-Samples Mann-Whitney U Test	.240	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Independent-Samples Mann-Whitney U Test Summary

Total N	615
Mann-Whitney U	53498.500
Wilcoxon W	90354.500
Test Statistic	53498.500
Standard Error	2186.005
Standardized Test Statistic	3.150
Asymptotic Sig.(2-sided test)	.002

Independent-Samples Mann-Whitney U Test Summary

Total N	150
Mann-Whitney U	3106.000
Wilcoxon W	5521.000
Test Statistic	3106.000
Standard Error	265.050
Standardized Test Statistic	1.175
Asymptotic Sig.(2-sided test)	.240

Independent-Samples Mann-Whitney U Test Summary

Total N	550
Mann-Whitney U	35605.000
Wilcoxon W	67231.000
Test Statistic	35605.000
Standard Error	1853.452
Standardized Test Statistic	-1.036
Asymptotic Sig.(2-sided test)	.300

Independent-Samples Mann-Whitney U Test Summary

Total N	700
Mann-Whitney U	75940.500
Wilcoxon W	127300.500
Test Statistic	75940.500
Standard Error	2661.894
Standardized Test Statistic	5.688
Asymptotic Sig.(2-sided test)	.000

Independent-Samples Mann-Whitney U Test Summary

Total N	700
Mann-Whitney U	61539.000
Wilcoxon W	112899.000
Test Statistic	61539.000
Standard Error	2622.579
Standardized Test Statistic	.282
Asymptotic Sig.(2-sided test)	.778

Independent-Samples Mann-Whitney U Test Summary

Total N	700
Mann-Whitney U	57297.500
Wilcoxon W	108657.500
Test Statistic	57297.500
Standard Error	2655.201
Standardized Test Statistic	-1.319
Asymptotic Sig.(2-sided test)	.187

Appendix 21: Difference Between Year Groups – Force x Bodyweight

Pairwise Comparisons of *School Year

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
4.00-6.00	-6.114	21.399	-.286	.775	1.000
4.00-5.00	-8.167	21.044	-.388	.698	1.000
4.00-3.00	53.173	19.844	2.680	.007	.044
6.00-5.00	2.053	24.155	.085	.932	1.000
6.00-3.00	47.059	23.117	2.036	.042	.251
5.00-3.00	45.006	22.789	1.975	.048	.290

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Appendix 22: Difference Between Year Groups – Total AIMS Score

Pairwise Comparisons of *School Year

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
3.00-4.00	-45.926	19.931	-2.304	.021	.127
3.00-5.00	-85.586	22.903	-3.737	.000	.001
3.00-6.00	-123.942	23.371	-5.303	.000	.000
4.00-5.00	-39.660	21.079	-1.881	.060	.359
4.00-6.00	-78.016	21.587	-3.614	.000	.002
5.00-6.00	-38.357	24.357	-1.575	.115	.692

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Appendix 23: Difference Between Year Groups – Self-Perception

Pairwise Comparisons of *School Year

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
4.00-3.00	15.999	17.683	.905	.366	1.000
4.00-5.00	-68.526	18.431	-3.718	.000	.001
4.00-6.00	-72.337	19.815	-3.651	.000	.002
3.00-5.00	-52.527	20.655	-2.543	.011	.066
3.00-6.00	-56.339	21.898	-2.573	.010	.061
5.00-6.00	-3.812	22.506	-.169	.866	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Appendix 24: Difference Between Year Groups – Physical Activity Engagement

Pairwise Comparisons of *School Year

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
6.00-3.00	8.092	23.430	.345	.730	1.000
6.00-5.00	17.446	24.418	.714	.475	1.000
6.00-4.00	63.396	21.641	2.929	.003	.020
3.00-5.00	-9.354	22.961	-.407	.684	1.000
3.00-4.00	-55.304	19.982	-2.768	.006	.034
5.00-4.00	45.950	21.132	2.174	.030	.178

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Appendix 25: Coefficient Table Females

activate

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.287**	.150*	.138*	.101	.123*	.142
		Sig. (2-tailed)	.	.000	.010	.010	.051	.017	.206
		N	374	374	293	344	374	374	81
	*Total AIMS Score	Correlation Coefficient	.287**	1.000	.454**	.134*	.226**	.138**	.310**
		Sig. (2-tailed)	.000	.	.000	.013	.000	.007	.005
		N	374	380	299	344	380	380	81
	*Total Self Perception	Correlation Coefficient	.150*	.454**	1.000	.144*	.170**	.039	.
		Sig. (2-tailed)	.010	.000	.	.020	.003	.496	.
		N	293	299	299	263	299	299	0
	*Total PA Enjoyment Score	Correlation Coefficient	.138*	.134*	.144*	1.000	.155**	.330**	.412**
		Sig. (2-tailed)	.010	.013	.020	.	.004	.000	.000
		N	344	344	263	344	344	344	81
	*Total Sports Played	Correlation Coefficient	.101	.226**	.170**	.155**	1.000	.326**	.430**
		Sig. (2-tailed)	.051	.000	.003	.004	.	.000	.000
		N	374	380	299	344	380	380	81
	*Total PA Levels Score	Correlation Coefficient	.123*	.138**	.039	.330**	.326**	1.000	-.041
		Sig. (2-tailed)	.017	.007	.496	.000	.000	.	.717
		N	374	380	299	344	380	380	81
	*Total Self Description Score	Correlation Coefficient	.142	.310**	.	.412**	.430**	-.041	1.000
		Sig. (2-tailed)	.206	.005	.	.000	.000	.717	.
		N	81	81	0	81	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 26: Coefficient Table Males

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.269**	.197**	.152*	.058	.109	.266*
		Sig. (2-tailed)	.	.000	.002	.013	.307	.053	.027
		N	314	314	245	271	314	314	69
	*Total AIMS Score	Correlation Coefficient	.269**	1.000	.479**	.218**	.196**	.260**	.322**
		Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.007
		N	314	320	251	271	320	320	69
	*Total Self Perception	Correlation Coefficient	.197**	.479**	1.000	.190**	.155*	.132*	.
		Sig. (2-tailed)	.002	.000	.	.007	.014	.037	.
		N	245	251	251	202	251	251	0
	*Total PA Enjoyment Score	Correlation Coefficient	.152*	.218**	.190**	1.000	.099	.304**	.459**
		Sig. (2-tailed)	.013	.000	.007	.	.103	.000	.000
		N	271	271	202	271	271	271	69
	*Total Sports Played	Correlation Coefficient	.058	.196**	.155*	.099	1.000	.263**	.209
		Sig. (2-tailed)	.307	.000	.014	.103	.	.000	.084
		N	314	320	251	271	320	320	69
	*Total PA Levels Score	Correlation Coefficient	.109	.260**	.132*	.304**	.263**	1.000	.496**
		Sig. (2-tailed)	.053	.000	.037	.000	.000	.	.000
		N	314	320	251	271	320	320	69
	*Total Self Description Score	Correlation Coefficient	.266*	.322**	.	.459**	.209	.496**	1.000
		Sig. (2-tailed)	.027	.007	.	.000	.084	.000	.
		N	69	69	0	69	69	69	69

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 27: Coefficient Table Year 3

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.244**	.084	.070	.023	-.022	.163
		Sig. (2-tailed)	.	.001	.354	.366	.765	.773	.291
		N	168	168	124	168	168	168	44
	*Total AIMS Score	Correlation Coefficient	.244**	1.000	.500**	.040	.135	.163*	.300*
		Sig. (2-tailed)	.001	.	.000	.610	.080	.034	.048
		N	168	170	126	168	170	170	44
	*Total Self Perception	Correlation Coefficient	.084	.500**	1.000	.095	.043	.069	.
		Sig. (2-tailed)	.354	.000	.	.293	.633	.445	.
		N	124	126	126	124	126	126	0
	*Total PA Enjoyment Score	Correlation Coefficient	.070	.040	.095	1.000	.104	.168*	.477**
		Sig. (2-tailed)	.366	.610	.293	.	.180	.030	.001
		N	168	168	124	168	168	168	44
	*Total Sports Played	Correlation Coefficient	.023	.135	.043	.104	1.000	.259**	.241
		Sig. (2-tailed)	.765	.080	.633	.180	.	.001	.115
		N	168	170	126	168	170	170	44
	*Total PA Levels Score	Correlation Coefficient	-.022	.163*	.069	.168*	.259**	1.000	.157
		Sig. (2-tailed)	.773	.034	.445	.030	.001	.	.309
		N	168	170	126	168	170	170	44
	*Total Self Description Score	Correlation Coefficient	.163	.300*	.	.477**	.241	.157	1.000
		Sig. (2-tailed)	.291	.048	.	.001	.115	.309	.
		N	44	44	0	44	44	44	44

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 28: Coefficient Table Year 4

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.294**	.230**	.166*	.163*	.162*	.135
		Sig. (2-tailed)	.	.000	.001	.028	.010	.010	.453
		N	249	249	216	176	249	249	33
	*Total AIMS Score	Correlation Coefficient	.294**	1.000	.433**	.165*	.269**	.141*	.300
		Sig. (2-tailed)	.000	.	.000	.028	.000	.024	.089
		N	249	256	223	176	256	256	33
	*Total Self Perception	Correlation Coefficient	.230**	.433**	1.000	.151	.173**	-.086	.
		Sig. (2-tailed)	.001	.000	.	.072	.010	.200	.
		N	216	223	223	143	223	223	0
	*Total PA Enjoyment Score	Correlation Coefficient	.166*	.165*	.151	1.000	.181*	.332**	.458**
		Sig. (2-tailed)	.028	.028	.072	.	.016	.000	.007
		N	176	176	143	176	176	176	33
	*Total Sports Played	Correlation Coefficient	.163*	.269**	.173**	.181*	1.000	.361**	.460**
		Sig. (2-tailed)	.010	.000	.010	.016	.	.000	.007
		N	249	256	223	176	256	256	33
	*Total PA Levels Score	Correlation Coefficient	.162*	.141*	-.086	.332**	.361**	1.000	.425*
		Sig. (2-tailed)	.010	.024	.200	.000	.000	.	.014
		N	249	256	223	176	256	256	33
	*Total Self Description Score	Correlation Coefficient	.135	.300	.	.458**	.460**	.425*	1.000
		Sig. (2-tailed)	.453	.089	.	.007	.007	.014	.
		N	33	33	0	33	33	33	33

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 29: Coefficient Table Year 5

activate

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.298**	.154	.199*	.078	.252**	.454*
		Sig. (2-tailed)	.	.000	.112	.019	.361	.003	.010
		N	139	139	108	139	139	139	31
	*Total AIMS Score	Correlation Coefficient	.298**	1.000	.364**	.192*	.193*	.126	.268
		Sig. (2-tailed)	.000	.	.000	.023	.022	.136	.145
		N	139	142	111	139	142	142	31
	*Total Self Perception	Correlation Coefficient	.154	.364**	1.000	.345**	.137	.396**	.
		Sig. (2-tailed)	.112	.000	.	.000	.151	.000	.
		N	108	111	111	108	111	111	0
	*Total PA Enjoyment Score	Correlation Coefficient	.199*	.192*	.345**	1.000	.095	.344**	.649**
		Sig. (2-tailed)	.019	.023	.000	.	.268	.000	.000
		N	139	139	108	139	139	139	31
	*Total Sports Played	Correlation Coefficient	.078	.193*	.137	.095	1.000	.315**	.320
		Sig. (2-tailed)	.361	.022	.151	.268	.	.000	.080
		N	139	142	111	139	142	142	31
	*Total PA Levels Score	Correlation Coefficient	.252**	.126	.396**	.344**	.315**	1.000	.224
		Sig. (2-tailed)	.003	.136	.000	.000	.000	.	.225
		N	139	142	111	139	142	142	31
	*Total Self Description Score	Correlation Coefficient	.454*	.268	.	.649**	.320	.224	1.000
		Sig. (2-tailed)	.010	.145	.	.000	.080	.225	.
		N	31	31	0	31	31	31	31

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 30: Coefficient Table Year 6

Correlations

			*Force Relative to BW	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score
Spearman's rho	*Force Relative to BW	Correlation Coefficient	1.000	.336**	.107	.279**	.045	.315**	.195
		Sig. (2-tailed)	.	.000	.314	.001	.607	.000	.216
		N	132	132	90	132	132	132	42
	*Total AIMS Score	Correlation Coefficient	.336**	1.000	.545**	.394**	.254**	.411**	.294
		Sig. (2-tailed)	.000	.	.000	.000	.003	.000	.059
		N	132	132	90	132	132	132	42
	*Total Self Perception	Correlation Coefficient	.107	.545**	1.000	.191	.254*	.270**	.
		Sig. (2-tailed)	.314	.000	.	.072	.016	.010	.
		N	90	90	90	90	90	90	0
	*Total PA Enjoyment Score	Correlation Coefficient	.279**	.394**	.191	1.000	.166	.496**	.399**
		Sig. (2-tailed)	.001	.000	.072	.	.056	.000	.009
		N	132	132	90	132	132	132	42
	*Total Sports Played	Correlation Coefficient	.045	.254**	.254*	.166	1.000	.249**	.347*
		Sig. (2-tailed)	.607	.003	.016	.056	.	.004	.024
		N	132	132	90	132	132	132	42
	*Total PA Levels Score	Correlation Coefficient	.315**	.411**	.270**	.496**	.249**	1.000	.424**
		Sig. (2-tailed)	.000	.000	.010	.000	.004	.	.005
		N	132	132	90	132	132	132	42
	*Total Self Description Score	Correlation Coefficient	.195	.294	.	.399**	.347*	.424**	1.000
		Sig. (2-tailed)	.216	.059	.	.009	.024	.005	.
		N	42	42	0	42	42	42	42

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 31: Coefficient Table Deprivation

Correlations

			*Deprivation Level	*Total AIMS Score	*Total Self Perception	*Total PA Enjoyment Score	*Total Sports Played	*Total PA Levels Score	*Total Self Description Score	*Force Relative to BW
Spearman's rho	*Deprivation Level	Correlation Coefficient	1.000	.027	-.149**	-.019	-.132**	-.028	.	-.002
		Sig. (2-tailed)	.	.480	.000	.634	.000	.459	.	.952
		N	700	700	550	615	700	700	150	688
	*Total AIMS Score	Correlation Coefficient	.027	1.000	.473**	.172**	.215**	.180**	.311**	.263**
		Sig. (2-tailed)	.480	.	.000	.000	.000	.000	.000	.000
		N	700	700	550	615	700	700	150	688
	*Total Self Perception	Correlation Coefficient	-.149**	.473**	1.000	.164**	.166**	.077	.	.161**
		Sig. (2-tailed)	.000	.000	.	.000	.000	.072	.	.000
		N	550	550	550	465	550	550	0	538
	*Total PA Enjoyment Score	Correlation Coefficient	-.019	.172**	.164**	1.000	.138**	.328**	.459**	.172**
		Sig. (2-tailed)	.634	.000	.000	.	.001	.000	.000	.000
		N	615	615	465	615	615	615	150	615
	*Total Sports Played	Correlation Coefficient	-.132**	.215**	.166**	.138**	1.000	.301**	.331**	.089*
		Sig. (2-tailed)	.000	.000	.000	.001	.	.000	.000	.020
		N	700	700	550	615	700	700	150	688
	*Total PA Levels Score	Correlation Coefficient	-.028	.180**	.077	.328**	.301**	1.000	.259**	.156**
		Sig. (2-tailed)	.459	.000	.072	.000	.000	.	.001	.000
		N	700	700	550	615	700	700	150	688
	*Total Self Description Score	Correlation Coefficient	.	.311**	.	.459**	.331**	.259**	1.000	.208*
		Sig. (2-tailed)	.	.000	.	.000	.000	.001	.	.010
		N	150	150	0	150	150	150	150	150
	*Force Relative to BW	Correlation Coefficient	-.002	.263**	.161**	.172**	.089*	.156**	.208*	1.000
		Sig. (2-tailed)	.952	.000	.000	.000	.020	.000	.010	.
		N	688	688	538	615	688	688	150	688

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			VAR00001	VAR00002	VAR00003
Spearman's rho	VAR00001	Correlation Coefficient	1.000	-.215	.129
		Sig. (2-tailed)	.	.525	.705
		N	11	11	11
	VAR00002	Correlation Coefficient	-.215	1.000	.682*
		Sig. (2-tailed)	.525	.	.021
		N	11	11	11
	VAR00003	Correlation Coefficient	.129	.682*	1.000
		Sig. (2-tailed)	.705	.021	.
		N	11	11	11

*. Correlation is significant at the 0.05 level (2-tailed).

VAR0001 = Deprivation, VAR0002 = Self-Perception, VAR0003 = Total Sports Played

Appendix 32: Differences Between Groups A+B

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	11220.000	.000	11495.000	5833.500	416.000	11108.000	7499.000
Wilcoxon W	29941.000	18915.000	30410.000	16564.500	1592.000	30023.000	23252.000
Z	-2.542	-15.858	-2.595	-3.952	-3.125	-3.075	-4.773
Asymp. Sig. (2-tailed)	.011	.000	.009	.000	.002	.002	.000

a. Grouping Variable: *Aims Percentile

Appendix 33: Differences Between Groups A+C

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	8404.000	.000	8573.500	3542.500	223.500	8540.500	6557.500
Wilcoxon W	20494.000	12561.000	21134.500	11417.500	784.500	21101.500	16853.500
Z	-3.254	-15.266	-3.529	-6.573	-3.740	-3.623	-3.764
Asymp. Sig. (2-tailed)	.001	.000	.000	.000	.000	.000	.000

a. Grouping Variable: *Aims Percentile

Appendix 34: Differences Between Groups A+D

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	8572.000	.000	10649.500	3170.500	230.000	9534.000	6960.000
Wilcoxon W	28873.000	21321.000	31970.500	17198.500	1010.000	30855.000	21495.000
Z	-6.058	-15.995	-4.317	-9.372	-4.300	-5.603	-5.068
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000

a. Grouping Variable: *Aims Percentile

Appendix 35: Differences Between Groups B+C

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	13939.000	.000	14002.000	6651.000	735.000	14620.500	11868.000
Wilcoxon W	26029.000	12561.000	26563.000	14526.000	1296.000	27181.500	27621.000
Z	-1.092	-16.495	-1.396	-3.856	-.548	-.757	-.958
Asymp. Sig. (2-tailed)	.275	.000	.163	.000	.583	.449	.338

a. Grouping Variable: *Aims Percentile

Appendix 36: Differences Between Groups B+D

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	14672.000	.000	17616.000	5804.500	822.500	16386.000	14595.500
Wilcoxon W	34973.000	21321.000	38937.000	19832.500	1602.500	37707.000	29130.500
Z	-4.181	-17.495	-2.050	-8.011	-.969	-3.168	-.481
Asymp. Sig. (2-tailed)	.000	.000	.040	.000	.332	.002	.630

a. Grouping Variable: *Aims Percentile

Appendix 37: Differences Between Groups C+D

Test Statistics[a]

	*Force Relative to BW	*Total AIMS Score	*Total PA Levels Score	*Total Self Perception	*Total Self Description Score	*Total Sports Played	*Total PA Enjoyment Score
Mann-Whitney U	12956.500	.000	15702.000	6972.000	605.500	13928.000	11049.500
Wilcoxon W	33257.500	21321.000	37023.000	21000.000	1385.500	35249.000	25584.500
Z	-2.722	-16.640	-.576	-4.864	-.430	-2.406	-1.387
Asymp. Sig. (2-tailed)	.006	.000	.565	.000	.667	.016	.165

a. Grouping Variable: *Aims Percentile

Appendix 38: Participant Information Sheet

HARTPURY

PARTICIPANT INFORMATION SHEET

Project Title:
Get Gloucestershire Going: Improving physical activity and movement skill competency in Gloucestershire's key stage two children. An inquiry, an insight and an intervention

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

1. Invitation Paragraph

You have been invited to take part in a focus group to discuss the feasibility and potential barriers to implementing a physical activity intervention in primary school classrooms.

2. What is the purpose of the study?

The purpose of the study is to work collaboratively with teachers in order to design an effective and sustainable intervention that increases levels of physical activity throughout the school day. The data collected will be used to help children become healthier and involved in physical activity in the future.

3. Why have I been chosen?

You have been chosen because you work with key stage two pupils from a Gloucestershire primary school. If you need any more information about the study, then please contact any member of the team on the details written above.

4. What will happen if I take part?

If you chose to take part in the study, you will be involved in an informal discussion with your fellow colleagues to discuss the potential barriers and limitations of implementing a physical activity intervention in your school. The session will be facilitated by one researcher, who will encourage you to share your honest ideas and opinions.

5. What are the benefits, or potential disadvantages to taking part?

This project aims to inform a larger year-long movement and physical activity intervention. There is often a disconnect between research and real-word settings. These focus groups intend to bridge the gap by involving teachers as much possible in the design and implementation of the intervention. Therefore, your participation is a chance for you to convey your thoughts, opinions and possible concerns.

6. Will my taking part in the study be kept confidential?
Yes. All data will be anonymised and stored on a secure university laptop. Upon transcription any identifiable information, such as names, will be changed to ensure anonymity. The data obtained will only be looked at by responsible individuals of the research team from Hartpury University Centre and will be stored in accordance with the Data Protection Act 2018.

7. What if I have any questions?
If you have any questions about what I have written above or anything to do with the study, please don't hesitate to contact me or anyone from the research team as detailed above. If after the study you are concerned about how any aspect of the research was conducted please contact Alice Cline (alice.cline@hartpury.ac.uk).

Appendix 39: Site Permission Form

Nam: Alice Cline
Email: alice.cline@hartpury.ac.uk

Site permission form:

To whom it may concern,

I __________________________, in my capacity as manager/owner of

____ grant permission for Alice

Cline to conduct research looking at childhood physical activity at my establishment on ________________.

I understand what the project involves and will facilitate work which will be presented as a PhD thesis, with aims to publish in an appropriate journal. I also understand that a paper and electronic copy will be kept at Hartpury University.

Yours sincerely,

Signature of manager/owner____

Location/facility____

Please print name/s: ____

Date: ____

HARTPURY

PARTICIPANT CONSENT FORM

Project Title:
Get Gloucestershire Going: Improving physical activity and movement skill competency in Gloucestershire's key stage two children. An inquiry, an insight and an intervention

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

Please initial box

I can confirm that I have read and understood the information sheet provided and have had the opportunity to ask questions. ☐

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason without any consequence. ☐

I understand that sections of the data obtained may be looked at by responsible persons from Hartpury University. I give permission for these individuals to have access to these records. ☐

I am happy for the data collected in this study to be used in future health related studies where data collected will be linked to health outcomes. ☐

____
Name

____
Signature

____
Date

Appendix 41: Interview Questions

- Introduction to who I am
- Why I am conducting the focus group
- Signing of participant consent forms
- Agreement to have the group recorded
- Thank you for participating

Tell me about physical activity in your school?

What do you do?
How much do you do?
How frequently do you do it?
Who delivers it?

Can you tell me about the current levels of physical activity during school time?

Breaktime?
Lunchtime?
Throughout the school day, during lessons?

Are there things related to physical activity that you would like to see changed in school?

If so, what are they?
Why is that?
How would you like them to change?
What kinds of things would you like to see happen?

Previous interventions have implemented movement into lessons through:

- Physically active learning
- Physical activity breaks
- Physical activity breaks related to learning content

What are your thoughts on implementing something similar in your school?

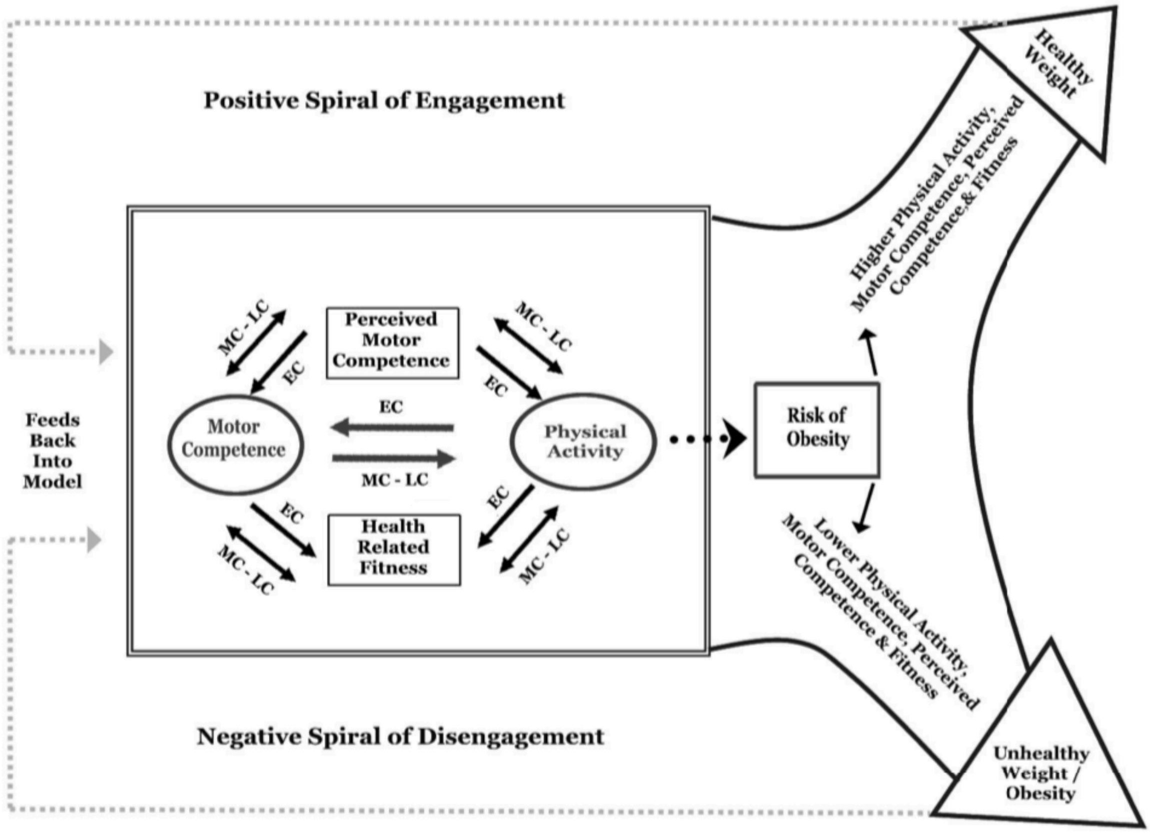
Can you think of any considerations that would be needed?
What do you think would prevent something like this from happening?
Can you think of anything that may help to encourage it?

Appendix 42: Thematic Analysis Table

Core Theme	Sub-Theme	Initial Code	Example of Raw Data
Capability	Physical Capability	Physical Activity Engagement	"I think it goes without saying really that the kids who are good are sports would be happier to do more physical activity inside the classroom, they enjoy being active because they know they can do it you know." - Alex, Focus Group 3
		Physical Activity Enjoyment	"It's clear the children who really enjoy it are the ones who are more likely to be doing it [Layla: Yeah they're always first to volunteer] it sounds obvious but if they like physical activity in the first place it's not hard to get them engaged" – Harriet, Focus Group 2
		Competition	I think competition can, well especially for our kids, put them off if they think they aren't very good at something." – Chloe, Focus Group 3.
	Psychological Capability	Teachers Confidence	If they [colleagues] feel a bit more confident with teaching different physical activity tasks they might be more likely to do them [Sarah: Yeah, no one likes teaching things they aren't confident on] more often – Jenny, Focus Group 5
		Teachers Fear	I think it's the getting it wrong isn't it and potentially if you have a child and they do something wrong and they hurt themselves you're in trouble… There is definitely that sort of fear – Vicky, Focus Group 1
		Teachers Knowledge	[talking about implementing more physical activity inside the classroom] I think realistically if the staff know what they are supposed to be doing, they know how to do it and they know why they are doing it it's much more likely to actually happen – Emily, Focus Group 1
Motivation	Automatic Motivation	Competition	"It would be good to compare classes, you know see how everyone has done, that would remind us to do it and help get everyone involved [pause] you know like a class competition" – Max, Focus Group 4.

	Reflective Motivation	Choice	"I think being flexible and giving teachers choice is a lot better than having the pressure of being told you must do it Monday, Wednesday and Friday. You know if you're giving someone choice they're probably going to be more motivated to do it" – Tom, Focus Group 3.
Opportunity	Physical Opportunity	Resources	"Resources for ideas are really important I think [pause] because it's all well and good saying do something or shall we do something but having a bank or collection of resources… something for the children to follow would be good" – John, Focus Group 1
		Space	"I'm just thinking of the class below mine, even tucking our chairs in, it makes such a loud noise for them so I'm thinking if we are stomping upstairs, it would create such a racket down here. So, I was thinking especially for space you know with the tables if we are trying to do something because we haven't really got loads of room" – Emily, Focus Group 1
		Time	"I think it's coming up with something that doesn't add too much to an already busy workload, you know I don't want to make their jobs even harder when everyone is pushed for time and feeling pressured about a busy day as it is" – Chloe, Focus Group 3
	Social Opportunity	Whole-School Approach	"I think it's something that would need the whole school on-board. You can't just have a few teachers trying to get everyone active, it's got to be everyone" – Shaun, Focus Group 4.
		Classroom Behaviour Management	"To be honest with you, I think you worry about the energy levels going through the roof and you not being able to be get it under control again and if it's that's happening everyday [pause] well, people just aren't going to do it" – Sarah, Focus Group 5.

Appendix 43: The developmental mechanisms influencing physical activity trajectories of children taken from Stodden *et al* (2008)



Appendix 44: Selecting the Target Behaviour

Potential target behaviours	Impact of behaviour change	Likelihood of Behaviour Change	Likelihood of Positively/Negatively Changing Other Behaviours	Measurement Feasibility
Unacceptable, unpromising but worth considering, promising, very promising				
Encouraging families to be more active over the weekend	Promising	Unpromising due to a lack of physical opportunity and physical/ psychological capability for parents	Promising	Unpromising due to feasibility of collecting physical activity data for children over weekend
Implementing a physical activity club before or after school	Unpromising due to a large majority of schools already implementing sport related after school clubs	Unpromising due to physical and social opportunity but worth considering	Promising	Promising
Encouraging more physical activity throughout the school day	Promising	Promising; although implantation would strong depend on teacher's motivation, capability and opportunity	Promising; however, care would need to be taken to avoid taking up time to teach core reading, writing and numeracy skills	Promising
Enabling children greater access to more sports clubs and/or facilities	Unpromising due to children being reliant on their parents physical and psychological capability to access resources	Unpromising for a project of this scale due to policy changes being required	Promising	Unpromising due to difficulty in recording current and future access and/or usability

Appendix 45: Linking COM-B Components to Intervention Functions

COM-B	**Intervention Functions**
Influencing Capability	
Knowledge	**Educate** about ways of enacting the desired behaviour or avoiding the undesired one
Skill	**Train** in cognitive, physical or social skills required for the desired behaviour or avoid the undesired one
Strength	**Train** or **enable** development of mental or physical strength required for the desired behaviour or to resist the undesired one
Stamina/Endurance	**Train** or **enable** endurance required for desired behaviour or sustained resistance to undesired one
Influencing Opportunity	
Time	**Train** or **restructure the environment** to reduce time demand or competing time demands for desired behaviour (and additionally use **restriction** to reduce undesired behaviour)
Resources	**Restructure the environment** to increase social support and cultural norms for desired behaviour (and additionally use **restriction** to reduce undesired behaviour)
Location/Physical Barriers	**Train** or **restructure the environment** to provide cues and prompts for desired behaviour (and converse for undesired behaviour)
Interpersonal Influences/ Cultural Expectations	**Restructure the social environment** or use **modelling** to shape people's ways of thinking
Influencing Motivation	
Plans	**Education, train** to form clearer personal rules/action plans, and train to remember and apply rules when needed
Evaluations	**Educate** or **persuade** to create more positive beliefs about desired, and negative ones about undesired, behaviours
Motives	**Persuade, incentivise, coerce, model** or **enable** to feel positively about the desired behaviour and negatively about the undesired one
Impulses/Inhibition	**Train** or **enable** to strengthen habitual engagement in the desired behaviour or weaken the undesired one
Responses	**Model** desired behaviour to induce automatic imitation

Appendix 46: Matrix of links between COM-B and intervention functions (Mitchie *et al* 2011)

Com-B Components	Intervention Function								
	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental Restructuring	Modelling	Enablement
Physical Capability					■				■
Psychological Capability	■				■				■
Physical Opportunity					■	■	■		■
Social Opportunity						■	■	■	■
Automatic Motivation		■	■	■	■		■	■	■
Reflective Motivation	■	■	■	■					

Appendix 47: Content and mechanisms of change of the selected BCTs in related to intervention functions and COM-B model

			Capability				Opportunity		Motivation				
			Physical	Psychological			Social	Physical	Reflective				Auto-matic
BCT	Function	Description	Skills	Knowledge	Memory, Attention and Decision	Behavioural Regulation	Social Influence	Environmental Context and Resources	Beliefs about Capabilities	Beliefs about Consequences	Professional Role and Identity	Optimism	Goals
Information on health consequences	Education Persuasion	Explaining the importance of physical activity and benefits to reducing sedentary behaviour		■						■	■		
Feedback on behaviour	Education Persuasion Incentivisation Training	Teachers to provide feedback on the children's behaviour, researcher to provide feedback on teacher's implementation				■			■	■			
Feedback on outcomes of behaviour	Education Persuasion Incentivisation Training	Research to share the results of the intervention with teaching staff once the intervention is complete		■					■			■	■
Prompts/Cues	Education Environmental Restructuring	Make use of posters, stickers and charts to help remind children and teachers			■	■		■					■
Self-monitoring of behaviour/ outcomes	Education Environmental Restructuring Enablement	Children and teaching staff to record how many physical activiy breaks they are completing each week			■	■		■					■
Verbal persuasion of capability	Persuasion	Reassurance to teachers that they are capable of implementing PA breaks							■		■	■	

Social comparison	Persuasion Modelling	Sharing examples of previous research and other schools and introducing leader boards		■		■	■		■		■	■	
Monitoring of behaviour by others	Incentive	Researcher to observe physical activity breaks and monitor frequency per class				■	■			■	■		
Monitoring of outcomes by others	Incentive	Research and teaching staff to monitor observable changes (health and educational)				■	■			■	■		
Rewarding completion	Incentive	Rewards for classes who have done the most and most improved mover of the week				■	■	■					■
Demonstration of behaviour	Training	Provide and demonstrate examples of exercises that will be performed in the classroom	■	■					■				
Instruction on how to perform behaviour	Training Education	Training with teachers on how to safely implement PA breaks, how to start/end each session	■	■					■				
Behavioural practice/rehearsal	Training	Prompt teachers to practice implementation at different times to find what works			■	■		■					
Habit formation	Training	Encourage teachers to form a habit so it becomes an established routine			■	■		■	■				
Graded tasks	Training	Set each year group weekly challenges that get progressively harder	■						■				■
Adding objects to the environment	Environmental Restructuring	Make use of stickers, charts, posters and activity trackers to help prompt children/teachers			■	■		■					■
Social support	Enablement	Encourage whole school approach lead by headteachers and PE leads					■		■	■	■	■	
Goal setting	Enablement	Agreeing with teaching staff on time/frequency/duration of physical activity breaks			■	■						■	■

Action planning	Enablement	Prompt teachers to include PA breaks as part of their lesson planning on a weekly basis											
Problem solving	Enablement	Identifying possible barriers to implementation and collaboratively finding solutions											
Reducing negative emotions	Enablement	Reassurance and guidance for if/when children are disruptive or being silly during PA break											
Reviewing behavioural/outcome goals	Enablement	Evaluating how the children have responded to the intervention via testing											

Appendix 48: Finalised structure and content of proposed intervention "Busy Brain Breaks"

Behaviour Change Technique	Behaviour Change Taxonomy	Function	Theoretical Construct	COM-B Component(s)
Teacher Training Prior to Intervention:				
1. Provide information on the importance of childhood physical activity, movement skill competency and sedentary behaviour to teachers	Natural Consequence	Education; Persuasion	Knowledge; Beliefs about Consequences	Psychological Capability; Reflective Motivation
2. Instruction on how to perform/implement physical activity breaks into lesson time throughout the school day	Shaping Knowledge	Training	Skills; Knowledge; Memory, Attention and Decision Making	Psychological Capability
Demonstration on how to introduce, coach and finish a movement break	Comparison of Behaviour	Training	Skills; Knowledge	Psychological Capability; Physical Capability
4. Behavioural practice/rehearsal of implementing a movement break with fellow teachers	Repetition and Substitution	Training	Skills; Knowledge; Memory, Attention and Decision Making	Physical Capability; Psychological Capability; Reflective Motivation
5. Social comparison with other schools who have successfully implemented physical activity during lesson time	Social Comparison	Persuasion; Modelling	Social Influences; Professional Role and Identity	Social Opportunity; Reflective Motivation
6. Problem solving through addressing any concerns the teaching staff have and finding solutions	Goals and Planning	Enablement	Skills; Knowledge; Memory, Attention and Decision Making	Psychological Capability; Reflective Motivation
7. Encouraging planning of implementing movement breaks into	Goals and Planning	Enablement	Skills; Knowledge; Memory, Attention and	Psychological Capability; Reflective Motivation

lessons (time, frequency, intensity)			Decision Making	
8. Goal setting (behaviour) to implement 3 x 5 minute movement break into lesson time per day	Goals and Planning	Enablement	Behavioural Regulation; Goals	Automatic Motivation
9. Goal setting (outcome) to improve physical activity levels and movement skill competency	Goals and Planning	Enablement	Behavioural Regulation; Goals	Automatic Motivation
10. Reducing negative emotions by talking with teachers and addressing barriers such as time constraints, work loads and space constraints	Regulation	Enablement	Optimism	Reflective Motivation
11. Verbal persuasion about capability by reassuring teachers they are capable and now have enough knowledge / the right skills to implement the activity breaks	Self-Belief	Persuasion	Beliefs about capabilities; Optimism	Reflective Motivation
12. Framing/Reframing by encouraging teachers to think of it as a tool to refocus children during lesson time and improve concentration and time on task behaviour	Identity	Persuasion; Enablement	Beliefs about capabilities; Optimism	Reflective Motivation
13. Identification as role model by suggesting the more teachers promote physical activity the more likely children are to engage in it	Identity	Persuasion; Enablement; Education	Beliefs about capabilities; Optimism	Reflective Motivation
During the Intervention:				

14. Teachers and children complete graded tasks that encourage various movement patterns that get progressively harder as time goes on	Repetition and Substitution	Training	Memory, Attention and Decision Making; Behavioural Regulation; Professional Role and Identity; Goals	Psychological Capability; Social Opportunity; Reflective Motivation
15. Prompts/Cues to help encourage movement breaks during lesson time; stickers around the classroom, activity tracker or chart	Association	Education; Environment Restructure	Memory, Attention and Decision Making; Behaviour Regulation; Environmental Context and Resources	Psychological Capability; Automatic Motivation; Physical Opportunity
16. Habit formation to encourage regular implementation of movement breaks inside the classroom	Association	Training	Memory, Attention and Decision Making; Behaviour Regulation	Psychological Capability
17. Self-monitoring of behaviour by asking teachers to record their daily/weekly physical activity levels	Feedback and Monitoring	Education Incentive Training Enablement	Behaviour Regulation	Psychological Capability; Reflective Motivation
18. Self-monitoring of outcomes by asking teachers to record how the children are doing and identify children who may need extra help	Feedback and Monitoring	Education Incentive Training Enablement	Behaviour Regulation	Psychological Capability; Reflective Motivation
19. Identify a material/social incentive or reward agreed by the school to encourage and reward either individuals or classes for achieving daily/weekly goals	Reward and Threat	Incentive	Behavioural Regulation; Social Influences; Goals	Psychological Capability; Social Opportunity; Automatic Reflection

20. Restructuring the physical/social environment by making sure the school timetable accommodates for 15 minutes of physical activity during lesson time, encouraging positive norms and values towards physical activity	Antecedents	Enablement	Social influences; Environmental Context and Resources	Physical Capability; Psychological Capability; Physical Opportunity; Social Opportunity;
21. Encouraging body changes such as improved movement and physical activity levels to encourage further physical activity through enjoyment and improved self-efficacy	Antecedents	Enablement	Skills; Beliefs about Capabilities	Physical Capability; Physical Opportunity
22. Encourage social support through leasing with researcher and encouraging senior staff members and/or PE leads to check in on other staff members and see how they are doing / if they need help	Social Support	Enablement	Behavioural Regulation; Social Influences	Social Opportunity
23. Monitoring of behaviour by others including watching a day of lessons being broken up by physical activity and giving feedback	Feedback and Monitoring	Incentive	Behavioural Regulation; Social Influences; Professional Identity	Psychological Capability; Reflective Motivation
24. Feedback on behaviour by listing positive points and possible points to work on/consider for next time if needed	Feedback and Monitoring	Incentive Education Training	Behavioural Regulation; Social Influences; Professional Identity	Psychological Capability; Reflective Motivation
After the Intervention:				

25. Reward completion by rewarding small behaviours at first, then weekly behaviours, then monthly behaviours, then term behaviours	Scheduled Consequence	Incentive	Behavioural Regulation; Goals	Psychological Capability; Automatic Motivation
26. Monitoring of outcome by others by reviewing children's physical activity levels and their movement skills	Feedback and Monitoring	Incentive	Behavioural Regulation; Social Influences; Professional Identity	Psychological Capability; Reflective Motivation
27. Feedback on outcomes by listing positive points and possible points to work on/consider for next time if needed	Feedback and Monitoring	Incentive Education Training	Behavioural Regulation; Social Influences; Professional Identity	Psychological Capability; Reflective Motivation
28. Review behavioural/outcome goals depending on how behaviour/outcomes have changed as a result of the intervention	Goals and Planning	Enablement	Goals	Automatic Motivation

Appendix 49: Busy Brain Break Weekly Tracker

BUSY BRAIN BREAKS

MONDAY			
TUESDAY			
WEDNESDAY			
THURSDAY			
FRIDAY			

Appendix 50: Most Improved Mover of the Week

MOST IMPROVED MOVER OF THE WEEK

THIS CERTIFICATE IS TO RECOGNISE

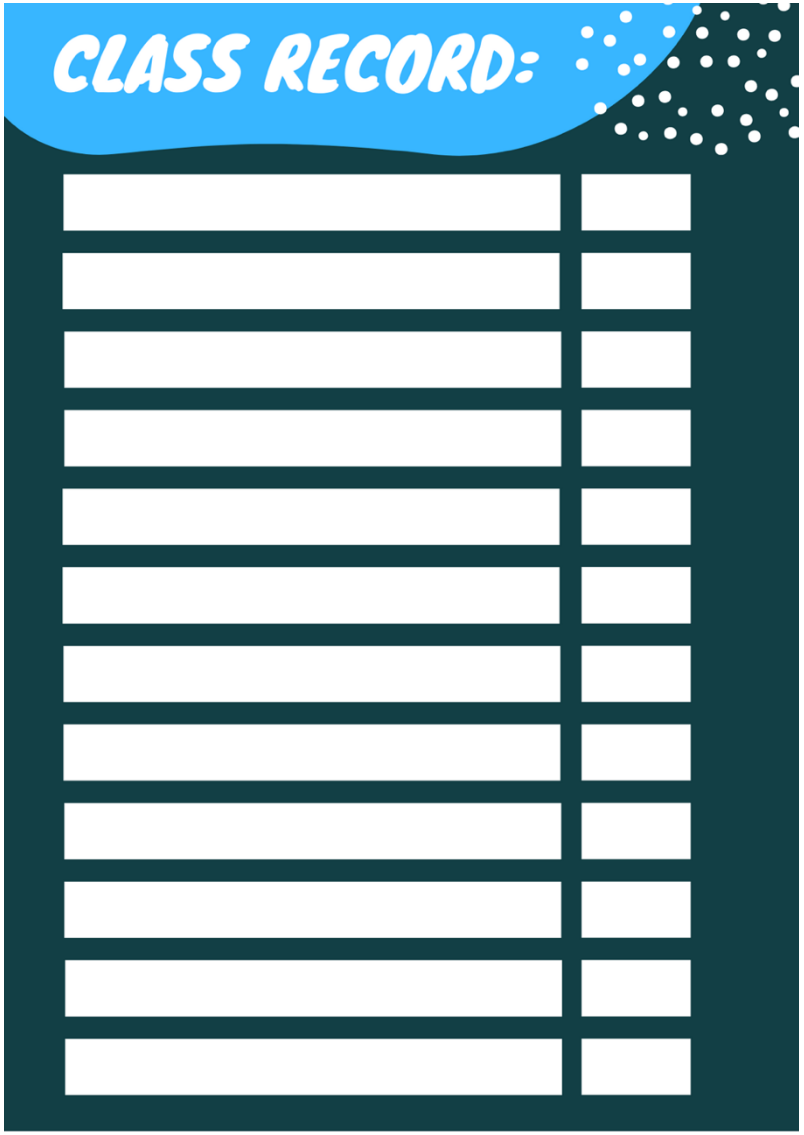
AS THIS WEEKS MOST IMPROVED MOVER!

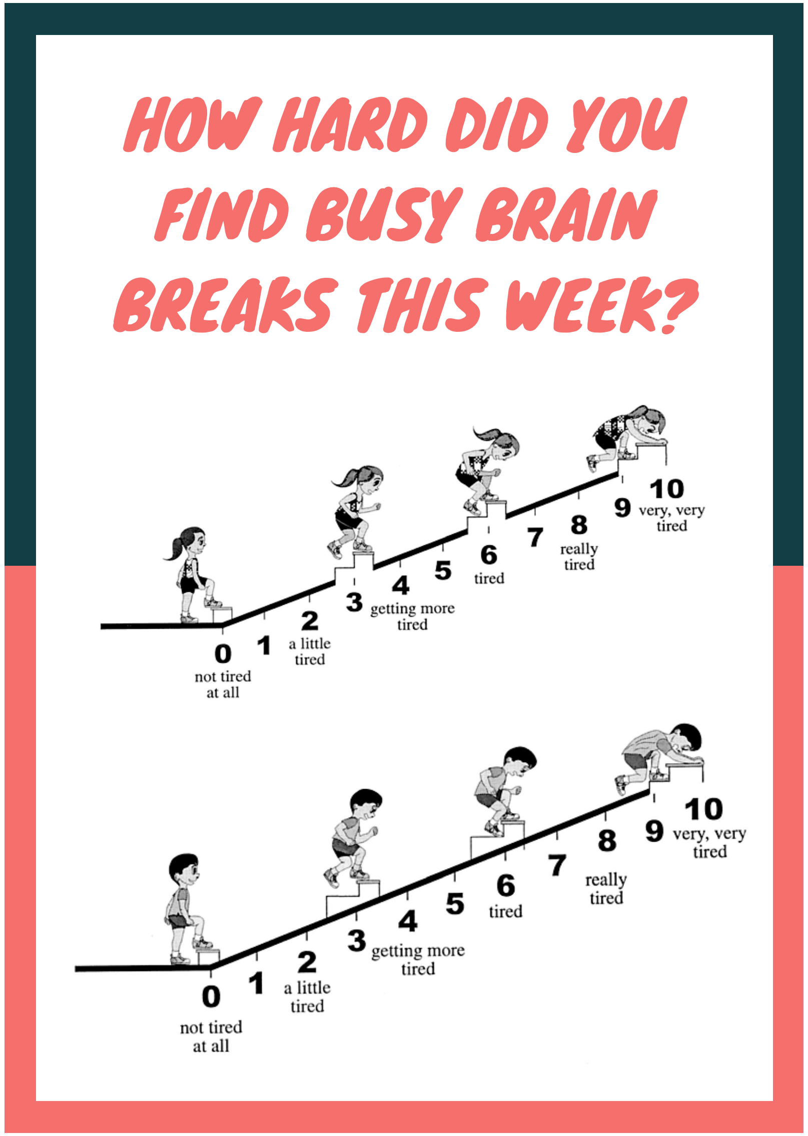
DATE

BUSY BRAIN BREAKS

TEACHER

Appendix 51: RPE Score Cards





Appendix 52: Busy Brain Break Posters

BUSY BRAIN BREAKS

3 MOVEMENT BREAKS A DAY
3 DAYS A WEEK (NON PE DAYS)

Fridays:

Record Children's RPE for the Week

Decide Who is Mover of the Week!

Mondays:

Mover of the Week shares:

-Weekly Class Results

-Individual Dose Result

Helps to Motivate the Class

Helps to Remind the Teachers!

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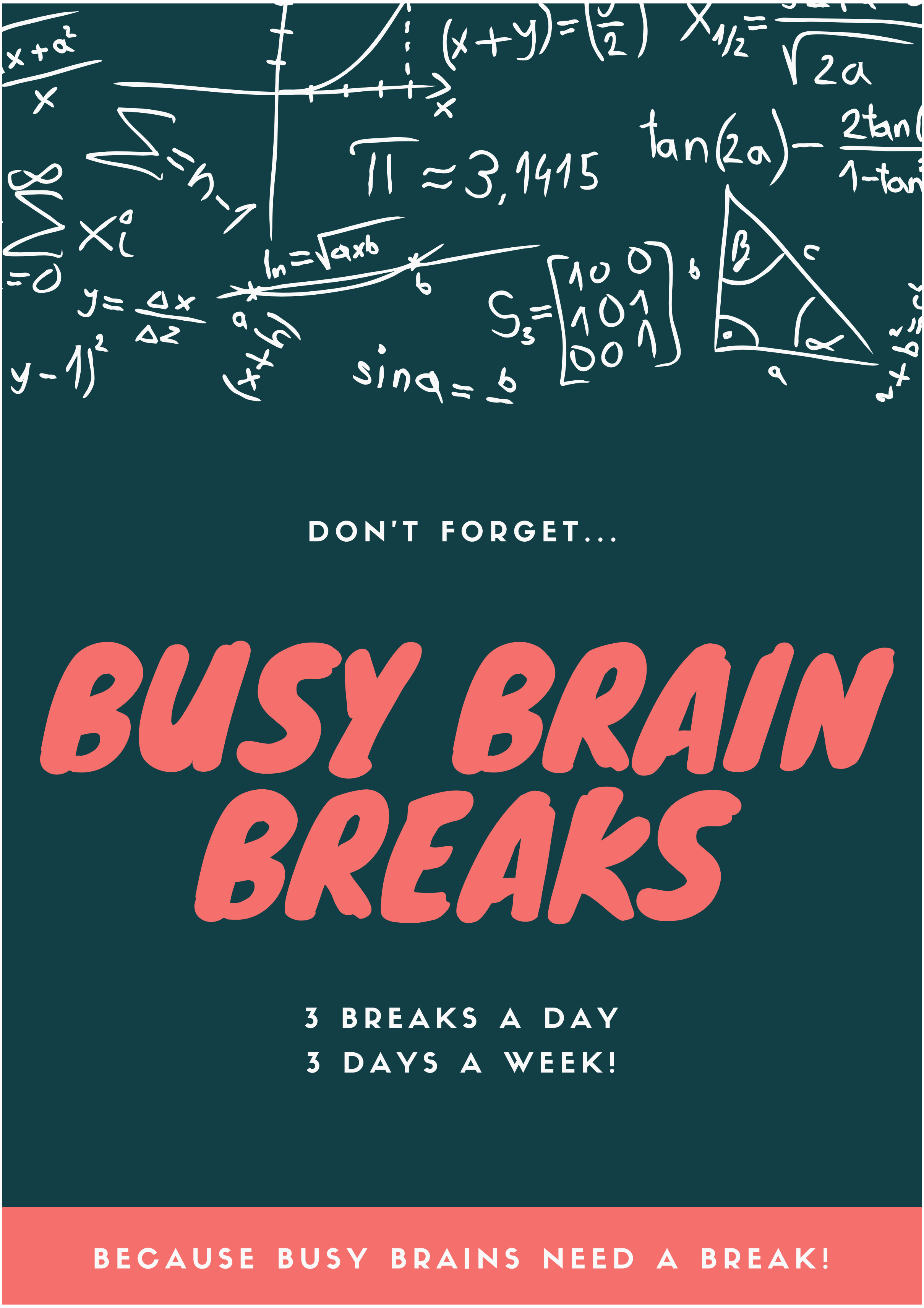
DON'T FORGET...
BUSY BRAIN BREAKS
3 BREAKS A DAY
3 DAYS A WEEK!
BECAUSE BUSY BRAINS NEED A BREAK!

FOR THE TEACHERS

BUSY BRAIN BREAKS:
TOP TIPS AND TRICKS

USE THE POWER OF PE

If the class are silly or find it difficult to complete the movements, try practicing the exercises during PE! They make for a great warm up and you can spend more time helping and correcting them!
(see exercise cards for more info)

TRY IT IF THE LESSON HAS BEEN TOUGH

Breaking up sitting time has proven to improve concentration and time on task behaviour - If it's clear the class need a break, make it an active one!!

SHARE IDEAS AND HELP EACH OTHER

Struggling to find them time, or to manage classroom behaviour? Your PE leads are there to support you! Share ideas, tips and tricks for managing to complete a busy brain break AND keep the kids focused!

RECOGNISE AND REWARD

Don't forget to pick a mover of the week! They can help to motivate the rest of the class, whilst reminding you to complete enough busy brain breaks to reach your goal!!

BECAUSE BUSY BRAINS.. NEED A BREAK!

QUESTIONS?
alice.cline@hartpury.ac.uk.

FOR THE PUPILS

BUSY BRAIN BREAKS

HOW TO BE SUPER MOVERS!

ENCOURAGE EACH OTHER!

Has someone in your class got better at squats? Tell them! Is someone finding press-ups difficult? Practice with them! Is the class getting tired towards the end? Encourage them all to keep going! You can all do it if you work together as a team

DO THE MOVEMENTS SLOWLY TO GET BETTER!

Some of the exercises are really tricky, especially without much space to do them in! Try to do them slowly and keep them controlled. You'll get better much more quickly that way!

TREAT IT LIKE A 5 MINUTE PE LESSON!

Make the most of having 5 minutes away from your desks and take your Busy Brain Break just as seriously as you would your PE lesson! Make sure you're doing the movements carefully and as properly as you can!

HELP TO REMIND YOUR TEACHER!

Your teacher already has lots to remember! Can you help by reminding them to complete a busy brain break? You can help to keep the board updated and reach your weekly goal!

BECAUSE BUSY BRAINS..
NEED A BREAK!

QUESTIONS?
alice.cline@hartpury.ac.uk.

Appendix 53: Head Teacher Information Sheet

HARTPURY

HEADTEACHER INFORMATION SHEET

Project Title:
Busy Brain Breaks: A classroom-based intervention designed to break up children's sedentary behaviour with short bouts of exercise in order to improve movement competency and increase physical activity levels.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

1. Invitation Paragraph
Both the teaching staff and children in your school who are aged 7-11 years have been invited to take part in this intervention. Please consider whether you are able to commit to the requirements stated below before deciding on whether your school can take part in the study.

2. What is the purpose of the study?
The purpose of the study is to explore the effects of a classroom based physical activity intervention on children's movement competencies and physical activity levels. The data collected will be used to help children become healthier and involved in physical activity in the future.

3. Why have I been chosen?
The staff and children in your school have been invited to take part in this study because they work in, or attend a primary school in Gloucestershire and are aged 7 to 11 years. During the study if any of the staff or children do not feel happy about anything that they are asked to do, they can stop at any time without fear of penalty. If you need any more information about the study, then please contact any member of the team on the details written above.

4. What will happen if I take part?
If you choose to take part, your teachers will be invited to a teacher training afternoon (or evening – whichever suits you!) in order to learn how to implement physical activity breaks

into the classroom. Our aim is to educate staff members so they feel confident in delivering short bouts of exercise. Once the training has taken place, baseline testing will be conducted with your students so we can measure the progress they make over the school year. Once the intervention has finished, we will test the children again so we can compare the data. The testing procedure is similar to the testing that took place during the last school year. Following written consent from parents, children will be required to leave the classroom in pairs and will firstly complete a number of short questionnaires asking them about their physical activity levels and enjoyment. They will then complete a movement screen, which involves the children completing 4 bodyweight exercises.
The intervention itself involves teachers implementing 3 short bouts of physical activity a day, each last 5 minutes. The intervention has been designed in collaboration with a number of primary school teachers across Gloucestershire so that is feasible and practically possible to do within the classroom environment. You will receive full support from myself, the researcher, along the way if you have any questions or concerns.

5. What are the possible disadvantages of taking part?
The exercises children will be completing are no harder than the physical activity they do during PE lessons. Should any child feel unwell or decide not to take part in the activities, they can choose to stop taking part. As stated above, the intervention has been designed by both researchers and practitioners so issues such as time and space constraints have been carefully considered and negotiated in order for the intervention to be easily implemented.

6. What are the possible benefits of taking part?
A growing body of research shows that children who are more active throughout the school day are more likely to have improved time on task behaviour, increased cognition and often perform better academically. In addition to these benefits, children who are more physically active are at a lower risk of developing physical and psychological health problems such as high blood pressure and depression/anxiety. Furthermore, studies show children who are more physically active are more likely to become physically active adults.

7. Will my taking part in the study be kept confidential?
The data being collected will be analysed in order to determine how Hartpury university can enhance your child's movement skill development and physical activity engagement. The data collected will be stored in compliance with the Data Protection Act 2018. All names, dates and personal information are completely anonymised and kept confidential at all times. Hard copies of information will be kept in a secure office. All files on a computer will be password protected and are only accessible by those listed as lead and co-researchers. The school will have access to the anonymised data for educational and curriculum purposes. The data is part of a longitudinal study and will not be disposed of.

8. What if I have any questions?
If you have any questions about what I have written above or anything to do with the study, please don't hesitate to contact me or anyone from the research team as detailed above. If

after the study you are concerned about how any aspect of the research was conducted please contact Alice Cline (alice.cline@hartpury.ac.uk).

Appendix 54: Head Teacher Consent Form

HARTPURY

HEADTEACHER CONSENT FORM

Project Title:
Busy Brain Breaks: A classroom-based intervention designed to break up children's sedentary behaviour with short bouts of exercise in order to improve movement competency and increase physical activity levels.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

	Please initial box
I can confirm that I have read and understood the information sheet provided and have had the opportunity to ask questions.	☐
I understand that the children's participation is voluntary and that I am free to withdraw my pupils at any time, without giving any reason, with out their medical care or legal rights being affected.	☐
I understand that sections of the data obtained may be looked at by responsible from Hartpury University. I give permission for these individuals to have access to these records.	☐
I am happy for the data collected in this study to be used in future health related studies where data collected will be linked to health outcomes.	☐

I agree to allow the pupils in my school to take part in the study.

School: ______________________________

Head Teacher: _________________________

Date: ________________

Appendix 55: Parent/Guardian Information Sheet

HARTPURY

Dear Parent/Guardian,
My name is Alice and I'm a PhD student at Hartpury University. Your child's primary school is taking part in an intervention we are running called 'Busy Brain Breaks'. This is an exciting project developed by the university to try and help improve physical activity levels during school hours. The project involves the children performing short bouts of bodyweight exercises (which I'm sure you'll be forced to try at home!).

What will happen if you child takes part?
To see if the intervention is working or not, we'd like to complete a short movement screen with the children at the start of the intervention and again at the end. Their movements will be analysed and later graded, so we can compare the start and end results. The children will also be asked to complete two short questionnaires about their physical activity levels and physical activity enjoyment. Some children will also be chosen to wear an accelerometer (similar to a fancy fit bit) to help measure their movement during the school day. We conducted similar data collection sessions last year, across various schools in Gloucestershire (including this one!) and the children absolutely loved it.

What will happen to the data we are collecting?
The data being collected will be analysed in order to determine how Hartpury university can enhance your child's movement skill development and physical activity engagement within the classroom. The data collected will be stored in compliance with the Data Protection Act 2018. All personal information will be completely anonymised and kept confidential at all times. Hard copies of information will be kept in a secure office. All files on a computer will be password protected and are only accessible by those listed as lead and co-researchers. The school will have access to the anonymised data for educational and curriculum purposes. The data is part of a longitudinal study and will not be disposed of.

What if I have any questions?
If you have any questions about what I have written above or anything to do with the research, please don't hesitate to contact me (alice.cline@hartpury.ac.uk).

If you are happy for your child to take part, please fill out the consent form provided and return to school prior to the data collection date confirmed with your school.

Thank you,

Alice Cline BSc (Hons), MSc (Dist), Post Graduate Researcher
Hartpury University, University of West of England

Appendix 56: Parent/Guardian Consent Form

HARTPURY

PARENT/GUARDIAN CONSENT FORM

Project Title:
Busy Brain Breaks: A classroom-based intervention designed to break up children's sedentary behaviour with short bouts of exercise in order to improve movement competency and increase physical activity levels.

Contact Details:

Alice Cline – alice.cline@hartpury.ac.uk

Child's Name: Date of Birth:

I can confirm I have read and understood the information sheet provided. I understand that my child's participation is voluntary and that they are free to withdraw at any time without consequence. ☐

I understand that sections of the data obtained may be looked at by responsible persons at Hartpury and I give my permission for the data to be used in future health related studies. ☐

I agree to allow my child to take part in the study.

Signature: **Date:**

HARTPURY

PARTICIPANT INFORMATION SHEET/CONSENT FORM

You have been selected to take part in a Hartpury University Centre study. You have been chosen because you are between the age of 7 - 11 years old and go to a primary school in Gloucestershire.

In the study you will have chance to part in a series of fun activities. You will also be asked to have some measurements take such as your height and blood pressure. All measurements are taken privately and will not be shared with anyone else from your class.

You will not be forced to take part and can stop at any time without fear of penalty or having to worry about being in trouble.
If you have any questions please ask any of the research team or your teacher.

I agree to take part in the above study.

Name:
Date:

Researcher's Name: Alice Cline
Signature:
Date:

Appendix 58: Site Permission Form

HARTPURY

SITE PERMISSION FORM

Name: Alice Cline
Email: alice.cline@hartpury.ac.uk

To whom it may concern,

In my capacity as manager/owner of ______________________, I grant permission for Alice Cline to conduct research looking at childhood physical activity at my establishment on ___________________.

I understand what the project involves and will facilitate work which will be presented as a PhD thesis, with aims to publish in an appropriate journal. I also understand that a paper and electronic copy will be kept at Hartpury University.

Yours sincerely,

Signature of manager/owner:

Location/facility:

Please print name/s:

Date:

Appendix 59: Process Evaluation Questionnaire (to be completed during the intervention)

School:
Teacher:
Year Group:
Class Name:

1) How are Busy Brain Breaks going?

2) How are you implementing Busy Brain Breaks?

3) Are you implementing them as originally planned?

4) Have you had to change the way you implement them at all?

5) Have you noticed any consequences (positive or negative) of Busy Brain Breaks?

6) Is there anything stopping you from doing Busy Brain Breaks more frequently?

7) Do you have any questions or concerns regarding Busy Brain Breaks?

Appendix 60: Interview Schedule

Teaching Background

Can you tell me a bit about your teaching background to begin with?

How long have you been teaching?
How long have you been at your current school?
How long have you been teaching this year group?
Do you have a specialist subject or additional responsibility?

What has your experience of delivering PE and/or physical activity been?

Do you deliver your own PE lessons?
Have you delivered much physical activity outside of PE?
What are your thoughts on delivering physical activity outside of PE?

How did you feel about Busy Brain Breaks before they started?

Thoughts?
Queries?
Concerns?

Initial Implementation: What happened at the start?

What happened when Busy Brain Breaks was first introduced inside the classroom?

Can you remember what you were thinking?
Can you remember the children's reactions/thoughts?
Can you give me an example?

Can you tell me about the initial impact it had on the class at the beginning?

Positive impact?
Negative impact? If so, what did you do?
Can you give me an example?

Did you have to make any changes to the way in which Busy Brain Breaks were implemented?

Can you give me an example?

Overall Successors: What was successful over the 10 weeks?

In what ways has Busy Brain Breaks been successful in your class?

Positive changes?
Movement?
Physical activity?
Time on task?

Can you tell me about what the children thought was successful/good?

Can you give me an example?

Overall Challenges: What was challenging over the 10 weeks?

Did you face any challenges as a result of Busy Brain Breaks?

Challenges in delivery?
Classroom behaviour?
Time?
Can you give me an example?
Did anything stop you from overcoming these challenges?

What suggestions would you give someone for overcoming those challenges?

What could be done differently?
Why did you do it that way?
Can you give me an example?

Previous focus groups identified possible barriers such as time, space, a busy workload, teacher confidence, resources, fear of getting it wrong, classroom behaviour

What is your experience of these challenges?
Can you give me an example?

Can you tell me about what the children thought was challenging/hard?

How did you overcome this?
Can you give me an example?

Sustainability:

Would you consider delivering Busy Brain Breaks again next year?

If yes, why?
If no, why?

Would you make any changes to Busy Brain Breaks?

If so why?
Can you give me an example?

Reflecting on your experience, if you were to advise someone who wanted to implement more physical activity inside the classroom, what would be your top 3 tips?

Do’s or dont’s?

Appendix 61: Thematic Analysis Table

Dimension	Theme	Code	Example
Reach	Data collected from researcher's participation information		
Adoption	Teacher's	Workload	"I was very aware oh my god one more thing you know every staff meeting we are concentrating on something different and particularly with SATs as well we do have a lot on our plates in terms of workload but once we had started it all my concerns melted away because it didn't really require anything from me, it wasn't any extra work to think about" – Participant 2, Teacher of Class 12.
		Time	"So, at first of all I was thinking how are we going to get through 9 in a week, because I know you said it was 3 a day over 3 days and I was thinking oh okay I'm not sure where that's going to fit in because our curriculum is so tight and things like that umm and that was a bit worrying thinking well where is this going to go" – Participant 9, Teacher of Class 9
		Resources	"I think the resources were so clear, it was really well designed because it was self-explanatory really you know teachers who don't know anything about any of those exercises would have only needed to watch a video once a twice with the children to understand what to do if that makes sense so the visual side of things and being able to see the exercises being done properly was a really good model" – Participant 7, Teacher of Class 1.
		Recognising Benefits	"I did think oh my goodness me, because it was three times a day, I just thought oh wow that's three interruptions in the day to do physical activity but I did whole-heartedly believe in the project and I could see the benefit of the project for the children in terms of getting them more active throughout the day" – Participant 12, Teacher of Class 5.
		Perceived Children's Enjoyment	"Yeah they were very excited and they were very positive about it, they liked the variety of it, especially being year 6 they liked the fact that it wasn't too childish" – Participant 2, Teacher of Class 12.
	Children's	Enjoyment	"It was nice to have a break and then it will keep you more focused when doing you work"
		Inclusivity	"The fact it was just the five minute they know that actually, even the ones who maybe struggle with the physical aspect of it, they can just appreciate that it is just 5 minutes not that sort of 15 minutes to run a mile and thought of a mile to some of them sounds quite far whereas this is just five minutes" – Participant 13, Teacher of Class 17.

Implementation	Adaptability	Changes Made	“We used mindfulness or a minute of silence at the end of each session before we got back to work. Sometimes we used GoNoodle, which has great breathing/mindfulness videos just to calm the class back down. Or even just to get the class to sit back in their chairs, close their eyes and think about what they can hear, smell, taste etc. I tried to make sure it didn't take up more time” – Particpant 3, Teacher of Class 24.
		Teacher’s Role	“I began walking around the classroom and engaging the children one on one who might have been struggling with a certain exercise so I’d go over and we’d working out what was going wrong together or if I saw someone who was maybe not your typical PE lover I’d go around and give them an extra bit of encouragement and you know say wow look at these press-ups so I made sure they got that individual praise” – Participant 11, Teacher of Class 15.
		Frequency of Sessions	“We began by doing it 3 times a day, 3 days a week, but in the end, I definitely found doing it twice a day everyday was better. Because I really liked to have it on set time each day between lessons because then I got used to it and so did the children. So, I forgot the children would remind me.” – Participant 6, Teacher of Class 22.
		Time of Sessions	“I focused on transitions between subjects so for example in the morning we did guided reading before English and I was finding that to be a struggle because children would talk and drag their heels so we started to a do Busy Brain Break in between and that meant the children would tidy up a lot quicker because as soon as I’ve pressed play on my laptop they hear the music and they’re like oh god we’ve got to tidy up so instead of them taking 5 minutes to tidy up they’d be tidying up in 30 seconds because they’d want to start the video so it was brilliant for the side of things” – Participant 9, Teacher of Class 9.
	Barriers	Space	“Space was definitely a challenge but we just had to make sure we were careful, the children had to look for a space and make sure they weren’t going to bump into anyone as we did the movements and once they were conscious of that it was absolutely fine” – Participant 6, Teacher of Class 22.
		Time	“Time especially… I don’t know if it’s different in year 6 I’m not sure but… because we’ve got so much to fit in in such a short space of time, obviously now we haven’t because we have got SATS, but if we had SATs you’ve got to fit it all in by May so that makes it quite a struggle to fit in all 3 which is why I didn’t get to do more Busy Brain Breaks a day” – Participant 1, Teacher of Class 26.
		Behaviour	“No, so like I said at the beginning it was, I had to have a few words a couple of times and maybe then again a few weeks in I had a few boys who were messing around or they were trying to do the exercises but they weren’t doing them sensibly so I’d say to them right you’re going to sit out for a

			minute and then they wouldn't do it again so yeah I don't know if it makes a difference because they're a bit older so they think actually I'm missing out by behaving like that so I didn't have any problems at all by the end of it." – Participant 1, Teacher of Class 26.
	Facilitators	Behaviour Management	"The points in lessons where the main event has happened and the kids have put the energy in that they are going to put it and restlessness is beginning and either you need a complete change of scene or you are desperate for the bell to go for break or umm you are going to have to g*et al*l fierce with them so they knuckle down which is horrible so instead of all of that you think right this room needs a change so it's Busy Brain Break time so I found it quite a positive thing, not just in terms of the actual exercise but in terms of the general classroom management because it gave me an extra tool" – Participant 2, Teacher of Class 12.
		Resources	"The fact that it was all up on there on the board the videos were really good you they were really good for them to follow and for us as teachers we knew that all the information they needed was up there on the screen so our job could then be more of a facilitating role which is nice because you know the children listen to us all day so it's something different for them" – Participant 14, Teacher of Class 19.
Efficacy	Physical	Movement	"I'm not sure how to explain it, they just looked more stable throughout all of the movements, at first they were all so wobbly sometimes bumping into each other but by the end they were a lot more stable" – Participant 1, Teacher of Class 26.
		Physical Activity	"It got us talking about physical activity and exercise more as a class and it got them talking about different movements they could do or they'd talk about the ones they found hard and they'd challenge themselves with the make it easy or make it harder chart and I think it was nice that discussed it because often we don't have sit down and talk about the benefits of being active enough" – Participant 16, Teacher of Class 10.
		Fitness	"I mean at the beginning they were physically unable to do some of the exercises for the full 30 seconds, so they would have to take little breaks and get back into it but towards the end most of them were able to do the exercises without taking breaks, or if they were taking breaks it was only for a couple of seconds rather than you know 10 seconds" – Participant 12, Teacher of Class 5.
	Educational	Focus	"Oh, it definitely re-focuses them, it kind of draws a line, you draw a line under the activity that they have just done and they take a big breath and they are ready, they are just more ready to learn." – Participant 14, Teacher of Class 19.

		Time on Task	"I think the focus came from having a break from work and being able to get up and move around and get rid of some energy. So rather than have a restless class and people wanting to chat or walk to the bin to sharpen their pencil they were focused on the exercise and moving their bodies and then that made them able to focus on the task at hand when they got back to their tables" – Participant 4, Teacher of Class 3.
		Social	"The children always gave feedback to each other too so whilst I was going around the class and reading the cues out from the board, the children would be encouraging each other and giving pointers which was really nice because it gave the class a sense of doing it together because sport can often be quite competitive whereas this definitely encouraged them to work together more" – Participant 14, Teacher of Class 19.
Maintenance	Future Plans		"Yeah, absolutely. I found there were some really good educational benefits in that the children were more focused and engaged once we had finished a Busy Brain Break, especially my class being 7 or 8 years old they need that release when they're getting fidgety and then even for someone like me who is not expert in movement I could see the progression in terms of physical ability throughout the way you know especially when it came to things like core strength and stability and also general fitness levels because right at the start we had lots of pink cheeks and stopping and starting but towards the end they were able to do the exercises for longer without stopping, so yeah I definitely would." – Participant 11, Teacher of 15.
	Adaptations		"I think it would be good to alternate Busy Brain Breaks with the daily mile because the daily mile is great when the sun is out and we already have a track outside, so maybe two days a week the children could do the mile and then the other three they could do Busy Brain Breaks because then they're getting a bit of variety too then." – Participant 3, Teacher of Class 24.