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Utilising active play interventions to improve physical activity and fundamental movement skills in children.

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Declaration of authenticity and author's rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

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Abstract

This thesis aimed to determine the effects of active play interventions on physical activity and fundamental movement skills (FMS) in children. Active play is "a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner", but is a neglected area of research.

This thesis presents four unique papers. Firstly, a systematic review (Chapter 3- published in BMC Public Health) on the effect of active play interventions on children's physical activity levels, moderate-to-vigorous intensity physical activity (MVPA), and FMS. The next two papers, a pragmatic evaluation and feasibility cluster RCT (Chapters 5 and 6) evaluated a school based 'Active Play' intervention, which consisted of a 1-hour outdoor physical activity session per week, incorporating 30 minutes of facilitated games and 30 minutes of free play. The pragmatic evaluation (chapter 5- published in Preventive Medicine Reports) aimed to determine the effect of participating in Active Play on school day physical activity, the proportion of time spent in MVPA during a typical session and FMS. The pragmatic evaluation was used to inform a feasibility cluster RCT (chapter 6- submitted to the Journal of Pilot and Feasibility Studies), which explored the feasibility of the Active Play intervention, and presented preliminary findings on four outcomes: physical activity levels, FMS, inhibition, and maths fluency. Paper four (Chapter 7- submitted to the Scottish Educational Review) aims to discuss the benefits of active play, summarise research into active play interventions and reflect on lessons learned for the school-based Active Play intervention.

There were three main findings from the present thesis: a) active play is an under researched area that needs greater focus, b) the school-based Active Play

intervention is promising (benefits from high amounts of MVPA) and c) children from Scotland have poor FMS.

Acknowledgements

Firstly, I would like to thank my supervisors, Professor John Reilly and Dr Adrienne Hughes for guiding me through the past three years. Your support, feedback and advice has been greatly appreciated and I have thoroughly enjoyed working with you both.

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List of Abbreviations

BMI= Body mass index

CHSP= Child Health Surveillance Programme

CMA= Comprehensive Meta-Analysis

CPM= Counts per minute

EPHPP= Effective Public Health Practice Project

FMS= Fundamental movement skills

GMQ= Gross motor quotient

HBSC= Health Behaviours in School Children study

ICAD= International Children's Accelerometry Database

METs= Metabolic equivalents

MABC-2= Movement Assessment Battery for Children-2

MVPA= Moderate-to-vigorous physical activity

PE= Physical Education

PRISMA= Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT= Randomised controlled trial

SALSUS= Scottish Schools Adolescent Lifestyle and Substance Use Survey

SES= Socioeconomic Status

SIMD= Scottish Index of Multiple Deprivation

WHO= World Health Organisation

WIAT= Wechsler Individual Achievement Test

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Summary of Publications, Submitted Manuscripts and Presentations

1. Publications and manuscripts under review from thesis

Chapter 3

Johnstone, A., Hughes, A. R., Martin, A., & Reilly, J. J. (2018). Utilising active play interventions to promote physical activity and improve fundamental movement skills in children: a systematic review and meta-analysis. *BMC Public Health*, *18*(1), 789.

Chapter 5

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2017). Pragmatic evaluation of the Go2Play Active Play intervention on physical activity and fundamental movement skills in children. *Preventive Medicine Reports*, *7,* 58-63.

Chapter 6

Johnstone, A., Hughes, A. R., Bonnar, L., Booth, J. N., & Reilly, J. J. (2018). An active play intervention to improve physical activity and fundamental movement skills in children of low socio-economic status: feasibility cluster randomised controlled trial. **Under review - submitted to the Journal of Pilot and Feasibility Studies in September 2018.**

Chapter 7

Johnstone, A., Hughes, A. R., & Reilly, J. J. (2018). Utilising active play to increase children's physical activity levels, improve FMS and raise academic attainment. **Under review - submitted to the Scottish Education Review in November 2018.**

2. Publications and manuscripts under review not from thesis

Hughes, A. R., Muggeridge, D. J., Gibson, A. M., **Johnstone, A.**, & Kirk, A. (2016). Objectively measured sedentary time in children and their parents. *AIMS Public Health*, *3*(4), 823.

Reilly, J. J., **Johnstone, A.**, McNeill, G., & Hughes, A. R. (2016). Results from Scotland's 2016 Report card on physical activity for children and youth. *Journal of Physical Activity and Health*, *13*(11 Suppl 2), S251-S255.

Hughes, A. R., **Johnstone, A.**, Bardid, F., & Reilly, J. J. (2018) Results from Scotland's 2018 Report Card on Physical Activity for Children and Youth *Journal of Physical Activity and Health.* **In press – to be published in November 2018.**

3. Conference presentations from thesis

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2016). Pragmatic evaluation of the Go2Play Active Play intervention on fundamental movement skills and physical activity in children. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2016.*

Johnstone, A., & Gallacher, A. (2017). Collaborative approach to delivering and evaluating the impact of Active Play on the health and wellbeing of Scottish primary school children. *Researching with and for Children, Edinburgh, UK. May 2017.*

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2017). Pragmatic evaluation of the Go2Play Active Play intervention: effects on fundamental movement skills and physical activity in children. *International Society of Behavioral Nutrition and Physical Activity, Victoria Canada. June 2017.*

Johnstone, A. (2017). Active Play Interventions: a contribution to a symposium on play. *International Society of Behavioral Nutrition and Physical Activity, Victoria Canada. June 2017.*

Johnstone, A., Hughes, A. R., Bonnar, L., Booth, J.N., & Reilly, J. J. (2018). A feasibility cluster randomised controlled trial of an active play intervention on physical activity and fundamental movement skills in children from low socio-economic status. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2018.*

4. Conference presentations not from thesis or based only partly on thesis data

Hughes, A. R., **Johnstone, A.,** McNeill, G., & Reilly, J. J. (2016). Results from Scotland's 2016 Report card on physical activity for children and youth. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2016.*

Reilly, J. J., **Johnstone, A.,** McNeill, G., & Hughes, A. R. (2016). Results from Scotland's 2016 Report card on physical activity for children and youth. *International Society for Physical Activity and Health, Bangkok, Thailand. November 2016.*

Hughes, A. R., **Johnstone, A.,** McNeill, G., & Reilly, J. J. (2016). Results from Scotland's 2016 Report card on physical activity for children and youth. *American College of Sports Medicine, Denver, USA. May 2017.*

Hughes, A. R., **Johnstone, A.,** McNeill, G., Reilly, J. J. (2016). Results from Scotland's 2016 Report card on physical activity for children and youth. *American College of Sports Medicine, Denver, USA. May 2017.*

Gallacher, A., & **Johnstone, A.** (2017). Active Play, a unique approach to developing children's physical literacy. *International Physical Literacy Conference, Cardiff, UK. June 2018.*

Hughes, A. R., **Johnstone, A.**, Bardid, F., & Reilly, J. J. (2018) Results from Scotland's 2018 Report Card on Physical Activity for Children and Youth. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2016.*

5. Awards and prizes

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2016). Pragmatic evaluation of the Go2Play Active Play intervention on fundamental movement skills and physical activity in children. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2016.* **First Prize for Best Student Poster.**

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2017). Pragmatic evaluation of the Go2Play Active Play intervention: effects on fundamental movement skills and physical activity in children. *International Society of Behavioral Nutrition and Physical Activity, Victoria Canada. June 2017.* **Shortlisted for Best Student Poster** (abstract rated in the top 3 of those submitted).

Johnstone, A., Hughes, A. R., Bonnar, L., Booth, J.N., & Reilly, J. J. (2018). A feasibility cluster randomised controlled trial of an active play intervention on physical activity and fundamental movement skills in children from low socio-economic status. *Scottish Physical Activity Research Connections Conference, Edinburgh, UK. November 2018.* **Second Prize for Best Student Poster.**

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Chapter 1: Introduction and literature review

1. Introduction

Physical activity has been defined as “any movement produced by the skeletal muscles which increases energy expenditure above resting state” (Caspersen, Powell & Christenson 1985). The positive health benefits of participating regularly in moderate-to-vigorous physical activity (MVPA) in childhood have been widely reported, including improved: blood cholesterol, blood pressure, weight management, bone density and mental wellbeing (Timmons et al., 2012; Janssen & Leblanc, 2010). The current UK guidelines recommend a minimum of 60 minutes of MVPA per day for children 5-18 years (Department of Health, 2011). The more recent Canadian ‘24-hour movement guidelines’, which look at a whole day approach, suggest that a healthy day would include 9-11 hours of sleep, 60 minutes of MVPA, several hours of structured and unstructured light physical activity, limit use of screen time to no more than 2-hours and limit amount of time spent sitting (Tremblay et al., 2016a). Despite these guidelines, Scottish children, as in other high-incomes countries, are typically not reaching the recommended minimum amount of 60 minutes of MVPA (Healthy Behaviours in School Children, 2012; McCrorie, Mitchell, & Ellaway, 2018; Reilly, Johnstone & Hughes, 2016a).

Children engage in physical activity from a variety of domains including, active commuting, recess, physical education (PE) and sports participation, which have been the focus of much research, and has been reviewed systematically in recent years (Hollis et al., 2016; Martin, Boyle, Corlett, Kelly, & Reilly, 2016; Reilly, Johnston, McIntosh, & Martin, 2016b). These systematic reviews aimed to determine how much MVPA is accumulated in each of these physical activity domains, which the authors argued have contributed to a useful but limited amount of MVPA (Hollis et al., 2016; Martin et al., 2016; Reilly, et al., 2016b; Janssen, 2014). This has led to the emergence of active play as a possible target for physical activity promotion efforts. Active play is "a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner" (Truelove, Vanderloo, & Tucker, 2017). Active play is often engaged in outdoors, which is associated with higher levels of physical activity and MVPA compared to indoor physical activity and other domains of physical activity such as PE, recess, active commuting and other sports and physical activities (Gray et al., 2015; King et al., 2011; Hollis et al., 2016; Martin et al., 2016; Reilly, et al., 2016b). Active play is also less restrictive than these domains as it can be engaged in before, during and after school, 365 days of the year (Janssen, 2014).

Recent intervention studies have highlighted the potential of active play to improve fundamental movement skills (FMS) (Adamo et al., 2016; Jones et al., 2011). FMS, defined as a set of skills which children should be competent in, such as, throwing, catching, running and jumping, are typically low in contemporary children from high-income countries (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Having good FMS has been suggested to improve children's ability to master basic movements required for more complex physical activities (including sports), which enables them to successfully engage in more physical activity as they mature (Lubans et al., 2010; Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012; Stodden & Goodway, 2007). Furthermore, research has suggested a possible link between higher intensity physical activity (i.e. MVPA), cognitively engaging activities and improved cognition and attainment (McMorris, Tomporowski, & Audiffren, 2009), with active play suggested to be a good way of achieving both enhanced cognition and attainment (Pesce et al., 2016; Tomporowski, McCullick, & Pesce, 2015).

This literature review explores children's current levels of physical activity, sedentary behaviour and obesity; discusses theories and concepts related to physical activity; examines different domains of physical activity and finally presents active play as a novel and potentially promising way of improving children's physical activity, FMS and cognition and attainment.

2. Health behaviours

2.1 Physical activity

Engaging in regular physical activity (as defined above) is associated with a range of physical, social, emotional and cognitive benefits as documented in recent systematic reviews (Janssen & Leblanc, 2010; Timmons et al., 2012). MVPA, defined as physical activity with an energy cost of >2.9 but <6.0 times resting energy expenditure, is particularly important to the associated health benefits (Department of Health, 2011; Pate, O'Neill, & Lobelo, 2008).

As noted above, in the UK, it is recommended that school aged children and adolescents (5-18 years) should be achieving at least 60 minutes of MVPA per day, include activities which strengthen muscle and bones at least three times a week and minimise the amount of time spent being sedentary (Department of Health, 2011). Recent guidance from Canada has moved away from the traditional 60 minutes/day of MVPA, used in most countries, to a whole day approach (Tremblay et al., 2016a). This approach called the '24-hour movement guidelines' suggest four movement behaviours: ‘sweating, stepping, sleeping and sitting’ should be engaged in daily at optimal levels for health benefits (Tremblay et al., 2016a). Specifically, 9-11 hours of sleep, at least 60 minutes of MVPA, several hours of structured and unstructured light intensity physical activities, limit screen time to no more than 2-hours and the amount of time spent sitting (Tremblay et al., 2016a). Evidence suggests that achieving these guidelines should produce health benefits such as reducing the risk of some cancers, type 2 diabetes, cardiovascular disease, obesity, mental wellbeing and poor bone health (Janssen & Leblanc, 2010; Timmons et al., 2012).

The extent to which Scottish children and adolescents comply with physical activity guidelines, at present, is complex and controversial, and differs depending on the source of the evidence. The most recent Scottish Health Survey (2017) reported that 76% (79% of boys and 72% of girls) of 2-15 year olds met the UK physical activity guidelines of 60 minutes of MVA per day. However, this national survey has been widely criticised for using subjective measures and categorising any physical activity reported by parents as MVPA, which leads to a substantial overestimation of time spent in MVPA and, therefore, the proportion of children reaching the guidelines (Scottish Health Survey, 2017). The only validation study of the Scottish Health Survey, which utilised accelerometers as the reference method, found that it over estimated daily MVPA by an average of two hours in children aged 6-7 years (Basterfield et al., 2008).

A recent nationally representative study conducted by McCrorie et al. (2018) in Scotland used ActiGraph accelerometers to determine the percentage of 10-11 year olds who met the UK physical activity guidelines using two different approaches (i.e. the daily approach vs the average approach). The daily approach is the percentage of children who engage in ≥60 minutes of MVPA each day (or each day they wore the monitor) and the average approach is the percentage of children with ≥60 minutes of MVPA on average across all days (or across all days they wore the monitor), which is the approach taken by the Scottish Health Survey (McCrorie et al., 2018). Only 11% of children aged 10-11 years achieved the recommended amount of physical activity using the daily approach; however, when using the average approach 68% achieved the guidelines (McCrorie et al., 2018). Although the average approach produces similar findings to those reported in the Scottish Health Survey, the daily approach suggests that the percentage of Scottish 10-11 year olds meeting the guidelines is low.

The Health Behaviours in School-Age Children (HBSC-2015) nationally representative survey of adolescents aged 11-15 years (World Health Organisation, WHO, defines a child up to age of 9.9 years and adolescent from 10.0 to 19.9 years) found that only 30% and 21% of 11-year-old boys and girls achieved ≥60 minutes of MVPA each day respectively (HBSC, 2015). Unlike the Scottish Health Survey, this survey measures MVPA using a validated questionnaire and used the daily approach to determine the percentage of children achieving the physical activity guidelines (Murphy, Rowe, Belton, & Woods 2015). The validation study recruited 419 participants to wear an accelerometer for eight consecutive days, which was compared to the HBSC questionnaire (Murphy et al., 2015). Murphy et al. (2015) concluded that the questionnaire had acceptable validity (71–82 % agreement level for seven days) and, therefore, the activity levels measured by the HBSC questionnaire are a more accurate reflection of Scottish adolescent's physical activity levels, at least at a group level (though less accurate for individuals) compared to those measured by the Scottish Health Survey (Murphy et al., 2015).

Until very recently, much of the evidence (predominately subjective measures) suggested that physical activity declines around the time children enter adolescence (Dumith, Gigante, Domingues, & Kohl, 2011); however, objective evidence suggests it declines much earlier than this (Reilly, 2016c; Cooper et al., 2011). A recent publication by Reilly (2016c) reviewed systematic reviews, longitudinal studies and the International Children's Accelerometry Database (ICAD) (Cooper et al., 2011) to determine the age at which objectively measured physical activity declines. ICAD is an archive of ActiGraph accelerometer data of over 20, 000 children from 10 different countries (Cooper et al., 2011). Findings suggested that there was little or no evidence that physical activity and MVPA decline around adolescence and that declines appear to happen much earlier at around five years of age, approximately around the time they begin school (Reilly, 2016; Cooper et al., 2011)

In summary, when adherence to the physical activity guidelines is determined using the daily approach (i.e. the UK physical activity guidelines), measured objectively or with a validated questionnaire, only a small proportion of Scottish children are achieving the recommended amount of 60 minutes of MVPA per day (HBSC, 2015; McCrorie et al., 2018). Furthermore, physical activity levels are declining around the age children start school, much earlier than initially thought (Reilly, 2016; Cooper et al., 2011), suggesting that interventions need to be developed to further increase the likelihood of MVPA levels increasing in children and adolescents.

To increase levels of physical activity and MVPA, the different domains of physical activity (active commuting, recess, PE, sport) should be reviewed to determine the extent to which they help children to achieve at least 60 minutes of MVPA per day.

2.2 Sedentary behaviour

Sedentary behaviour is "any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017). It is recommended by both the UK's 2011 physical activity guidelines, and the recent Canadian 24-hour movement guidelines that children should 'minimise the amount of time they spend sedentary' (Department of Health, 2011; Tremblay, et al., 2016a). Presently, there is no specific guideline on the maximum amount of time UK children should spend in sedentary behaviour or the frequency prolonged periods of sedentary behaviour should be interrupted by light intensity physical activity. However, the Canadian Guidelines also recommend that children and adolescents should spend no more than two hours in recreational screen time per day (Tremblay, et al., 2016).

Level of sedentary behaviour is often reported as the amount of time children and adolescents spend in 'screen time' (TV viewing in particular), despite being sedentary through other non-screen based behaviours (for example, homework). This makes quantifying true levels of sedentary behaviour in children and adolescents problematic.

In Scotland, the HBSC (2015) reported that 11-year-old boys and girls spend 62% and 51% of their waking day watching two or more hours of television, 61% and 42% playing computer games for two hours or more and 44% and 45% using computers (excluding games) for two hours or more. These figures relate to the weekday only, the weekend was reported separately and the proportion of children and adolescents engaging in each of these behaviours for two or more hours was even higher at the weekend (HBSC, 2015). Given that the new Canadian 24-Movement Guidelines recommend no more than two hours of recreational screen time per day, the amount of time Scottish adolescents are spending on screens is high.

Measuring sedentary behaviour objectively in children and adolescents is preferable (McCrorie et al., 2018), but there are still no guidelines for total sedentary time as noted above. In a nationally representative study in Scotland previously described by McCrorie et al. (2018), the authors found that adolescents (*n* =774) aged 10-11 years spent a mean of 7.5 hours per day in objectively measured sedentary time. A high proportion of sedentary time was also reported in a longitudinal study conducted in the North of England, in which, sedentary time was measured objectively in 405 children aged 7 years old and then again 24 months later when they were 9 years old (Basterfield et al., 2010). The authors found that at 7 years old, participants spent 78% of their waking hours sedentary and this increased to 81% at follow-up (at 9 years old) (Basterfield et al., 2010).

Guidelines on total sedentary time are yet to be developed, which currently, creates difficulty when interpreting the amount of time children are spending in sedentary behaviour. However, given the HBSC (2015) survey found that children are exceeding the two hours of recommended screen time per day over a number of different types of devices; it appears that both screen time and total time spent in sedentary behaviour is high, occupying a large proportion of the 24-hour period.

2.3 Overweight and obesity

The recent World Health Organisation’s (WHO) Ending Childhood Obesity report (2016) suggested that addressing low levels of physical activity (particularly MVPA) and high levels of sedentary behaviour is central to improving overweight and obesity, by both contributing to prevention and treatment of obesity.

A recent systematic review conducted by Elmesmari, Martin, Reilly and Paton (2018) compared the prevalence of objectively measured MVPA and sedentary behaviour in obese and non-obese children and adolescents. A total of 26 studies were included and the majority of these (*n* =19) found that time spent in MVPA was significantly higher in the non-obese children and adolescents compared to their obese counterparts and four studies found levels of MVPA to be similar (Elmesmari et al., 2018). Furthermore, all studies found that obese children spent significantly more time being sedentary than their non-obese counterparts (Elmesmari et al., 2018). This study suggested that obesity is probably both a cause and consequence of low levels of physical activity and high sedentary time.

The prevalence of overweight and obesity in Scotland’s child population is high and has remained relatively constant over the last 10 years, despite efforts by the Scottish Government to decrease the levels of overweight and obesity (Scottish Health Survey, 2017; Child Health Surveillance Programme, 2017). The Child Health Surveillance programme (CHSP) is a database of 51,529 children in primary 1 who have had their BMI measured (CHSP, 2017). Findings suggested that 22.9% of primary 1 children were overweight/obese, of which, 12.4% were overweight and 10.5% were obese (defined as- BMI at or above the 85th centile for UK children and adolescents in 1990) (CHSP, 2017). Findings from the Scottish Health Survey (2017) reported that 28% of boys and 34% of girls aged 2-15 years are overweight (including obese) using the same definition as CHSP (2017). Both surveys highlighted that children living in the most deprived areas (measured using the SIMD) had higher levels of overweight and obesity compared to children living in the least deprived areas (Scottish Health Survey, 2017; CHSP, 2017). CHSP (2017) found that prevalence of overweight (including obesity) was 18.3% in the least deprived areas compared to 26.4% in the most deprived areas.

2.4 Summary of the prevalence of physical activity, sedentary behaviour and, overweight and obesity

Evidence presented thus far suggests that the proportion of children and adolescents in Scotland achieving the physical activity guidelines are low. Additionally, most children and adolescents are exceeding the screen time limits and, despite no guidelines on total sedentary behaviour, the proportion of time children and adolescents are spending being sedentary is high. A recent systematic review suggested that low levels of MVPA and high levels of sedentary time are a cause and consequence of obesity and the WHO recommended that these behaviours need to be addressed to tackle levels of overweight and obesity. The following section presents some theories and concepts underpinning physical activity behaviour.

3. Theories and concepts underpinning physical activity

To increase physical activity levels in childhood and encourage positive physical activity habits from the earliest age, it is important to understand key theories and concepts that underpin and influence children’s physical activity behaviour. A detailed review of the theoretical and conceptual basis is beyond the scope of the present thesis, but the reader is referred to key literature referenced in the present section for more detail.

3.1 The Socio-ecological Model for Health

Physical activity levels in childhood can be influenced by multiple factors and one relevant model is the Socio-ecological Model for Health (Figure 1), which has four interconnecting sections: policy, physical environment, social environment, individual factors and an inner circle that relates to an individual's genetic make-up (i.e. factors they cannot change such as age and gender) (Dahlgren & Whitehead, 1991). Examples of 'individual factors' are knowledge and self-efficacy, which can influence an individual's physical activity behaviour (Sallis, Owen, & Fisher, 2008). The social environment layer of the model suggests that significant others can influence physical activity behaviour, for example, family, peers and teachers (Sallis et al., 2008). The next layer, 'physical environment' suggests that factors such as; weather, facilities and safety might influence an individual's physical activity behaviour (Sallis et al., 2008). Finally, 'policy' is a key area as it can inhibit or promote physical activity as Local Authorities or Government usually develop relevant policy (Sallis et al., 2008). The Socio-ecological Model can help understand how each of these layers influences a child's likelihood to engage in physical activity including active play (the Socio-ecological Model applied to active play is discussed in section 5.2), and what may inhibit and/or promote these behaviours. Furthermore, interventions to promote physical activity should target multiple layers of the Socio-ecological Model for Health.

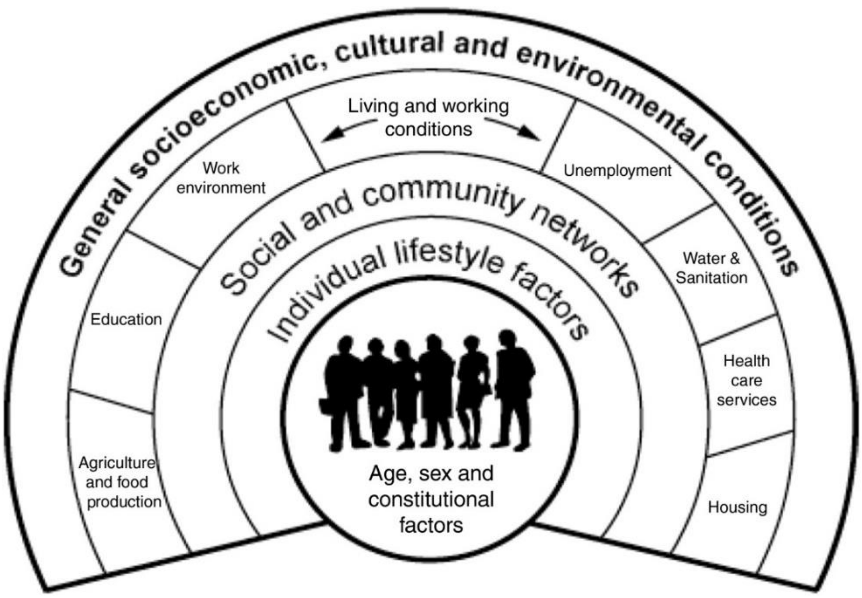

Figure 1. Dahlgren and Whitehead's Socio-ecological Model for Health

3.2 Stodden and Goodway's conceptual model

It has been hypothesised that to increase physical activity levels, FMS need to be developed in childhood. As mentioned in the introduction section of the present chapter, FMS are the basic skills required for more complex sports and physical activities; examples are, throwing, catching, running and jumping (Lubans et al., 2010). Stodden and Goodway (2007) presented a conceptual model which aimed to highlight the complex relationship between perceived and actual motor competence (or FMS), physical activity and weight status throughout childhood and adolescence (Stodden & Goodway, 2007). The model proposed that a lack of motor competence (or perceived motor competence) leads to low levels of physical activity and an unhealthy weight (Stodden & Goodway, 2007). Alternatively, a high level of motor competence (or perceived high level) is associated with increased levels of physical activity and thus leads to a healthy weight (Stodden & Goodway, 2007). Stodden and

Goodway suggested that children and adolescents who have higher motor competence are more likely to participate in sports and activities, resulting in increased levels of physical activity (Stodden & Goodway, 2007). Evidence of the relationship between FMS competency and physical activity is discussed in section 5.7 of the present chapter.

3.3 Physical Literacy

It is important that children establish a positive relationship with physical activity, and one concept that addresses this is physical literacy. Defined as, 'the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life' (International Physical Literacy Association, 2017), physical literacy is a concept first proposed in 1993 and gained further attention in 2001 with the work of Margaret Whitehead (Whitehead, 2001). The key elements described in the definition are interrelated and influence each other (Whitehead, 2010). Motivation to engage in physical activity can increase confidence and physical competence in those physical activities, and thus enhance motivation to continue engaging in physical activity (Whitehead, 2010). Increased confidence and competence allow an individual to partake in physical activity in a range of settings, which might be more challenging and thus further enhances confidence and competence (Whitehead, 2010). Finally, the ability to engage in physical activity across a range of environments and settings increases motivation and enhanced motivation encourages an individual to seek more challenges (Whitehead, 2010).

Recent emergent research in Canada has highlighted that Canadian children have low levels of physical literacy and this is affecting their physical activity levels

(Trembley et al., 2018; Belanger et al., 2018). The Canadian Assessment of Physical Literacy tool was developed to assess four domains: motivation and confidence, physical competence, knowledge and understanding, and physical activity behaviour (Francis et al., 2016). According to the Canadian Assessment of Physical Literacy tool, a total score of 100 can be given with physical activity behaviour and physical competence given more weighting (32 points each) than knowledge and understanding and motivation and confidence (18 points each) (Francis et al., 2016). Scores are interpreted into four categories: beginning, progressing, achieving, or excelling which are adjusted for age and gender (Francis et al., 2016).

Trembley et al. (2018) aimed to characterise children's physical literacy levels; 10,034 children aged 10.1 (± 1.2) years were recruited and had their physical literacy assessed using the Canadian Assessment of Physical Literacy tool. Findings suggested that boys scored a mean of 63.1 (±13.0) and girls scored a mean of 62.2 (±11.3) out of a possible 100 (Trembley et al., 2018). These scores classify the children at the 'progressing' stage, and given they scored just over half marks, their physical literacy levels are viewed to be low (Trembley et al., 2018).

In a separate study, Belanger et al. (2018) recruited 2956 children aged 10.6 years (± 1.2) to determine the relationship between physical literacy scores in Canadian children who meet the physical activity guidelines. Physical literacy was assessed using the Canadian Assessment of Physical Literacy tool and adherence to the guidelines was assessed using pedometers (Belanger et al., 2018). Findings suggested that only 20% of participants met the physical activity guidelines and those meeting the guidelines had significantly higher physical competence ($p <$ 0.0001; Cohen's d = 0.44) and motivation and confidence ($p < 0.0001$; Cohen's d =

0.39) (Belanger et al., 2018). The knowledge and understanding domain were not associated with guideline adherence (Belanger et al., 2018).

The findings from Canada highlight the need to enhance children's physical literacy levels, and as Whitehead (2010) suggested if a child has a positive relationship with physical activity from an early age, they are more likely to be a physically literate individual and maintain this relationship with physical activity as they mature into adulthood (Whitehead, 2010). Whitehead (2010) and Trembley et al. (2018) highlighted that active play was a natural way of developing children's physical literacy.

3.4 Summary

These models and concepts are important to understanding physical activity behaviour and how physical activity can be promoted. Each layer of the Socio-ecological Model for Health should be considered when trying to increase physical activity levels. Furthermore, a focus on developing children's FMS and ensuring they develop their physical literacy from a young age should enhance the likelihood of increasing children's physical activity levels further.

4. Domains of physical activity

Children can engage in physical activity through different domains including active transport, recess, physical education, sports participation and active play (Department of Health, 2011). Three of the domains active commuting to school, recess and physical education involve physical activity gained within school hours, and sports participation and active play can be engaged in both within and outside of school hours. Physical activity gained through active commuting, recess, physical education and sport will be examined in more detail in the subsequent sections, leading on to a separate discussion on how active play may be an important but neglected way of promoting physical activity and MVPA in children.

4.1 Physical activity gained through active commuting

Active commuting is usually defined as walking or cycling to and from school (Merom, Tudor-Locke, Bauman, & Rissel, 2006). Transport Scotland (2017) reported that 60% of primary school aged children actively commute to school and the HBSC (2015) reported a slightly lower figure of 46% among 11-15-year olds. However, the distance of the commute is often very short as the HBSC (2015) survey suggested that 43% of active commutes to school last approximately 5-15 minutes.

Martin et al. (2016) conducted a systematic review to determine the amount of objectively measured MVPA being accumulated while walking to and from school per day and how this contributed to children's total MVPA during a typical school day and non-school day. A total of nine studies were included for primary school aged children (Martin et al., 2016). When the studies were pooled, a mean MVPA of 17 minutes was gained per school day, which equated to 23% of children's daily MVPA being accumulated from commuting to school (Martin et al., 2016). However, when looking at this across the whole year, as children typically attend school for only half the year, this equated to 8 minutes of MVPA being accumulated commuting to and from school (Martin et al., 2016). Therefore, the potential to increase MVPA and physical activity levels solely through promoting active transportation to school may be minor, as the prevalence of active commuting to school is low, journeys are short, and children typically attend school on only 180-190 days per year. These conclusions are similar to Janssen (2014) who suggested that active commuting to school can make a useful contribution to daily MVPA for those who routinely commute, there is potential for only a limited improvement in total physical activity and MVPA unless there is a substantial increase in the prevalence of active commuting to school and to other locations, in the distances travelled to school, and the intensity of physical activity during the commute (Janssen, 2014; Martin et al., 2016).

4.2 Physical activity gained through recess

Recess (or school break times in the UK) may have a slightly greater influence on children's physical activity and MVPA levels as all children are provided with the opportunity to play during school break times five days a week.

In a systematic review conducted by Reilly et al. (2016b), the authors determined how much recess contributes to objectively measured MVPA in children and adolescents. Two relevant databases were searched and a total of 26 studies met the eligibility criteria, of which, 24 focussed on primary school children (Reilly et al., 2016b). When the studies were pooled the mean time spent in objectively measured MVPA was 12 minutes per school day (Reilly et al., 2016b). Given that children only spend half of their year at school, this equates to 6 minutes of MVPA per day being accumulated averaged over the whole year, which was less than active commuting.

However, with improvements made to recess, there may be further potential to increase physical activity and MVPA levels. Parrish, Okely, Stanley and Ridgers (2013) conducted a systematic review aimed at examining the effects of recess interventions school-aged children's physical activity levels. A total of nine RCT's (*n* =8) or controlled studies (*n* =1) were identified, each of which utilised different intervention strategies including, playground markings, physical structures, playground areas, loose-parts equipment or a combination of more than one of these to increase children’s physical activity levels (Parrish et al., 2013). With only nine studies included in the review, findings were inconclusive (Parrish et al., 2013). However, five studies demonstrated a positive effect (*n* =4 were statistically significant) on children’s physical activity levels with playground markings and equipment appearing particularly beneficial (Parrish et al., 2013). The studies that found significant intervention effects found a 4 to 13 % increase in mean MVPA during recess (Parrish et al., 2013). The other four studies either found no intervention effect (*n* =2) or a negative intervention effect (*n* =2).

For recess interventions to enhance children’s MVPA levels further, the duration of recess would need to increase or more strategies (such as equipment, playground markings) would have to be implemented. Implementation of these strategies may be difficult in Scotland given the reduced budgets schools have to spend on equipment and ‘wet play’ where children are often kept indoors when the weather is poor.

4.3 Physical activity gained through physical education

Primary school PE provides children with another opportunity to be physically active, but at present, Scottish policy states that children should only receive at least two hours of PE per week (Scottish Government, 2018). In primary, 99% of schools were provided at least 120 minutes of PE to all pupils; however, this was self-reported by the schools, therefore, it might be children are receiving less that the two hours as stated by Scottish policy (Scottish Government, 2018). Furthermore, given that children only attend school during half of their year, the contribution to children’s MVPA is likely to be small.

A systematic review by Hollis et al. (2016) determined the amount of time elementary children spend in MVPA during PE in studies published between 2005 and 2014. After searching relevant databases, 13 studies were found to be eligible, of which, only seven were included in the meta-analysis and only four utilised objective measurements (Hollis et al., 2016). The authors found that when the studies were pooled, children spend an average of 33% of their PE time in objectively measured MVPA, but as little as 12% of their time in PE was in MVPA in some studies (Hollis et al., 2016). One of these included studies, was a pilot randomised controlled trial conducted in Scotland (Fisher et al., 2011). At baseline, before the intervention began, the authors measured physical activity objectively and found that the intervention group spent 20% of their time in PE in MVPA and the control group only spent 9% (Fisher et al., 2011).

PE provides children with a small but useful contribution to their MVPA levels; however, given that they are only exposed to a maximum of two-hours per week for half the year, the potential for PE to increase MVPA further is limited. Therefore, unless the duration, frequency or intensity of PE was increased then PE is unlikely to enhance children's MVPA further.

Overall, school based physical activity domains collectively make a useful contribution to children's physical activity and MVPA levels, but only on the days they attend school. Furthermore, evidence has suggested children's fitness and physical activity levels often decline during the summer holidays (Carrel, Clark, Peterson, Eickhoff & Allen, 2007). Therefore, to increase physical activity outside school hours, more focus may need to be given to physical activity domains that can be engaged in both during and outside of school. Sport and active play are two physical activity domains that may be useful in increasing children's daily MVPA. Sport will now be discussed before reviewing the evidence for active play as a way of helping children achieve the recommended amount of MVPA.

4.4 Physical activity gained through organised sport

According to the Scottish Health Survey (2017), 67% of children and adolescents (2-15 years) participated in sport at least once per week, and the Scottish Schools Adolescent Lifestyle and Substance Use Survey (SALSUS) (2017) reported 66% of 13-15 year olds (75% for boys and 58% for girls) reported 'doing a sport' at least once a week. The Scottish Health Survey (2017) also found that sports participation was lower among children from deprived areas with children from the most deprived areas reporting participating in sport at least once a week, 23% less than those from the least deprived areas. It should be noted that both surveys are based on subjective measures, they do not report how many sport sessions per week on average, or measure time spent in MVPA during the sports sessions.

The evidence surrounding the contribution of sport to children's daily MVPA is limited and unlike the previous sections on active commuting, recess and PE, a systematic review summarising this research could not be found. A study conducted by Brazendale et al. (2015) aimed to determine the amount of time children spend in objectively measured MVPA during an hour's session of commonly played sports and activities. Of the sports reviewed, they found that during soccer children spent 29% of their time in MVPA and during dodgeball they spent 34% (Brazendale et al., 2015). Although there are a vast number of sports children can engage in, and these are only two examples, they do suggest that they may provide a useful contribution to children's MVPA, but surveillance needs to be improved to clarify this.

However, there are also many barriers to participating in sport (Basterfield, et al., 2016; Eime, Young, Harvey, Charity, & Payne, 2013). Basterfield et al. (2016) highlighted that parents of English primary school children often cite time, money or transport as reasons why their children do not participate in sport. Furthermore, in this study children highlighted the negative consequences of participating in sport including, a dislike of sport, feelings of exclusion and lack of competency (Basterfield, et al., 2016). Findings from Basterfield et al. (2016) highlight that there are still many restrictions to participating in sport.

4.5 Summary of physical activity gained through active commuting, recess, physical education and sport

Physical activity gained through schools has its benefits, including engaging all children to increase their MVPA levels, particularly those children who would not otherwise engage in structured and/or unstructured physical activity outside school hours (Dobbins, De Corby, Robeson, Husson, & Tirilis, 2009; Story, Nanney, & Schwartz, 2009). Encouraging MVPA through active commuting, recess and physical education provide a useful contribution to helping children achieve the physical activity guidelines, but the amount of MVPA being accumulated in these domains is small and is less than the recommended 60 minutes/day (Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016a).

Encouraging physical activity that children can engage in during and outside of school may provide an additional opportunity to be physically active and increase children's MVPA, and one type is sport. The evidence on the contribution sport has on children's MVPA is limited, but a relatively high proportion of children report participating in sport at least once per week, and some types of sports generate reasonable levels of MVPA (SALSUS, 2017; Scottish Health Survey, 2017).

However, sport often requires parents to transport their children to a venue to participate, or the costs can often result in many children, particularly those from a lower SES, not being able to participate (Basterfield, et al., 2016).

This leads to the consideration of active play, which has been a physical activity domain that has been a neglected area of research thus far. This is discussed further in Chapter 3. Children nowadays have swapped some active play time for screen time (Marshall, Gorely & Biddle, 2006) and this is impacting their adherence to the physical activity guidelines and their psychological wellbeing (Page, Cooper, Griew & Jago, 2010). But active play may have the potential to increase MVPA levels across most of the child population given that it could potentially be engaged in 365 days of the year, both during and outside school hours (Janssen, 2014). Therefore, the evidence surrounding active play, including the barriers and facilitators, its benefits and in particular how active play interventions might be important to address the low levels of physical activity and MVPA will now be discussed.

5. Active play

5.1 Definition

The importance of play is outlined in the United Nations (UN), ‘Rights of the Child’; article 31 states that every child has the right to engage in all types of play (UN General Assembly, 1989). There are many different types of play that children can engage in, but active play is most likely to increase levels of physical activity and MVPA, thus helping children to achieve the physical activity guidelines. The definition of active play, along with other related types of play are presented in Table 1. Although there is no consensus on the definition of active play, a recent systematic review proposed that active play is “a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner” (Truelove et al., 2017). Many definitions remain in the literature but as the systematic review by Truelove et al. (2017) aimed to promote a working definition for researchers, the above definition will be used for the purposes of this thesis. The following sections will detail the facilitators and barriers to active play and then review the benefits it has on increasing physical activity, particularly MVPA, and improving fundamental movement skills, cognition and attainment.

Table 1. Common definitions of play types related to active play

Active play	“a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner” (Truelove et al., 2017).
Free play	“behaviour that is freely chosen, personally directed and intrinsically motivated”. (Scottish Government, 2013)
Outdoor play	“unstructured physical activity that takes place outdoors in the child’s free time” (Veitch et al., 2006)

5.2 Facilitators and barriers to active play

The potential of active play on increasing children’s MVPA levels is discussed in section 5.4, but firstly it is important to explore the barriers and facilitators to widen the understanding of the factors influencing why children do and do not engage in active play. The barriers and facilitators are discussed in relation to the policy, physical environment and social environment layers of the Socio-ecological Model for Health (Sallis et al., 2008; Dahlgren & Whitehead, 1991).

The Scottish Government (2013) published the first Scottish policy document specifically related to play in 2013. The national play strategy highlighted the benefits of play and the importance of promoting play opportunities at home, in school and in the community (Scottish Government, 2013). The most recent Active Healthy Kids Report Card highlighted that Scotland had a generally favourable environment for active and outdoor play, with relatively good access to places to play outdoors and relatively low perceived concerns about the safety of playing outdoors (Reilly et al., 2013). The data source this was taken from was the Scottish Household Survey (2015), which highlighted that 91% of parents reported that their children had at least one place to play; however, only 64% of parents felt it was safe for their children to play at a park with 2 or 3 friends. Parental concerns are often cited as a reason for limiting children's outdoor active play. In Scotland, the youngest age parents consider it would be safe for a child to play without supervision is 9 years old for streets nearby their homes and 10 years for the playground and park, which might indicate low levels of unsupervised active play in Scottish children under 9 years (Scottish Household Survey, 2015). In a qualitative study conducted in Australia, 94% of parents of children aged 8 years old had safety concerns regarding their children playing outside without adult supervision with concerns of strangers the main reason given (Veitch, Bagley, Ball, & Salmon, 2006). This study also divided the participants into low (n =23), medium (n =35) and high (n =20) socioeconomic status. Findings suggested that parental safety concerns were greater in areas with higher deprivation (Veitch et al., 2006). In the Scottish

Household Survey (2015), parents of children living in the 20% most deprived areas were 12% less likely to think it was safe for their child to play at the park with two or three friends compared to the Scottish average (64%).

As well as parents, peers, teachers, nursery workers, after school care and playworkers can also promote (or inhibit) children's active play (Scottish Government, 2013). Some research suggests that children influencing each other can have an impact on increasing children's active play and physical activity (Whitebread, 2012; Jago et al., 2011). In the qualitative study mentioned previously by Veitch et al. (2006), 40% of parents reported that the absence of a nearby friend was detrimental to their child playing outdoors. This was echoed in a qualitative study by Brockman, Jago and Fox (2011) who also reported that children perceived play as 'participating with nearby friends.

Parents and teachers are often concerned about children injuring themselves when playing. The recent Position Statement on Active Outdoor Play (Tremblay, et al., 2015), which utilised two systematic reviews conducted by Gray et al. (2015) and Brussoni et al. (2015) (further explained in section 5.4 of the present chapter) to inform its findings, highlighted that injuries do occur during play, but most are minor (bruising, sprains etc.). More serious injuries such as fractures are less common, and in fact, the Position Statement highlighted for every 10, 000 hours of playing, there were only 1.5 injuries (Tremblay, et al., 2015; Nauta, Martin-Diener, Martin, Van Mechelen and Verhagen, 2015). Although active play is the domain of physical activity that could be engaged in 365 days of the year and is being encouraged in Scotland through policy, there are barriers, such as parental safety concerns (physical and social environment), that may prevent them from doing so. Therefore, tackling parental perceptions, ensuring there are safe places to play and allowing children to play with their friends might ensure more children are engaging in active and outdoor play more often and receive the associated health benefits.

5.3 The benefits of active play

Physical activity levels are typically low in children from high-income countries, and efforts to increase physical activity levels have typically focussed on recess, active commuting and physical education, which have made limited improvement to children's habitual physical activity and MVPA levels (Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016a). Therefore, the benefits of active play as a way of promoting physical activity levels (particularly MVPA) will be discussed further, followed by other potential benefits of active play, such as fundamental movement skills, cognition and attainment.

5.4 Effects of active play on physical activity and MVPA

There is increasing awareness of the possibility that increased engagement in active play has the potential for population wide gains on children's habitual physical activity and MVPA levels given that it can be engaged anywhere for extended periods of time, 365 days of the year (Janssen, 2014). The Active Healthy Kids Report Card assesses the performance of children and adolescents in a range of physical activity behaviours (sports participation, PE, active commuting and active play) (Tremblay et al., 2014; Tremblay et al., 2016b). It was first developed in Canada, and in 2016, was replicated in 38 other countries (Global Matrix). The Report Card uses a grading system (A = 81-100%, B = 61-80%, C = 41-60%, D = 21-40%, F = 0-20%), which are assigned depending on the proportion of children achieving a benchmark for each physical activity behaviour (Tremblay et al., 2014).

For example, if 81-100% of children were achieving the benchmark for physical activity guidelines (overall physical activity) they would receive an 'A' grade. A recent study by Janssen (2014), examined how much energy an average Canadian school-aged child (6-11 years of age) would expend if they were to improve each of the physical activity behaviours included in the Canadian Active Healthy kids Report Card by one grade. Key findings from Janssen (2014) were that active play is the domain of physical activity in which school-aged children expend the most energy (186 kcal/ day) and which could make the greatest contribution to reaching the Active Healthy Kids Report Card benchmarks. Whereas sports participation (23 kcal/day), active commuting (16 kcal/day) and physical education (6 kcal/day) had much less potential for increasing children's habitual physical activity levels (Janssen, 2014). Furthermore, if one hour spent in front of the screen was replaced by active play then Janssen (2014) estimated that an additional 49 kcal/day would be expended. Janssen (2014) concluded that active play is imperative in the fight against low levels of MVPA, total physical activity and childhood obesity.

The 2016 Active Healthy Kids Report Card compared the grades for active play across the 38 countries involved (Global Matrix 2.0). The benchmark for active play is the percentage of children and youth who engage in unstructured/unorganised active play for several hours a day and grades are assigned depending on the proportion of children achieving that benchmark (as described in the previous paragraph) (Tremblay et al., 2016b). The active play grades for the countries involved in the Global Matrix 2.0 is presented in Table 2. The most interesting finding is that only 17 countries of the 38 who produced a report card in 2016, could provide a grade for active play (Reilly et al., 2016a; Tremblay et al., 2016b).

Scotland was one of those countries who could not grade active and outdoor play because we are not adequately measuring how many children are participating in daily active play and how many hours they are engaging in active play for (Reilly et al., 2016a). If active play is to be promoted, then better surveillance on the percentage of Scottish engaging in active play regularly and how many of hours for, is required to understand more about this behaviour in a Scottish context (Reilly et al., 2016a). Furthermore, findings from the 2016 Active Healthy Kids Report Card for Scotland highlighted that Scotland had good infrastructure for physical activity (B grade), but this did not translate to a high grade for overall physical activity (F grade) (Reilly et al., 2016a; Tremblay et al., 2016b). A logical solution is to encourage active and outdoor play, which should require little or no infrastructure.

Table 2. Global Matrix 2.0 active play grades per country

Active Play Grade	**Country**
B	Ghana, Kenya, Netherlands
B-	New Zealand
C+	Belgium, Spain
C	Finland, Nigeria, Wales
D+	Canada, Zimbabwe
D	Mozambique, Portugal, Slovenia
D-	China, Mexico
F	Thailand
INC	Australia, Brazil, Chile, Colombia, Denmark, England, Estonia, Hong Kong, India, Ireland, Japan, Korea, Malaysia, Poland, Qatar, Scotland, South Africa, Sweden, United Arab Emirates, United States, Venezuela

As previously mentioned, two systematic reviews were published in 2015 to inform the Canadian Outdoor Play Position Statement (a review and policy document for the lay public), which aimed to bring together evidence on the benefits of risky outdoor play and active play (Tremblay et al., 2015; Brussoni et al., 2015; Gray et al., 2015). The first systematic review by Brussoni et al. (2015) looked at the relationship between risky outdoor play and children's health. Risky outdoor play was defined in the review as 'thrilling and exciting play that can include the possibility of physical injury', including; play at height and speed, rough and tumble play and play where a child can disappear (Brussoni et al., 2015). Of the 21 eligible studies included in this systematic review, six reviewed the relationship between risky play and physical activity, and in all six there was evidence of a relationship between risky play (specifically independent mobility) and increased total physical activity or MVPA (Brussoni et al., 2015). However, all six of these studies were observational and lacked objective measurement of physical activity and MVPA (Brussoni et al., 2015). The other review used to inform the Canadian Outdoor Play Position statement was conducted by Gray et al. (2015) and examined the relationship between outdoor time and physical activity and sedentary behaviour. Of the 28 eligible studies included in this systematic review, 16 looked at the relationship between outdoor time and habitual physical activity and all reported a positive relationship, with greater exposure to outdoor time being associated with higher levels of physical activity (Gray et al., 2015). However, all but one study had a cross sectional design and only seven measured physical activity using an accelerometer (Gray et al., 2015). The findings from these two systematic reviews concluded that risky and active outdoor play are essential for good childhood health (by increasing physical activity and, decreasing sedentary behaviour, among other outcomes) (Brussoni et al., 2015; Gray et al., 2015; Tremblay et al., 2015).

Cooper et al. (2010) also investigated whether outdoor time was associated with objectively measured physical activity in English adolescents. Participants (*n* =1010, mean age 11 ± 0.4 years) wore an ActiGraph accelerometer to measure physical activity and a GPS device to track outdoor time, both of which are robust, objective measures (Cooper et al., 2010). The authors found that total physical activity (cpm) was significantly higher when children were outdoors than indoors (Cooper et al., 2010). Counts per minute (cpm- a measure of the total volume of physical activity) ranged from 966 to 1431 when children were outdoors, and from 388 to 609 when they were indoors. However, the authors did not report how much time was spend in MVPA (Cooper et al., 2010). King et al. (2011) reviewed the correlates of objectively measured physical activity in 480 English children aged 7 years (244 boys/236 girls). The authors found that children's perceived interest of active play was positively correlated (p <0.001) with objectively measured habitual physical activity (King et al., 2011). However, they did not objectively measure the proportion of time spent in active play, they only measured children's interest in active play.

Brockman, Jago and Fox (2010) conducted research within the UK on the prevalence of active play and the association between self-reported active play and objectively measured MVPA in 10-11 year olds (*n* =747). Findings suggested that boys and girls who reported participating in active play five or more times a week achieved an average of 44 and 34 minutes of total MVPA per day, respectively (Brockman et al., 2010). Whereas girls who reported that they never participated in active play, participation in MVPA was lower at 27 minutes/day and boys who reported never engaging in active play achieved an average of 39 minutes of MVPA per day, which is only slightly lower than those reporting five days or more (Brockman et al., 2010). Moreover, Brockman et al. (2010) suggested that participating in regular active play (5 days a week) was associated with significantly higher mean total physical activity (cpm) across the whole week (boys $p < 0.01$, girls $p < 0.01$).

In an interesting study conducted by Brazendale et al. (2015) in the USA (previously discussed in section 4.4 of the present chapter), the authors determined the amount of time children spent in MVPA during an hour's session of commonly played sports and activities. One of these activities was free play, where the activity leaders gave children basic equipment to play with; unusually the free play was indoors unlike active play, which normally occurs outdoors (Brazendale et al., 2015). Nonetheless, findings suggested that children spent an average of 35% of their time in MVPA during an hour's session of free play, which was higher than the average percentage of time spent in MVPA for other sports and activities including, soccer (29%), kickball (17%), tag games (21%), dodgeball (34%) and relay races (21%) (Brazendale et al., 2015). Findings of this study suggest that free play (where children are free to play with equipment with little adult involvement) can generate more MVPA compared to sports such as soccer and dodgeball, where often the assumption is that sport would produce a higher level of MVPA (Brazendale et al., 2015). The study by Brazendale et al. (2015) had a relatively large sample size of 267 children (mean age 7.5 years) and utilised accelerometers, the preferred method to measure physical activity; however, the findings might not be generalisable to the rest of the population as it was conducted in one setting, in the USA.

In summary, evidence suggests that outdoor time is associated with higher MVPA and physical activity levels; active play is the domain of physical activity that is often engaged in outdoors and children's interest in active play is associated with increased physical activity and MVPA levels. Furthermore, children who report participating in active play 5 days a week engage in higher levels of total physical activity (Brockman et al., 2010), and it is often engaged in at a higher intensity compared to other sports and physical activities (Brazendale et al., 2015).

Given the low levels of physical activity in children from high-income countries (Tremblay et al., 2016b) and the potential for population-wide gains in habitual physical activity and MVPA from the promotion of active play (Janssen, 2014), it might be that interventions utilising active play are required to increase levels of MVPA and physical activity.

5.5 Effects of active play interventions on physical activity and MVPA

Chapter 3 of this thesis presents a systematic review of controlled active play interventions to promote physical activity, which indicate improvements in total physical activity and MVPA levels; however, few interventions exist (Johnstone, Hughes, Martin, & Reilly, 2018). Chapter 5 of this thesis is a pragmatic evaluation of a school-based Active Play intervention which proved promising in terms of improvement in physical activity and FMS and was, therefore, evaluated using a more robust design (Chapter 6) to form the basis of a larger definitive trial (Johnstone, Hughes, Janssen, & Reilly, 2017).

In addition to the school-based Active Play intervention discussed, this section of the present chapter will review interventions that have utilised active play to increase children's physical activity and MVPA and these were also included in the systematic review (discussed in more detail in Chapter 3).

Goldfield et al. (2016) examined the effects of a 6-month active play intervention on children's (mean age 3.4 years) physical activity levels. The intervention took place in a pre-school where staff received educational workshops designed to inform and encourage them to allow children to have more active and outdoor play (Goldfield et al., 2016). Time spent in physical activity and MVPA during the preschool day was measured using an Actical accelerometer at baseline and follow-up (Goldfield et al., 2016). Findings suggested that there was a statistically significant increase in total physical activity (minutes/ preschool day) in the intervention group compared to the control group (p = 0.002; 95% CI: 8.9, 36.1), but MVPA (minutes/ pre-school day) did not significantly increase in the intervention group compared to the control (p= 0.085; 95% CI: -1, 14) (Goldfield et al., 2016). In the intervention group, total physical activity increased by 19 minutes/preschool day and MVPA increased by 12 minutes/preschool day (Goldfield et al., 2016).

An intervention by Engelen et al. (2013) targeted primary school aged children (6 years old) in a playground setting. The 13-week intervention involved two information sessions for staff who were on playground duties to improve their knowledge on physical activity and active play, and loose parts equipment (recyclable materials such as tyres, crates, plastic bottles etc.) was provided during break times to encourage active play (Engelen et al., 2013). School day physical activity was measured using an ActiGraph accelerometer at baseline and then again at follow-up 13-weeks later (Engelen et al., 2013). There was no significant increase in time spent (minutes/school day) in MVPA (p = 0.19) in the intervention group vs the control group (Engelen et al., 2013). Both of these active play interventions were cluster RCTs but had small participant numbers and physical activity was only measured during the school day.

Outside of the school day, O'Dwyer, Fairclough, Knowles and Stratton (2012) conducted a 10-week community family-based active play intervention to determine if English children aged 3.8 (0.6) years increased their objectively measured physical activity (O'Dwyer, et al., 2012). Families (n =77) were randomly allocated to either the intervention or control group and the intervention group received 20 minutes of an education component (parents only) and 40 minutes of active play (children and parents) (O'Dwyer, et al., 2012). O'Dwyer et al. (2012) found a significant intervention effect in the intervention group compared to the control group for time spent in total physical activity on a weekday (+4.70; CI: 2.96 to 9.44) and weekend (+10.24; CI: 10.24 to 18.08). MVPA was not measured in this study.

These three studies are included in the systematic review and the effect of these active play interventions on physical activity and MVPA is reviewed in more detail in Chapter 3.

5.6 Summary of the effects of active play and active play interventions on physical activity and MVPA

Active play has been suggested to have population wide gains on children's physical activity and MVPA as it can be engaged in all year round, at all times of the day. However, there are important barriers to participating in active play, including, parental safety concerns. Active play is often engaged in outdoors and outdoor time is associated with increased levels of physical activity. When children engage in active play and free play, it is typically engaged at MVPA and recent active play interventions seem to be promising in increasing physical activity levels.

Active play has benefits beyond increasing physical activity levels; the potential effects of active play on fundamental movement skills will now be reviewed.

5.7 Effects of active play on fundamental movement skills

FMS are usually characterised by object control and locomotor skills, defined as the manipulation of an object using a part of the body and travelling from one place to another, respectively (Lubans, et al., 2010). There is a consensus amongst researchers that being competent in FMS improves the child's ability to master basic movements required for more complex sports and physical activities which may increase physical activity levels as children mature; however, there is no substantial and consistent empirical body of evidence to support this (Hardy et al., 2012).

As previously described in section 3 of the present chapter, the conceptual model by Stodden and Goodway (2007), suggested that perceived or actual motor competence (or FMS) in childhood may be related to physical activity levels and weight status (i.e. a high level of motor competence is associated with increased levels of physical activity and a healthy weight). Robinson et al. (2015) conducted a narrative review examining the published evidence that relates to components of Stodden and Goodway's conceptual model. The evidence discussed highlighted that motor competence (or fundamental movement skills) had a positive association with physical activity in children and adolescents (Robinson et al., 2015).

One of the studies included in Robinson et al's (2015) narrative review was a systematic review conducted by Lubans et al. (2010) which aimed to review the evidence between FMS and physical activity levels and other health related outcomes. Of the 21 eligible studies, 13 studies looked at the association between FMS and physical activity and of the 13 studies, 11 showed a positive association with physical activity (Lubans et al., 2010). However, the strengths of these associations were not provided (Lubans et al., 2010).

Robinson et al. (2015) also included a more recent systematic review examining the associations between physical activity and FMS (Logan, Kipling Webster, Getchell, Pfeiffer and Robinson, 2015). Of the studies included in the review, 12 reported a positive correlation between FMS and physical activity, but the strength of these correlations varied ($r = 0.16$ to $r = 0.55$) (Logan et al., 2015).

In summary, Stodden and Goodway (2007) suggested that perceived or actual motor competence (or FMS) is associated to physical activity levels and two separate systematic reviews have supported these associations (Lubans et al., 2010; Logan et al., 2015).

Despite the apparent positive associations between FMS and physical activity in children and adolescents, many Western children have been found to have poor FMS. Hardy et al. (2012) assessed seven FMS in a large sample of Australian children and adolescents (n =6917, 7-14 years) and found that the percentage of children and adolescents who had low competency in all FMS ranged from 46% in boys aged 14 years to 98% of girls aged 9 years (Hardy et al., 2012). Furthermore, low competency of FMS was worse in those from low socio-economic backgrounds and those who had poor cardio-respiratory fitness (Hardy et al., 2012). The

Australian Active Healthy Kids Report Card (methodology for report card presented in section 5.4) added a FMS indicator to their 2016 report card (Schranz et al., 2016). They utilised data from the Australian Schools Physical Activity and Nutrition Survey of over 7000 children and adolescents, in which participants had four locomotor and three object control skills assessed (Hardy, King, Espinel, Okely, & Bauman, 2011; Schranz et al., 2016). The report card assigned Australian children a grade 'D' for their FMS (Schranz et al., 2016). More specifically, 23% of boys and 29% of girls demonstrated mastery (can perform all components of the skill) in the locomotor skills and 43% of boys and 17% of girls demonstrated mastery in the object control skills (Hardy et al., 2011; Schranz et al., 2016).

Much of the surveillance of children's FMS has been conducted in Australia and there has been no national survey measuring children's FMS in Scotland. However, based on evidence presented from Australia, it appears that FMS competency is low and, therefore, interventions are required to improve children's FMS.

Robinson et al. (2015) suggested that children could only develop their FMS through structured activities. However, recent intervention studies have utilised active play interventions to promote FMS in pre-school aged children and may have been successful (Adamo et al., 2016; Jones et al., 2011). Jones et al. (2011) delivered a 20-week structured FMS intervention which also utilised unstructured activities to improve pre-school aged children's (4 years old) FMS. Findings suggested that total FMS score significantly increased in the intervention group (n =52) compared to the control group (n =45) ($p < 0.001$; 6 month difference = 2.08; 95% CI: 0.76, 3.4) (Jones et al., 2011). A study conducted by Adamo et al. (2016), which is the same study by Goldfield et al. (2016) mentioned in the previous section on physical activity, examined the effect of an active play intervention (by encouraging preschool staff to provide the children with more opportunities for active and outdoor play) on FMS. Results highlighted a statistically significant increase in the intervention group compared to the control for total FMS score (p = 0.025; ES =0.59) and percentile (p = 0.020; ES =0.61) (Adamo et al., 2016). The intervention group increased their total score by 4.2 (CI: 0.5, 7.9) and of 9.6 (CI: 1.3, 18.0) for percentile (Adamo et al., 2016). The study by Adamo et al. (2016) was included in the systematic review and the effect of this active play intervention on FMS is reviewed in more detail in Chapter 3.

Roach and Keats (2018) compared two separate 8-week interventions (2x 45 minute sessions) to a free play control group in children aged 3-5 years. The interventions were a skill-based intervention involving an instructional approach to developing FMS where children rotated around stations that targeted various skills and a planned active play intervention that utilised fun games to develop FMS (Roach & Keats, 2018). Findings suggested a statistically significant intervention effect ($p < .05$) for the skill-based intervention and the planned active play interventions but no improvements in the control group (free play). However, attendance was significantly higher in the free play group (p = 0.002) and planned active play group (p =0.03) compared to the skill-based group, which may indicate that participants preferred the more play-based approaches. However, there was small participant numbers in each of the groups: free play (n =19), active play (n =16), skill station (n =16), which mean findings should be interpreted with caution.

In summary, the evidence base for active play interventions in improving children's FMS is limited and further research is required to determine the potential of active play in improving children's FMS.

5.8 Effects of active play on cognitive performance and educational attainment

Cognition is "any process that allows an organism to know and be aware" (Tomporowski et al., 2015). The relationship between physical activity on children's cognitive performance is an area of research that is gaining increasing interest. Systematic reviews have demonstrated positive associations between the effect of both acute (e.g. effects of participating in a single physical activity session) and chronic (e.g. effects of a 10-week intervention) effects of physical activity on cognitive performance and attainment (Rasberry et al., 2011; Verburgh, Königs, Scherder, & Oosterlaan, 2014), and physical activity interventions have also found cognitive improvements (Vazou, Pesce, Lakes, & Smiley-Oyen, 2016).

It has been hypothesised that engaging in MVPA that is also cognitively engaging (i.e. targets FMS development) improves executive functions (see Figure 2), which would then lead to improvements in educational attainment (particularly maths) (McMorris et al., 2009; Tomporowski et al., 2015). Tomporowski et al. (2015) defined executive functions as "the capacity to think before acting, retain and manipulate information, reflect on the possible consequences of specific actions, and self-regulate behaviour". Types of executive functions include working memory, inhibition, planning, attention and problem solving (Tomporowski et al., 2015; Booth et al., 2014; Diamond, 2013; Guiney & Machado, 2013) and are required in many areas of learning including, mathematics, literacy, reading and science. In physical activity research, inhibition (defined by Tomporowski et al., 2015 as "the ability to withhold actions or modify behaviours") and maths related attainment are commonly used methods of assessing executive functions and attainment in children (Donnelly et al., 2016).

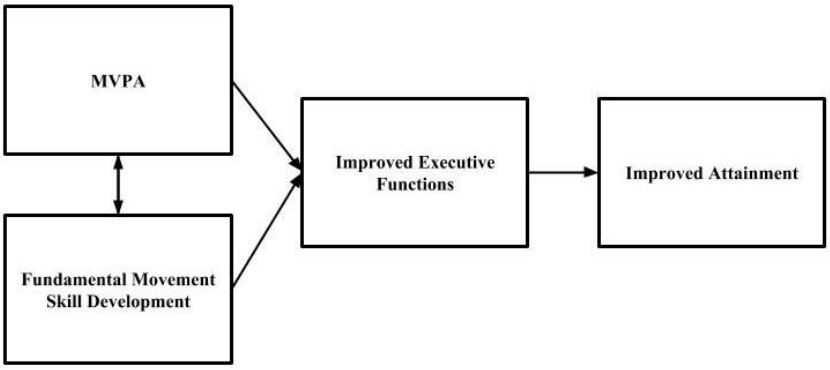

Figure 2. Diagram highlighting how a combination of high intensity physical activity and FMS development (or motor skills) can enhance children's executive functions (redrawn from Tomporowski et al., 2015).

Hillman et al. (2014) aimed to determine the effects of the FITKids intervention on children's executive functions. This was a 9-month intervention involving children aged 8-9 years (intervention n = 109; control n = 112), in which they participated in a two-hour afterschool physical activity programme per day (Hillman et al., 2014). Inhibition was assessed using a Flanker Test and results indicated a significant improvement in reaction time (32.0 milliseconds, 95% CI: 6.9 to 57.2) in the intervention group compared to the control group from baseline to follow-up.

Donnelly et al. (2009) examined the effect of a three-year physical activity intervention on academic achievement. The intervention consisted of 90 minutes of academic active lessons that were spread throughout the school week (Donnelly et al., 2009). Attainment (i.e. reading, writing, maths and oral language) was measured using the Wechsler Individual Achievement Test-2nd Edition (WIAT-II) (Donnelly et al., 2009). The authors found significant improvements in attainment (reading, writing, maths and oral language) in the intervention group compared to the control group, with the biggest improvements in maths (+7 score in maths) (Donnelly et al., 2009).

Interventions looking at the effect of MVPA on executive functions and attainment have provided evidence to support the aforementioned hypothesis. In the Medical College of Georgia trial, participants (n =222 aged 7-11 years; overweight BMI >85th percentile) were assigned to two exercise conditions: low dose (20 minutes/day) or high dose (40 minutes/day) and a control group received an educational component (McMorris et al., 2009). The exercise conditions were high intensity (measured using heart rate monitors) and focused activities that would include all participants and be enjoyable (McMorris et al., 2009). Executive functions and maths attainment were assessed, and the authors reported a dose response relationship with planning (p = 0.015), but not math's achievement (p =0.06) (McMorris et al., 2009). There were no significant intervention effects for other executive functions, but the authors did find significant effects on maths fluency (p = 0.01) (McMorris et al., 2009).

Play is vital in the development of children's brain structure and functioning (i.e. important for developing executive functions) (Yogman et al., 2018). Active play is a type of physical activity which is particularly likely to promote MVPA (Janssen, 2014) and, therefore, likely to improve children's cognitive performance (Pesce et al., 2016; Tomporowski et al., 2015). This concept has been supported in recent studies which have reported associations between active outdoor play and cognitive outcomes in primary school aged children (Pesce et al., 2016). Pesce et al. (2016) conducted a 6-month cluster RCT that determined the effect of an enhanced PE intervention on motor coordination and cognition (inhibition and working memory). Classes were randomised to either the intervention (18 classes, *n* = 232 participants) or control (18 classes, *n* =228 participants) (Pesce et al., 2016). The intervention involved a 1-hour session of enhanced PE, which involved a deliberate play approach of cognitively engaging fun games delivered by a PE specialist and the control group received normal PE (Pesce et al., 2016). Motor coordination was assessed using the Movement Assessment Battery for Children (M-ABC) and cognition (inhibition and working memory) was assessed using the RNG task (number sequencing game), the researchers also measured participant's frequency in outdoor play outside of school hours using a questionnaire (Pesce et al., 2016). Findings indicated significant improvements in motor coordination in the intervention group compared to the control group: manual dexterity (p =0.03), ball skills (p =0.05), static/dynamic balance (p =0.03) (Pesce et al., 2016). Of the cognitive outcomes, only inhibition improved in the intervention group compared to the control group (p =0.03) (Pesce et al., 2016) with no improvement in working memory. The measurement of outdoor play was also suggested to be a mediating factor, for example, the intervention effects were more pronounced in children who reported playing outdoors more frequently (Pesce et al., 2016). Indicating that outdoor active play might play a pivotal role in both FMS development and cognitive performance.

In summary, it seems that MVPA that is cognitively engaging is particularly likely to stimulate cognitive performance and thus improve educational attainment.

Physical activity interventions have suggested possible improvements to cognition and attainment, particularly inhibition and maths performance. It might be that active play is particularly likely to produce these benefits given that it is a domain of physical activity that is often engaged in at a moderate to high intensity. A study conducted by Pesce et al. (2016), suggested that outdoor active play might play a pivotal role in improving children's cognition.

5.9 Co-benefits of active play

Active play is also likely to have benefits beyond the scope of the present thesis, but nonetheless important, such as social and emotional development. These will be briefly discussed in the present thesis to add to the knowledgebase of active play for researchers who may want to investigate additional outcomes in the future, and to set the thesis work in a wider context.

The importance of play and its wider benefits have recently been discussed in the American Academy of Paediatrics, 'Power of Play' report which aimed to highlight the benefits of play and the importance for paediatric providers to promote more play opportunities (Yogman et al., 2018). The social and emotional benefits of playing with parents and peers were discussed (Yogman et al., 2018). When children play with their friends, they are continuously navigating conflict, such as what game to play and what the rules are (Yogman et al., 2018). This encourages children to problem solve, cooperate and communicate, which are skills required throughout childhood and into adulthood and ultimately enable an individual to foster better relationships in their life (Burdette & Whitaker, 2005). Children who are not allowed time to play freely exhibit greater levels of anxiety and depression in adulthood (LeMoyne & Buchanan, 2011; Schiffrin et al., 2014). Gray (2011) suggested a possible link between generational increases in anxiety and depression and the reduction of play over this time, which may affect an individual's ability to control their emotion and have a lower quality of life (Gray, 2011). Quality of life could be enhanced by the introduction of active play interventions. Hyndman, Benson, Ullah and Telford (2014) conducted a 7-week intervention to determine if increased active play opportunities (provision of loose parts equipment in the school playground) improved quality of life. Participants were 123 children (7.0 years ±1.9) in the intervention group and 152 children (mean 8.2 years ±2.1) in the control group (Hyndman et al., 2014). Although findings suggest a non-significant effect on children's mean psychosocial quality of life in the intervention group compared to the control (+5.46; 95% CI: -0.22-11.14, $p = 0.06$), there was an improvement and the significance was borderline. It might be that a longer active play intervention is required to improve quality of life.

In summary, it appears that play and active play is important for enhancing children's social and emotional skills and this has been summarised in the Canadian Position Statement on Active Outdoor Play (Tremblay et al., 2015).

6. Conclusions

To conclude, levels of physical activity and MVPA are low in many children from high-income countries; with the known negative health consequences, it is vital that physical activity and MVPA are increased so children can gain the desired benefits. Recent systematic reviews have highlighted that recess, active commuting and PE currently only make an important but relatively small contribution to supporting children to achieve the physical activity guidelines ((Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016b). Furthermore, there is little scope for these domains to increase children's MVPA levels further, particularly as these are school-based domains and school only accounts for around half of days of the year (Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016b; Janssen, 2014). Organised sport might provide more potential for increasing MVPA levels, but it can be expensive and requires parents to transport children to and from sessions (Basterfield, et al., 2016).

One potential strategy to increase physical activity, which requires further investigation, is active play. As argued by Janssen (2014), the potential for active play as a way of promoting MVPA in children is huge as it is the type of physical activity children can engage in for extended periods of the day and is less restrictive than other domains of physical activity (i.e. it can be engaged in 365 days of the year). Few studies have examined the effect of active play on children's physical activity and MVPA levels as discussed later in this thesis, but evidence so far has suggested that it may be promising. Furthermore, active play might be a good way of developing FMS, which are associated with increased levels of physical activity. Emergent research has also suggested a link between MVPA, FMS and enhanced cognition (important for attainment) and given that active play is often engaged in at a higher intensity, it may be an important way of enhancing children's cognition. However, despite this conceptual and empirical case for more active play interventions there seems to be relatively little empirical evidence on this topic.

7. Aims and Structure of Thesis

The aim of this thesis is to determine the effects of active play interventions on children's physical activity levels and fundamental movement skills. To address this, the present thesis consists of four studies, presented in four manuscripts, two of which have been published and another two have been submitted to relevant journals (one to the Journal of Pilot and Feasibility Studies and the other to the Scottish Educational Review).

Chapter 3 presents a systematic review of the evidence on the effects of active play interventions on children's physical activity levels (particularly MVPA) and FMS. This was the second study I conducted during my PhD but is presented first in this thesis as it sets the context for the subsequent chapters. This study was conducted second because initially I had a Master of Philosophy (MPhil) Studentship to research the pragmatic evaluation and I then received a two-year studentship which extended my MPhil into a PhD to continue the reseearch into active play. The systematic review was published in BMC Public Health in June 2018.

Chapter 5 and 6 present two studies evaluating the impact of a school-based 'Active Play' intervention currently being delivered in Scotland. The first is a pragmatic evaluation (Chapter 5) which determined if participating in the Active Play intervention (ne Go2Play) increased children's school day physical activity and improved their FMS. This was the first study I conducted during my PhD (initially as part of my MPhil) and was published in Preventive Medicine Reports in June 2017. The findings from this study were used to inform the feasibility cluster RCT (Chapter 6), which determined the feasibility of the Active Play intervention and presented preliminary findings on four outcomes: physical activity levels, FMS, inhibition, and maths fluency. This paper was submitted to the Journal of Pilot and Feasibility Studies in September 2018.

Since the present thesis is a PhD by manuscript, each of these three studies is complemented with a detailed methodology chapter to provide more information and justification of the procedures used before the manuscripts are presented. Chapter 2 provides the methodology for the systematic review and chapter 4 provides a combined methodology for the pragmatic evaluation and feasibility cluster RCT.

The final manuscript (Chapter 7) presents a paper submitted to the Scottish Educational Review in November 2018 for their special issue on Play in Scotland. The aim of this paper is to summarise key findings of the systematic review, pragmatic evaluation and feasibility RCT, and provide recommendations on how more active play can be promoted.

The thesis concludes with a discussion (Chapter 8) which summarises the main findings of the present thesis, presents the main strengths and limitations, links to current policy in Scotland and provides recommendations for future research.

Chapter 2: Methodology of systematic review

1. Preface

The systematic review, 'utilising active play interventions to promote physical activity and improve fundamental movement skills in children: a systematic review and meta-analysis' (Chapter 3), was published in BMC Public Health in June 2018. The aim of the present chapter is to provide complementary additional detail and justification on the methodology used which could not be provided in the published manuscript (presented in Chapter 3) due to a restriction on word limits.

Dr Anne Martin, an expert in conducting systematic reviews, guided the present systematic review. AJ was the lead author and led on all aspects of the systematic review. Synthesis was supported by JJR and a 4th year undergraduate student (supervised by AJ), JJR and AH supported assessing quality, AM supported the methodology and meta-analysis. All authors supported the design of the review, revision and approval of final manuscript to BMC Public Health.

2. Introduction and context

Before the systematic review search commenced, a novel research question was developed that related to the research topic, active play. Active play is "a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner" (Truelove et al., 2017). This was informed by a review of the literature (Chapter 1), which highlighted that active play interventions on important outcomes such as physical activity and fundamental movement skills (FMS) were a neglected area of research. Therefore, the primary research questions were to determine the effect of active play interventions on children's physical activity levels (particularly moderate-to-vigorous physical activity- MVPA) and FMS. The secondary aims were to determine the effect of active play interventions on children's cognitive performance and weight status. The co-benefits of active play interventions were not added as an outcome to the present systematic review as there was a concern that too many outcomes would dilute the interpretation of the systematic review and might make the workload unmanageable.

3. Planning phase

3.1 Literature search and inclusion

A search for published and ongoing systematic reviews was completed to check if previous or ongoing reviews had answered these questions, and none were found. The review was registered on PROSPERO (CRD42017055530) on 20th January 2017.

The next step was to determine an inclusion and exclusion criteria for each part of the PICOS framework (Population, Intervention, Comparison, Outcome and Study Design). Search terms in relation to the PICOS framework (Population, Intervention, Comparison, Outcome and Study Design) were then created, which involved formulating key words related to the research questions, for example children, active play, RCT, physical activity and then developing a list of related terms for each of these key words. The next step was to take these search terms and apply them to relevant databases to begin the literature search. This information is presented in Table 1 and described in more detail in Chapter 3 (section 4.1) along with an example of a search strategy.

Table 1. Systematic review inclusion and exclusion criteria and justification

	Inclusion	Exclusion
Population	Apparently healthy children and adolescents aged- 3-12 years old were included as this is the likely age that children tend to engage in active play (Brockman, Jago & Fox, 2010).	Studies of children with any intellectual, physical or cognitive disabilities, which may impair their ability to engage in active play, were excluded.
Intervention	The intervention had to consist of either solely active play (as defined by Truelove et al 2017) or predominately active play. Active play was determined to be the predominant component if the time allocation for active play was reported as being greater than or equal to any of the other intervention components. The intervention could take place in a range of settings including school (including pre-school), community (located in a community centre, park or streets) or home-based interventions (The Scottish Government, 2013). The intervention must have lasted at least 8 weeks in duration, to minimise the impact of short-term and/ or novelty effects. Two school-based systematic reviews looking at the effect of physical activity interventions only included studies that lasted at least 12-weeks in duration (Kriemler et al., 2011; Brown & Summerbell, 2009); therefore, due to active play being an emerging area of research, the authors lowered the duration to 8-weeks to capture as many active play interventions as possible.	Any intervention that was related solely or largely to sport, physical education or active video games was excluded.

Comparison	The intervention had to be compared to a comparison or control group, who had to receive either no treatment, another physical activity intervention, other lifestyle intervention, waiting-list control or attentional control (i.e. placebo).	Uncontrolled studies were excluded.
Outcome	There were two primary outcomes, physical activity and FMS. Physical activity must have measured habitual or total physical activity, or MVPA using an objective method (for example using an accelerometer). FMS had to be measured using a valid and reliable assessment tool (for example the TGMD-2 or Movement ABC-2). Secondary outcomes of the present systematic review were cognitive performance and weight status. Cognitive performance should have been measured using direct observation (e.g. time on task), questionnaires or laptop-based assessments of standard cognitive tasks (such as a flanker test). Weight status had to be measured objectively using a stadiometer and electronic scales or any other valid assessment of height and weight.	Physical activity measured using observation or questionnaire or an objective measurement that does not give an intensity (for example pedometers) or studies that measured a small period of the day such as recess interventions were excluded. Recess interventions were excluded if they only measured changes in physical activity during the recess period. The present study aimed to review evidence on physical activity over a greater period of time, enough to represent school day, habitual or total physical activity, or MVPA. Studies that self-reported FMS were excluded. Studies that reported self-report weight status were excluded.
Study Design	Studies included in the systematic review had to be RCTs, cluster RCTs or comparison studies.	Non-RCTs were excluded.

3.2 Databases

Four databases: Medline, SportDiscus, PE Index, ERIC were searched to increase the likelihood that all relevant studies would be found and to keep the project manageable. The number of databases searched in previous systematic reviews, in a similar research area, have varied from three (Martin et al., 2016), to five (Brussoni et al., 2015; Gray et al., 2015), to seven (Gibson, Cornell, & Gill, 2017). These databases were chosen because the emerging nature of active play research is likely to cross over multiple disciplines; for example, education, health and physical activity, which would increase the likelihood that relevant studies were captured. Furthermore, similar systematic reviews looking at risky play, outdoor play and recess have used similar databases (Brussoni et al., 2015; Gibson et al., 2017; Gray et al., 2015; Martin et al., 2016). References from each of these databases were then uploaded to Endnote where they were screened.

4. Literature search

4.1 Screening

The screening approach has been described in detail in Chapter 3, section 4.1 but briefly, one researcher (AJ) screened the titles and abstracts, with another researcher checking 10% of the included and excluded articles. It would have been preferable to also have two researchers screening the titles and abstracts in duplicate but due to time constraints, this was not possible. Two researchers independently screened all the full text articles (AJ and assistant).

4.2 Data extraction

Data was extracted by one researcher (AJ) and checked by a second (JJR), which is standard practice in the process of conducting a systematic review. Details of contact with authors of eligible studies is also reported in Chapter 3, section 4.2.

4.3 Assessing the quality of included studies

As detailed in Chapter 3 (section 4.4), the Effective Public Health Practice Project (EPHPP) was used to assess the quality of the included studies in the present systematic review. Study quality was assessed by two independent reviewers (AJ and JJR), and in instances when the two reviewers could not agree a third (AH) was brought in for mediation.

The EPHPP tool was developed for any subject area in public health to assess the quality of quantitative studies across a variety of designs (including RCTs and cluster RCTs) for the purposes of systematic reviewing (Thomas, Ciliska, Dobbins, & Micucci, 2004). This tool provides a standardised way of reviewing the quality of studies; it provides simple instructions making it a time effective approach, is widely used and is free to use (Thomas et al., 2004). However, it cannot assess qualitative studies, but as the present systematic review aimed to evaluate quantitative interventions, this was not an issue.

The EPHPP tool assesses six domains: selection bias, study design, confounders, blinding, data collection method, and withdrawals and dropouts using a strong, moderate or weak scoring system that rates the quality of each of these components on a scale of 1-3 (Thomas et al., 2004).

Critically appraising the quality of the methodology used in studies is important to help determine if we have confidence in the findings presented, as a weak design could result in a bias and lead to an underestimation or overestimation of the findings presented (Higgins & Green, 2011).

There are a number of tools to assess the risk of bias. Table 2 presents an overview of two tools that were considered for assessing the risk of bias for the systematic review. One consideration was the Cochrane Collaboration Risk of Bias Tool (CCRBT), which assesses the risk of bias in RCTs only (Higgins & Green, 2011). The CCRBT assesses six domains of bias (Table 2) and for each of these domains, several items are assessed within each (Higgins & Green, 2011). A judgement of high risk, low risk or unclear risk is then assigned for each domain, which is then totalled to give a high, moderate or low overall grade (Higgins & Green, 2011).

A study conducted by Armijo-Olivo, Stiles, Hagen, Biondo and Cummings, (2012) reviewed the differences between the EPHPP and the CCRBT tools when evaluating the quality of twenty RCTs. Inter-rater reliability of both tools was assessed; Cohen's kappa was used to assess inter-rater reliability across the domains and intra-class correlation coefficients (ICC) were used to assess the inter-rater reliability for the final grade (Armijo-Olivo et al., 2012). The authors found that the EPHPP tool had fair inter-rater reliability (k = 0.60) when scoring the six domains and excellent inter-rater reliability for the final grade (ICC =0.77; 95% CI 0.51–0.90) (Armijo-Olivo et al., 2012). Whereas, the CCRBT tool had a slight inter-rater reliability for the individual domains (k = 0.30) and fair to moderate agreement (ICC =0.58; 95% CI 0.20–0.81) for the final grade (Armijo-Olivo et al., 2012). The authors also found that there was very poor inter-rater reliability between the EPHPP and the CCRBT tools when assigning the final grade (k =0.006) (Armijo-Olivo et al., 2012). The discrepancies between these two tools might be partly due to the way they are scored; the EPHPP tool is easier to score because the information required is often contained in the paper being assessed, whereas the CCRBT requires a more subjective judgement, which might explain the lower reliability of inter-rater agreement compared to the EPHPP tool. Therefore, the EPHPP was chosen because it is simple to use, low-cost, widely chosen and has excellent inter-rater reliability for the final grade.

5. Analysis

5.1 Meta-analysis and narrative synthesis

Details of the meta-analysis and narrative synthesis are in Chapter 3 (section 4.3), but briefly, a meta-analysis was conducted using Review Manager 5.3 software for the MVPA outcome only. Review Manager was chosen to conduct the meta-analysis as it is recommended by Cochrane (Higgins & Green, 2011). The Comprehensive Meta-Anlaysis (CMA) software was also considered; however, the standard version costs $495, whereas Review Manager is free to download and was sufficient for the needs of the meta-analysis. A narrative synthesis was conducted on all outcomes which was guided by the Cochrane Handbook (Higgins & Green, 2011).

Table 2. Overview of tools to assess the risk of bias of primary studies

Quality Assessment Tool	Types of Study Designs	What Does It Assess	Quality Level	Validity and Reliability
Effective Public Health Practice Project (EPHPP) (Thomas et al., 2004).	Assesses risk of bias in a number of study designs including RCT's (among others).	1. Selection Bias 2. Study Design 3. Confounders 4. Blinding 5. Data Collection Methods 6. Withdrawals and Dropouts Additional two sections but not included in score.	1. High 2. Moderate 3. Weak	Fair inter-rater agreement for each domain (0.60) and excellent agreement for the final grade (ICC= 0.77; 95% CI 0.51–0.90). (Armijo-Olivo et al., 2012). Test-retest reliability indicated a Kappa statistic of 0.74 (Thomas et al., 2004).
Cochrane Collaboration Risk of Bias Tool (CCRBT) (Higgins & Green, 2011)	Assesses risk of Bias in RCT's only	1. Adequacy of sequence generation 2. concealment of allocation 3. blinding 4. completeness of follow-up 5. freedom from reporting bias Others such as differences in relation to baseline measures, reliable primary outcomes, contamination	1. High 2. Moderate 3. Low	Slight inter-rater agreement for each domain (0.30) and fair to moderate agreement for final grade (ICC = 0.58; 95% CI 0.20–0.81). (Armijo-Olivo et al., 2012).

6. Conclusions

The aim of the present Chapter was to provide additional detail on the methods used, and why these methods were chosen for the published systematic review in Chapter 3, which will now be presented.

Chapter 3: Utilising active play interventions to promote physical activity and improve fundamental movement skills in children: a systematic review and meta-analysis

Published in BMC Public Health in June 2018

1. Preface

The literature review highlighted gaps in the evidence for the effect of active play interventions on physical activity (particularly MVPA), FMS and cognition. The aim of this chapter was to systematically review the evidence on the effect of active play interventions with a strong design on the aforementioned outcomes.

As previously discussed, the present systematic review was published in BMC Public Health in June 2018. The paper is presented in the same format as was published in the journal and, therefore, the referencing system (reference list presented at the end of this chapter) is not APA as is used in the other non-manuscript chapters in this thesis.

AJ was the lead author and led on all aspects of the systematic review. Synthesis was supported by JJR and a 4th year undergraduate student, JJR and AH supported assessing quality, AM supported methodology and meta-analysis. All authors supported the design of the review, revision and approval of final manuscript to BMC Public Health.

2. Abstract

Background: Children's physical activity levels are low and efforts to improve their physical activity levels have proven difficult. Freely chosen and unstructured physical activity (active play) has the potential to be promoted in a variety of settings and potentially every day of the year in contrast to other physical activity domains, but active play interventions are an under-researched area. Therefore, the primary aim of this systematic review was to determine the effect of active play interventions on children's physical activity levels, particularly moderate-to-vigorous intensity physical activity (MVPA), and fundamental movement skills (FMS).

Methods: Studies were included if they were solely or predominantly active play randomised or cluster randomised controlled trials that targeted children aged 3-12 years. They had to report on at least one of the following outcomes: objectively measured physical activity, FMS, cognition and weight status. During December 2016, four databases (PE Index, SPORTDiscus, Medline and ERIC) were searched for relevant titles. Duplicates and irrelevant titles and abstracts were removed. The included studies had their quality assessed using the Effective Public Health Practice Project (EPHPP) tool. Suitable studies were combined in a meta-analysis using a random-effect model. A narrative synthesis was conducted for all outcomes.

Results: Of the 4033 records, 91 studies were eligible for full text screening, of which 87 were removed, leaving four studies (representing 5 papers). The meta-analysis of two studies highlighted there was no significant effect of active play interventions on MVPA. However, the narrative synthesis suggested that active play interventions may increase total volume of physical activity. Only two studies examined the effect of active play interventions on children's FMS, one study examined effects on weight status and none examined effects on cognition.

Conclusions: Due to the small number of eligible studies and their heterogeneity, the review could not draw firm conclusions on the effect of active play interventions on children's physical activity levels. High-quality active play interventions, targeting different times of the day (school and after school) in different populations and settings, and with a wider range of outcomes, are required to determine the potential of active play

Keywords: Active play, Fundamental movement skills, Cognition, Weight status, Children, Physical activity, Moderate-to-vigorous physical activity, Systematic review

3. Background

Engaging in regular physical activity from a young age offers wide ranging health benefits including, reduced risk of cancer, overweight and obesity, depression and diabetes [1, 2]. However, many children from the most high-income countries are not achieving the recommended minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day [3-5]. Efforts to encourage children to engage in physical activity have tended to focus on four domains: active transportation, recess, physical education (PE) and sports. Recent systematic reviews have suggested that the amount of MVPA being accumulated in these domains is limited, particularly as these domains are largely school-based, and schooldays represent little more than half of all days in a year [6-10]. Community and home-based interventions to promote physical activity are less common, despite the potential for interventions outside of school [11]. One novel area of research is the role active play may have on the contribution to children's habitual physical activity and MVPA levels [12-15].

Active play is 'a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner' [16]. Active play could potentially be influenced by multiple levels from policy to environment (school/ pre-school and safe places to play outdoors), to those who influence active play (teachers, parents and peers) to the children themselves, which provides potential opportunities to target active play interventions. Furthermore, it is often engaged in outdoors, which is associated with higher habitual physical activity and MVPA levels, as shown in recent observational studies and systematic reviews [13, 17-18]. Active play might have the potential for greater population wide gains on habitual physical activity and MVPA levels compared to other domains of physical activity [15]. It is a relatively unrestrictive domain of physical activity: it can be engaged in before school, during school, after school, when schools are on holiday, and often requires no specific infrastructure [12-15].

In low-middle-income countries where physical activity levels are often higher than in high-income countries, children tend to spend more time in active play [5]. However, in high-income countries, it is not clear how often children engage in active play as public health surveillance of this domain is poor. For example, only 17/38 participating countries were able to assign a grade to active play in the recent Active Healthy Kids Global Matrix [4, 5]. It is thought that with the emergence of screen time activities and parental safety concerns, many children are not engaging in active play every day. Therefore, interventions may be required to promote active play in childhood [19, 20].

Active play may generate additional benefits beyond increasing MVPA and physical activity levels, including improved fundamental movement skills (FMS), weight status and cognitive performance [15, 21-24]. FMS are the basic skills children should be competent in such as jumping, running, catching and throwing, and are related to children's physical activity levels, for example, if children have good FMS, they are more likely to be physically active [25-28]. Active play may be a promising way of developing FMS in children [21, 22]. Furthermore, Pesce et al suggested that active play may improve children's cognitive performance, particularly if it is combined with activities that develop FMS (or motor skills) [23].

Despite the potential for active play to increase children's physical activity levels and improve their FMS, cognitive performance and weight status, we are unaware of any systematic review of interventions to promote active play in children [15, 21, 23]. Therefore, the primary aim of this systematic review was to determine the effect of active play interventions in increasing children's physical activity levels and improving FMS, and to characterise the interventions used. The secondary aim was to determine the effect of active play interventions on improving cognitive performance and weight status in children.

4. Methods

4.1 Literature search and inclusion

The present systematic review is reported following the PRISMA statement for conducting systematic reviews and meta-analyses. The protocol was registered on PROSPERO on the 20th January 2017 (CRD42017055530).

Four relevant electronic databases, MEDLINE, SPORTDiscus, PE Index and ERIC were searched during December 2016. The search strategy followed the

PICOS (population, intervention, comparison, outcomes and study design) framework. The inclusion and exclusion criteria are detailed below. The search was limited from 2000 to 2016 given that active play is an emerging area of research, and the search was for studies that used objective measurement of physical activity (which only became available in the late 1990's). The authors also restricted the search to English language studies only due to the impracticalities of translating papers. An example of a search strategy for the MEDLINE database is provided in Table 1, which was adapted for the three other databases. Full literature search details are available from the corresponding author on request.

Table 1. Search strategy in Medline

child*.tw.	moderate-to-vigorous.tw.
(boy* or girl*).tw.	"moderate to vigorous".tw.
youth*.tw.	fitness.tw.
(pupil* or student* or schoolchild* or primar*).tw.	physical* activ*.tw.
(young adj2 (person* or people)).tw.	(cardio adj2 respiratory adj2 fitness).tw.
Elementary*.tw.	Motor Activity/
Kindergarten*.tw.	"fundamental movement skill*".tw.
Grade*.tw.	movement skills.tw.
1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	(motor adj2 skills).tw.
"Play and Playthings"/	(gross adj2 motor adj2 development).tw.
"active play*".tw.	(motor adj2 development).tw.
(outdoor adj2 play*).tw.	"gross motor skill*".tw.
"outdoor play*".tw.	(Motor adj2 compet*).tw.
"physically active play*".tw.	(Motor adj2 develop*).tw.
physical* activ* play*.tw.	(motor adj2 proficiency).tw.
(outdoor adj2 activ* adj2 play*).tw.	Locomotor.tw.
(unstruct* adj2 activ*).tw.	object control.tw.
"playground".tw.	(movement adj2 compet*).tw.
"recess".tw.	Cognition/
	learning.tw.

(recreation* adj1 activ*).tw.	"executive function*".tw.
(activ* adj2 free adj2 play).tw.	(cognitive adj2 performance).tw.
"active free play*".tw.	"inhibition".tw.
"physical play".tw.	(working adj2 memory).tw.
playground*.tw.	"memory".tw.
Parks, Recreational/	(self adj2 regulation).tw.
11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26	"self-regulation".tw.
Randomized Controlled Trial/	behav*.tw.
Control Groups/	"attainment".tw.
compar*.tw.	"Weights and Measures"/
Control*.tw.	Body Weight/
(control* adj1 trial*).tw.	(body adj2 mass adj2 index).tw.
"random* cont*".tw.	"body mass index".tw.
allocat*.tw.	BMI.tw.
28 or 29 or 30 or 31 or 32 or 33 or 34	(weight adj2 status).tw.
Exercise/	(overweight or obesity).tw.
(physical* adj2 activ*).tw.	Adiposity.tw.
exercis*.tw.	Fat.tw.
(physic* adj2 fitness).tw.	36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80
(physic* adj2 endurance).tw.	10 and 27 and 35 and 81
(physical activity adj2 (level* or intensit* or energy expenditure)).tw.	limit 82 to yr="2000 -Current"
"MVPA".tw.	limit 83 to English language

References were imported into Endnote and duplicates were removed at which point one researcher screened the titles and abstracts with another researcher checking 10% of the included and excluded articles. Two researchers then independently screened relevant full text articles. If the researchers could not agree during any part of the screening process, then a third researcher was consulted to resolve the disagreement. Reference and citation lists of the final included papers were examined to find any potential eligible studies missed during the database search.

4.1.1 Population

Apparently healthy children and adolescents aged- 3-12 years old were included in the present systematic review as this is the age that children tend to engage in active play [29]. Studies of children with any intellectual, physical or cognitive disabilities, which may impair their ability to engage in active play, were excluded.

4.1.2 Intervention

For inclusion in the present review, the intervention had to consist of either solely active play (as defined above) or if the intervention was multi-component, active play had to be the predominant component [16]. Active play was determined to be the predominant component if the time allocation for active play was reported as being greater than or equal to any of the other intervention components. Decisions on whether to include or exclude papers were based on the description of the intervention in the paper. The intervention could take place in a range of settings including school (including pre-school), community (located in a community centre, park or streets) or home-based interventions [30]. Any intervention that was related solely or largely to sport, physical education or active video games was excluded because these activities do not fall into the definition of active play.

The intervention must have lasted at least 8 weeks in duration, to minimise the impact of short-term/ novelty effects. Two school-based systematic reviews looking at the effect of physical activity interventions only included studies that lasted at least 12-weeks in duration [31, 32]; therefore, due to active play being an emerging area of research, the authors lowered the duration to 8-weeks to try to capture as many active play interventions as possible.

4.1.3 Comparison

The intervention had to be compared to a comparison or control group, who received either no treatment, another physical activity intervention, other lifestyle intervention, waiting-list control or attentional control. Uncontrolled studies were excluded.

4.1.4 Outcome

There were two primary outcomes, physical activity and FMS. Studies looking at the effect on physical activity must have measured habitual or total physical activity, or MVPA using an objective method (for example using an accelerometer) to be included. Recess interventions, which have been subject to many systematic reviews previously, were excluded if they only measured changes in physical activity during the recess period. The present study aimed to review evidence on physical activity over a greater period of time, enough to represent school day, habitual or total physical activity, or MVPA. Physical activity measured using observation or questionnaire, or an objective measurement that does not give an intensity (for example pedometers), or studies that measured a small period of the day such as recess interventions were excluded.

Fundamental movement skills had to be measured using a valid and reliable assessment (for example the Test of Gross Motor Development-2 or Movement Assessment Battery for Children-2). Studies that self-reported FMS were excluded.

Secondary outcomes of the present systematic review were cognitive performance and weight status. Cognitive performance should have been measured using direct observation (e.g. time on task), questionnaires or laptop-based assessments of standard cognitive tasks (such as a flanker test) [33]. Weight status had to be measured objectively using a stadiometer and electronic scales or any other valid assessment of height and weight. Studies that reported self-report weight status were excluded.

4.1.5 Study design

Studies included in the systematic review had to be randomised controlled trials, cluster randomised controlled trials or comparison studies where the sample had been randomised. Non-randomised controlled trials were excluded.

4.2 Data extraction

Data were extracted by one of the authors and checked by a second. All authors agreed on what data should be extracted, which included study information (e.g. study design), population details, intervention characteristics (e.g. setting, duration and frequency of the intervention), details of the comparison or control group, outcomes (e.g., how and when outcomes were measured) and results.

In instances where data were missing, or additional information was required for the eligible studies, the study authors were contacted to provide the relevant information. Two authors were contacted to determine if the study interventions and designs met the inclusion criteria; one for additional information on the intervention and the other to ascertain whether the study was randomised [34, 35]. Another author was contacted for additional data, which they were unable to provide [36].

4.3 Data analysis and synthesis

A meta-analysis was conducted using the Review Manager 5.3 software for the MVPA outcomes only using random-effect models. Due to the small number of studies and the heterogeneity of the data, the authors could not conduct a meta-analysis for the other outcomes. Combined effect sizes were weighted by the sample size and standard error of the primary study. Effect sizes were reported as mean differences and 95% confidence intervals. The statistical heterogeneity was assessed using the I^2 statistic.

A narrative synthesis was conducted on outcomes in which a meta-analysis could not be conducted (total physical activity, FMS, cognition and weight status); with interventions described by reviewing the type, duration and setting. The authors of the present systematic review considered doing sub-group analysis by the type of active play (indoor or outdoor), age (pre-school or school) and setting (school, community or home); however, due to the small number of eligible papers, this was not possible.

4.4 Quality assessment

Two reviewers independently assessed the quality of the eligible papers using the quality assessment tool of the Effective Public Health Practice Project (EPHPP) [37]. In instances where the two reviewers could not agree on the quality of the paper, a third reviewer was consulted. Briefly, the EPHPP tool assesses selection bias, study design, consideration of confounders, blinding, data collection method, withdrawals and dropouts using a scoring system that rates the quality of each of these components as strong, moderate or weak [37]. The EPHPP tool has strong inter-rater reliability and construct validity [37, 38].

5. Results

5.1 Characteristics of eligible studies

The PRISMA flow diagram is presented in Figure 1 [39]. Of the 4033 articles identified from four databases, 91 were eligible for full text screening. Of these, four studies (representing five papers) were eligible for inclusion. One further paper was identified when searching references of the four included studies [24], however this paper was a part of a study already included but reported different outcomes [22]. Reasons for exclusion are reported in Figure 1.

An overview of the included studies is presented in Table 2. One study was conducted in Canada [22, 24], one in Australia [34] and the other two in Europe (Italy and England) [35,36]. The eligible studies had a relatively small number of participants ranging from 76 to 221 in total (intervention and control group) [22, 24, 34-36]. Adamo et al and Goldfield et al [22, 24] (mean age 3.4 years), and O'Dwyer et al (mean age 3.8 years) targeted pre-school children [36], whereas Engelen et al [34] (mean age 6.0 years) and Tortella et al (intervention- mean 5.6 years; comparison – 5.7 years) targeted school-aged children [35]. One study was conducted in a pre-school setting [22, 24], two were school-based [34, 35] and the final study was based in a community setting [36]. All of the included studies were cluster randomised controlled trials [22, 24, 34-36]. The duration of the intervention varied from 10-weeks, [35, 36], 13-weeks [34] and 6-months [22, 24].

Two studies assessed objectively measured physical activity as the only outcome [34, 36], one assessed FMS only [35] and the final study (representing two papers) objectively measured physical activity, FMS and weight status [22, 24]. None of the four studies included assessed the child's cognitive performance.

PRISMA 2009 Flow Diagram

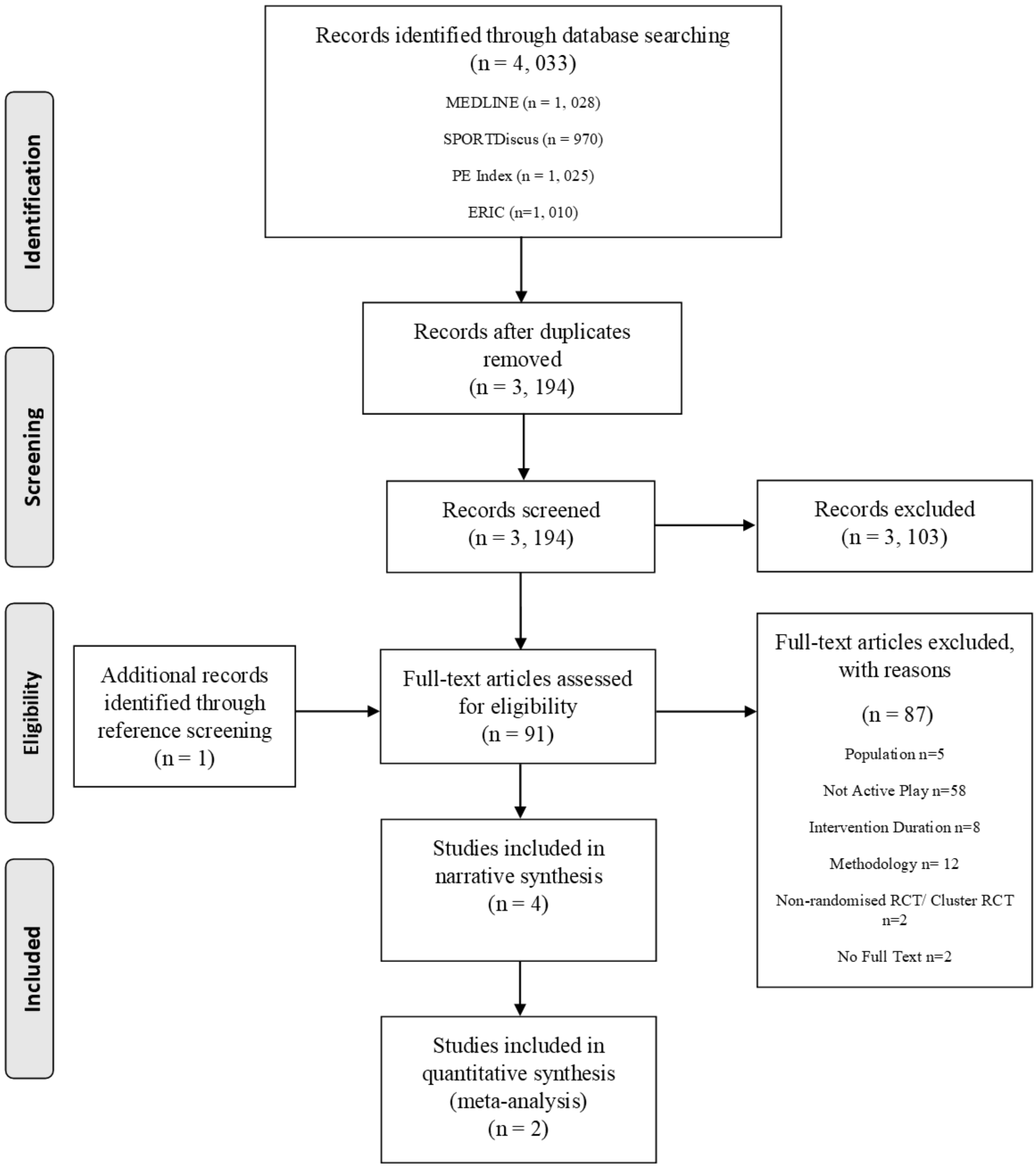

Figure 1 — Flow diagram of number of articles retrieved during the literature search and study selection.

5.2 Intervention descriptions

A range of active play interventions was utilised in the four included studies. The interventions by Adamo et al and Goldfield et al took place in child-care centres and involved two-three hour workshops for the care providers to encourage active and outdoor play for the children (3-5 years) [22, 24]. During these workshops, the care providers received an active play manual and equipment, which aimed to facilitate active and outdoor play with pre-school aged children [22, 24].

Engelen et al and Tortella et al utilised playground settings for their active play interventions [34, 35]. Engelen et al provided loose play equipment (e.g. tyres, crates, recycled plastic and fabric) for children in a school playground [34]. Tortella et al brought children from the local kindergarten to the playground for the intervention once a week for one hour [35]. Tortella et al then divided the playground into motor skill specific areas (balance, dexterity, mobility) where the children played for 10 minutes each and the remaining 30 minutes was free play [35].

Finally, O'Dwyer et al delivered a parent and child (pre-school children-mean age 3.8 years) active play intervention in the community [36]. Over the 10-week period, the families had five contact sessions lasting one-hour delivered by playworkers: for the first 20 minutes, the parents and children were separated, and the parents received an educational component and the children participated in active play, and for the final 40 minutes, they participated in active play together [36].

5.3 Quality assessment

Table 3 presents the quality rating of each of the four studies graded by the EPHPP tool. Three [34-36] of the four included studies were rated as 'weak' using the EPHPP tool and the other as ‘moderate’ [22, 24]. Studies were typically rated weak for the ‘selection bias’, ‘study design’ and blinding categories.

5.4 Effects of the interventions

5.4.1 Moderate-to-vigorous intensity physical activity

Figure 2 presents the results from the meta-analysis on MVPA from two studies [24, 34]. These two studies were found to be homogenous (I^2= 0%) but there was no significant effect on MVPA (*p*= 0.71; MD= 1.12, 95%CI: -4.83, 7.06) when the two studies were pooled.

5.4.2 Total volume of physical activity

Three of the included studies examined the effects of the active play interventions on total physical activity, but we could not conduct a meta-analysis because the data the authors reported varied (minutes/school day physical activity, counts per minute, weekday and weekend minutes/day) [24, 34, 36].

Goldfield et al [24] found that the intervention group increased their pre-school day total physical activity by 19 minutes (95% CI: 9, 30) whereas the control group decreased their pre-school day total physical activity by 3 minutes (95% CI: -12, 6) [24].

O’Dwyer et al [36] reported a significant increase in total physical activity during the weekday and weekend in the intervention group compared to the control group [36]. The intervention increased total physical activity by 5 minutes (95% CI: 3, 9) during the weekday and by 10 minutes (95% CI: 2, 18) during the weekend compared to the control group [36].

Table 2. Overview of included studies

Author, year and setting	**Study design**	**sample size intervention / control**	**Age** (range or mean ± SD)**, sex** (n or % m/f	**Intervention duration**	**Outcome(s)**	**Intervention Details**	**Comparison / Treatment**	**EPHPP Quality Rating**
Adamo et al 2016 & Goldfield et al 2016 Canada	Cluster RCT	40/ 43	**Intervention:** age (3.4 ± 0.3), sex (18/22) **Control:** age (3.4 ± 0.4), sex (23/20)	6-months	PA measured using an Actical accelerometer FMS measured using the TGMD-2 Weight status measured using stadiometer and digital scales.	Two 3-hour training workshops to childcare providers. Workshops encouraged childcare providers to provide more outdoor active play (manuals provided). Basic equipment provided. Bi-weekly booster sessions provided.	Regular childhood curriculum	Moderate
Engelen et al 2013 Australia	Cluster RCT	113/ 108	**Intervention:** age (6.0 ± 0.6), sex (59/54) **Control: age,** (6.0 ± 0.6), sex (60/48)	13-weeks	PA measured using an ActiGraph accelerometer	Loose parts equipment provided in the playground. Two-hour information session for staff on playground duties aimed at highlighting the benefits of active free play.	Standard break times	Weak
O'Dwyer et al 2012 England	Cluster RCT	33/ 43	**All:** age (3.8 ± 0.6), sex (52%/48%),	10-weeks	PA measured using an ActiGraph accelerometer	5 sessions over 10 weeks. 60 minutes delivery. The first 20 minutes children and parents were separated. Parents received educational component and children participated in active play. Final 40 minutes both children and parents participated in active play together.	No treatment	Weak

Tortella et al 2016 Italy	Cluster RCT	71/ 39	**Intervention:** age (5.6 ± 0.31), sex (41/30) **Control:** age (5.7 ± 0.3), sex (22/17)	10-weeks	FMS measured using Movement ABC	30 minutes of free play and 30 minutes of structured activities once a week for 10 weeks in the playground	No treatment	Weak

Table 3. Quality assessment

Study	Selection Bias	Study Design	Confounders	Blinding	Data Collection Methods	Withdrawals and Drop-outs	Total
Adamo et al 2016 & Goldfield et al 2016	Moderate	Strong	Weak	Moderate	Strong	Strong	**Moderate**
Engelen et al 2013	Weak	Weak	Moderate	Moderate	Strong	Strong	**Weak**
O'Dwyer et al 2012	Weak	Weak	Weak	Weak	Strong	Strong	**Weak**
Tortella et al 2016	Weak	Weak	Weak	Weak	Strong	Weak	**Weak**

Engelen et al did not find a significant increase in school day accelerometer counts per minute in the intervention group compared to the control (95% CI: -144, 116) [34]. At baseline, total counts per minute in the intervention group were 216 (SE=5) and this was 217 (SE=5) at follow up, whereas at baseline the control groups total counts per minute were 199 (SE=5) and this was 197 at follow up (SE=5) [34].

5.4.3 Fundamental movement skills

Two of the studies included in the present systematic review analysed the effects of an active play intervention on children's FMS [22, 35]. A meta-analysis could not be conducted due to the different methods used to measure FMS.

Adamo et al utilised the Test of Gross Motor Development-2 to assess children's fundamental movement skills [22]. The authors found that both the gross motor quotient score (95% CI: 0.7, 10.7; p= 0.025;) and percentile (95% CI: 2.2, 24.5; p= 0.020) significantly increased in the intervention group compared to the control [22]. The intervention group had a mean change of 4.2 (95% CI: 0.5, 7.9) for gross motor quotient score and a mean change of 9.6 (95% CI: 1.3, 18.0) for percentile [22]; the control group had a mean change of -1.5 (95% CI: -4.8, 1.8) for gross motor quotient score and a mean change of -3.7 (95% CI: -11.1, 3.7) for percentile [22].

Tortella et al used a combination of assessments to measure FMS, including the Test of Motor Competence, Movement Assessment Battery for Children and the Test of Physical Fitness [35]. They assessed performance in a range of skills including one leg balance, balance on beam, balance on platform, heel to toe walking task and throwing a medicine ball [35]. They found significant improvements in all of the aforementioned skills in the intervention group compared to the control group apart from one-leg balance (right foot) [35].

5.4.4 Cognitive performance

None of the studies included in the present systematic review investigated the effects of active play interventions on children's cognitive performance.

5.4.5 Weight status

One of the studies included in the present systematic review investigated the effects of an active play intervention on children's weight status [24]. This study found that participating in a 6-month active play intervention did not significantly decrease BMI-z score in the intervention group compared to the comparison group [24], although the intervention group did have a decrease in BMI-z score of -0.2 (95% CI: 0.0, 0.4; *p*= 0.087) [24].

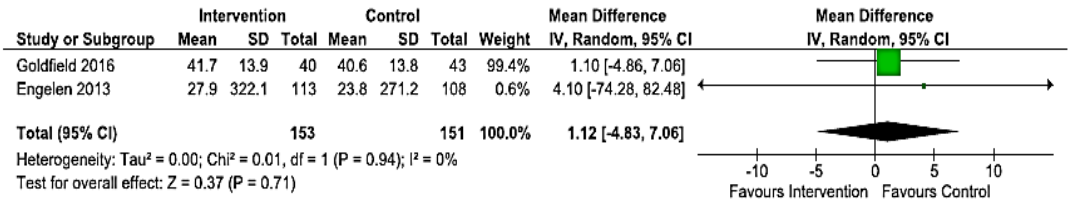

Figure 2. Effect of active play interventions on minutes/pre-school or school day spent in moderate-to-vigorous physical activity (MVPA)

6. Discussion

The present systematic review highlighted that there is limited randomised controlled research on active play interventions, despite the potential benefits they may have on children's physical activity levels, FMS, cognition and weight status:

only four eligible studies (described in 5 separate papers) were identified [22, 24, 34-36]. A meta-analysis was conducted on the MVPA outcome only and showed there was no significant effect [24, 34]. However, the evidence base on utilising active play as a domain in childhood physical activity interventions seems very small at present.

Research efforts aimed at increasing levels of physical activity and MVPA in children have largely focussed on other school-based domains, including recess, PE and active commuting. Comparable systematic reviews looking at other domains of physical activity have included a greater number of eligible RCTs and cluster RCTs, for example; recess interventions (*n* =9), elementary school PE (*n* =13) and active commuting (*n* =32) [8-10]. Janssen recently suggested that active play has the biggest potential for increasing children's physical activity levels due to its unrestrictive nature [15], i.e. active play can be promoted before, during and after school and when schools are on holiday.

Three of the included studies utilised a pre-school or school setting and only one utilised a community setting. Schools provide a good opportunity to promote physical activity as they have access to all children, in particular, children who might not otherwise engage in physical activity [40, 41]. However, given that children only spend half of their time in school, other settings (community or home) outside school hours need further attention [40, 41].

Active play is often engaged in outdoors, and outdoor time is associated with higher MVPA levels [13, 17]. A recent observational study in English children suggested that engaging in physical activity after school hours is important to increasing children's habitual physical activity and, in particular, MVPA levels [18].

Specifically, children who engaged in physical activity (most likely through active play) after school 3-4 times per week achieved a mean of 8 minutes more MVPA per day [18].

The meta-analysis conducted in the present systematic review suggested that active play interventions have little effect on increasing MVPA levels. However, this meta-analysis was conducted on only two studies, these were rated as weak and moderate quality, and utilised different types of accelerometers and accelerometer cut points to determine time spent in MVPA. Furthermore, the interventions differed in duration and type with one study lasting 13-weeks and focussing on recess in primary schools, and the other lasting 6-months and aimed at promoting outdoor active play in a pre-school setting [24, 34].

It might be that active play has a greater effect on children's total volume of physical activity in addition to, or instead of, any effects on MVPA. Although a meta-analysis could not be conducted on the studies which measured total volume of physical activity as an outcome, three studies included in the present systematic review found improvements in total physical activity in the active play intervention groups. Both O'Dwyer et al and Goldfield et al found a statistically significant increase in total physical activity (minutes/day) in the intervention group compared to the control [24, 36]. O'Dwyer et al conducted a 10-week community-based intervention and utilised an ActiGraph accelerometer to measure total physical activity [36]. The intervention group increased their total physical activity by 5 minutes and 10 minutes during the weekday and weekend, respectively [36]. Goldfield et al conducted a longer pre-school intervention lasting 6-months and found that pre-school day total physical activity increased by 19 minutes in the intervention group [24]. Despite these two studies varying in intervention design, setting and duration, and the device used to measure physical activity (ActiGraph and Actical), they do suggest that promoting active play may be a potentially useful way to increase the total volume of habitual physical activity.

A recently published non-randomised controlled study, by the authors of the present systematic review, also found improvements in percent time in light physical activity and MVPA. This was a school-based intervention in which classes received two active play sessions per week for 5-months, which elicited a 16% and 3% increase in light physical activity and MVPA, respectively [21]. However, these findings need to be confirmed by a fully powered future definitive cluster RCT [21].

In addition to potential effects of active play on physical activity, increased engagement in active play also has the potential to improve FMS, and low FMS among children in the developed world is a topic of increasing interest [25-28]. In the present systematic review, two included studies examined the effect of an active play intervention on children's FMS (or gross motor development) [22, 35]. These two studies utilised different intervention designs with one opting for a pre-school setting and encouraging more outdoor active play opportunities and the other offering kindergarten children a one-hour per week active play session at a local park [22, 35]. These two active play interventions utilised different methods of assessing children's FMS but both significantly improved FMS in the intervention group compared to the control [22, 35]. However, these two studies were of weak to moderate quality, which highlights the need for more high-quality studies to test the extent to which active play interventions can improve FMS.

The development of FMS might improve both physical activity and weight status: Stodden presented a conceptual model proposing that developing FMS in children increased their physical activity levels and thus in turn promoted healthy weight in children [28, 42]. Janssen also recommended that interventions aimed at reducing levels of overweight and obesity in children should include an active play component, as the potential gain in terms of energy balance seemed greater than for interventions that targeted other domains of physical activity in children [15, 20].

Only one study in the present systematic review looked at the effect of an active play intervention on reducing overweight and obesity [24]. Although, this study did not find a significant intervention effect the intervention group did have an apparent decrease in BMI-z score [24]. Future active play intervention studies could consider including measures of weight status as outcomes, and preferably, body composition rather than simple proxies for body composition as these are more likely to be able to detect intervention effects [43].

None of the included papers in the present review looked at the effects of active play interventions on cognitive performance. Research has suggested a likely association between physical activity levels, in particular, MVPA and improved cognition [33, 44, 45]. Furthermore, it has been suggested that active play might be particularly beneficial to improving children's cognition as it is likely to be engaged in at a high intensity (MVPA), often takes place outdoors and involves cognitively engaging activities [23, 46]. The combination of MVPA and cognitive engagement may be particularly helpful for the development of cognitive skills relevant for school performance [23, 44]. Future studies should consider assessing cognitive and/or educational outcome measures, and additionally, measures of other social and emotional outcomes as these might also be improved by engaging in more active play. Active play is an enjoyable experience for children, which is important because it relates to their likelihood of being physically active throughout their life course and thus acquiring good FMS and improving their cognition [23].

As the evidence base for active play is limited, there is huge potential for future research into its effects on physical activity and other outcomes. Studies aimed at exploring the barriers and facilitators to active play have highlighted that many parents are concerned about children’s safety and therefore limit their active play opportunities, and this is particularly prevalent in more deprived communities [19]. Given that parents who engage in higher levels of physical activity are also likely to have children who are more physically active, then future intervention research should consider a parental component, as they are the decision makers in most children’s lives. Only one study in the present systematic review had a parental component [36].

During the systematic review process, the authors were aware that the vague nature of the definition of active play (provided above) could be problematic. A recent systematic review by Truelove et al aimed to provide a working definition for active play [16]. Key elements of this definition are ‘freely chosen’ and ‘unstructured’; however, all of the included studies in the present systematic review involved adult involvement in varying amounts, ranging from providing more opportunities for active play (increased outdoor time, more equipment to encourage free play) within a (pre) school context to playworkers facilitating an intervention. Due to poor surveillance of active play (discussed above), we cannot be certain the amount of time children spend engaging in active play, but given low levels of physical activity among children in developed countries, it appears to be low [5]. Therefore, if active play has huge potential for increasing physical activity, there may need to be some adult involvement to provide more opportunities for active play, but we need to consider whether this really does conform to the definition of active play. Time allocation of active play within an intervention, i.e. does most of the intervention consist of 'active play' may support this or it might be best to consider further sub-definitions of active play, such as 'active free play', 'facilitated active play' etc.

Since the present systematic review found only a small amount of published randomised controlled evidence, a search for ongoing trials was carried out using appropriate terms in www.clinicaltrials.gov and www.isrctn.com in November 2017. Three ongoing, potentially eligible randomised controlled studies were identified; two will assess physical activity levels, FMS, weight, and cognition and the other will assess physical activity levels only. These ongoing studies will see the evidence base for active play increase modestly in the near future.

6.1 Review and evidence base strengths and weaknesses

The present systematic review aimed to consider the most robust intervention studies by only including randomised controlled study designs, which has limited the number of included studies by excluding other study designs. For practical reasons, we were unable to review studies in languages other than English, which may have limited the number of included studies. While all eligible studies were RCTs, three of the four included studies were rated weak and one was rated moderate using the EPHPP tool, so the published evidence base is small and not of the highest quality. The present systematic review was also limited to searching from 2000 to the end of

2016. The rationale for this is that we included only studies with objectively measured physical activity outcomes (only available since the late 1990s), active play is an emerging area of research, and the most recent evidence was considered to be the most generalisable. We also did not review the evidence surrounding social and emotional effects of active play, which needs further exploration in interventional research as well as a future systematic review.

Overall the present systematic review suggests that few RCTs have tested the efficacy of active play interventions in children, have only tested efficacy over a relatively short period, and have only examined efficacy for a very limited number of outcomes. Furthermore, it seems that none of the included studies in the present systematic review assessed the fidelity of their respective interventions, meaning that we could not determine why these interventions did not have the desired effect on MVPA and FMS. Future RCTs should also assess the fidelity of the interventions to determine if they were implemented as intended. This would provide essential information to the field by providing a deeper understanding as to why interventions might not provide the desired result.

7. Conclusions

The present systematic review aimed to determine the effect of active play interventions on children’s physical activity levels, FMS, cognition and weight status. Due to the small number of eligible studies and their heterogeneity, the review could not draw firm conclusions on the effect of active play interventions on these outcomes. High-quality active play interventions, targeting different times of the day (school and after school) in different populations and settings, and with a wider range of outcomes, are required to determine the potential of active play in increasing physical activity levels and improving FMS, cognition and weight status in children.

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Chapter 4: Methodology for the pragmatic evaluation and feasibility cluster RCT

1. Preface

The aim of the present Chapter is to provide additional detail and justification on the methodology used in the pragmatic evaluation (Chapter 5) and feasibility cluster RCT (Chapter 6) which could not be provided in the manuscripts due to restrictions on word limits. The pragmatic evaluation was the first study conducted as part of the present thesis and was published in Preventive Medicine Reports in June 2017. The feasibility cluster RCT was the final study conducted and was sent to the Journal of Pilot and Feasibility Studies to be reviewed in September 2018.

For the Pragmatic Evaluation, AJ planned and conducted the study and was lead author. Two undergraduate students supported data collection for the FMS outcome, working under the supervision of AJ. AH and JJR provided guidance on each aspect and XJ provided training and support for the physical activity outcomes. All authors read and approved of the final manuscript.

For the feasibility cluster RCT, AJ planned and conducted the study and was lead author. Seven undergraduate students supported the data collection across all outcomes, working under the supervision of AJ. AH advised on the design of the study and supported the analyses, JB advised and supported on the inhibition and maths fluency outcome, LB advised and supported analysis of the inhibition outcome and JJR and AH supported all aspects of the study. All authors read and approved the final manuscript.

2. Introduction and context

This Chapter will justify and describe the methods used in the pragmatic evaluation (Chapter 5) and the feasibility cluster RCT (Chapter 6). Both of these studies evaluated the effect of the same school-based Active Play intervention (delivered by playworkers from local play charities), which involved a one-hour outdoor active play session incorporating 30 minutes of facilitated games and 30 minutes of free play (described in more detail in section 5). The pragmatic evaluation was a 5-month intervention and examined the effect on participant's school day physical activity levels (particularly moderate-to-vigorous- MVPA), fundamental movement skills (FMS) and the proportion of time spent in MVPA during an Active Play session. The feasibility cluster RCT was a 10-week intervention and evaluated the feasibility of the intervention and provided initial results on its possible effects on participant's school day physical activity levels (particularly MVPA), FMS, the proportion of time spent in MVPA during an Active Play session, inhibition and maths fluency. The pragmatic evaluation had some important limitations (described below and in Chapter 5), but was used to inform and enhance the methodology for the feasibility cluster RCT.

The aim of this chapter is to provide a justification for each outcome that was measured in the pragmatic and/or the feasibility RCT, summarise key differences in methodology between these two studies and provide a comprehensive description of the methodology for the pragmatic evaluation and feasibility cluster RCT,

3. Justification for methods used to measure outcomes

The outcomes measured across the pragmatic evaluation and feasibility cluster RCT were school day physical activity, FMS, the proportion of time spent in MVPA during an Active Play session, inhibition and maths fluency. The aim of this section is to detail what methods were used to assess these outcomes and provide an evidence base as to why these methods were chosen.

3.1 School day physical activity and the proportion of time spent in MVPA during an Active Play session.

For physical activity, there were two main outcomes of interest for both the pragmatic evaluation and feasibility cluster RCT: school day physical activity and the proportion of time spent in MVPA during an Active Play session. The subsequent sections will jointly describe and justify the methodology for these physical activity outcomes.

3.4.1 Subjective versus objective methods of measuring physical activity

Children's physical activity can be measured either subjectively or objectively (Prince, et al., 2008). Subjective methods include questionnaires, diaries and surveys and objective methods include accelerometers (ActiGraph, ActivPAL, Actical), heart rate monitors and pedometers (Prince, et al., 2008). Despite their usefulness at a population level, subjective methods are affected by reliability and validity issues due to the requirement of humans to accurately answer questions or recall their physical activity levels and, therefore, have a tendency to overestimate true levels of physical activity in children and adults (Prince et al., 2008; Trost, 2007; Basterfield, et al., 2008). In contrast, objective methods are more valid and reliable as they do not require participants to recall or report their physical activity levels and, therefore, reduce the potential of self-report bias (Prince et al., 2008; Trost, 2007).

Objective methods have improved physical activity research as it has increased the accuracy of physical activity measurement and allowed researchers to detect changes in physical activity levels (Janz, 2006). Heart rate monitors are one type of objective method that can be used to measure physical activity levels. There are typically two types of heart rate monitors; one that is strapped to the chest and sends the data to a monitor worn on the wrist or one that is worn solely on the wrist (Achten & Jeukendrup, 2003). The heart rate monitor is largely used in exercise or sports training to ensure athletes are working at the correct physical activity intensity (Achten & Jeukendrup, 2003). They are less commonly used in habitual physical activity research, particularly in the child population as they cannot detect physical activity intensities accurately and they can be labour intensive and expensive (Rowlands, Eston, & Ingledew, 1997). Furthermore, physical activity is not the sole reason for an increase in heart rate and fitter children often display a lower resting and exercising heart rate compared to children who are less fit (Rowlands et al., 1997). Given these weaknesses, accelerometers are used more widely in childhood physical activity research and the ActiGraph and activPAL were initially considered to measure school day physical activity and the proportion of time spent in MVPA during an Active Play session for the pragmatic evaluation and feasibility cluster RCT.

3.4.2 Objectively methods of measuring physical activity: ActiGraph and activPAL accelerometers

Accelerometers are the preferred choice for measuring children's free-living physical activity, particularly when the intensity of physical activity is of interest, as they are practical and are used widely, which can be beneficial for comparative reasons (Trost, 2007). Accelerometers are a valid and reliable way of measuring children's duration, frequency and intensity of physical activity across a desired period of time (day, weeks etc.) (Trost, 2007). The ActiGraph and the activPAL accelerometers are both examples of commonly used accelerometers to measure children's physical activity and sedentary behaviour. The activPAL is attached to the thigh using adhesive tape and detects changes in posture (sitting/lying, standing and stepping) and, therefore, has been primarily used in sedentary behaviour research (Davies et al., 2012; Janssen et al., 2014). Whereas the ActiGraph is more common in physical activity research, particularly to measure and detect changes in MVPA (Trost, 2007; Robusto & Trost, 2012), which was one of the main outcomes of the Active Play intervention. The differences between the ActiGraph and activPAL, which were the two accelerometers considered for measuring physical activity and MVPA in the present thesis and why the ActiGraph was chosen, are presented in Table 1.

For the pragmatic evaluation and feasibility cluster RCT, physical activity was measured using the ActiGraph accelerometer, which is a small, unobtrusive monitor attached to an elastic waist-belt and worn on or slightly above the child's right hip (Sasaki, John & Freedson, 2011; Hänggi, Phillips & Rowlands, 2013; Trost, Mciver, & Pate, 2005). Despite its usefulness, validity and reliability in measuring children's free-living physical activity and MVPA, the ActiGraph does not accurately measure cycling and it cannot be worn when swimming (Trost, 2007; Trost, et al., 2005). However, as physical activity was only measured during the school day in the pragmatic evaluation and feasibility cluster RCT, both of these issues did not affect the validity of the physical activity measurement. The ActiGraph cannot accurately determine whether an individual is standing or sitting due to the monitor being placed on the child's hip; however, it is an accurate measure of sedentary time (Trost, 2007; Ridgers et al., 2012). Sedentary behaviour is defined as "any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017). Sedentary time captures low intensity movement that would indicate low levels of energy expenditure (≤1.5 METs), but this may include time spent standing, which is not sedentary behaviour (Ridgers, et al., 2012). Ridgers et al. (2012) conducted a study to examine the agreement between the ActiGraph and activPAL for assessing sedentary time. Children (*n* = 48) aged 10.3 (± 1.2) years were asked to wear the ActiGraph and activPAL accelerometer at the same time for two school days. For whole school day, findings suggested a moderate to high level of agreement of 69.4% - 75.7% between the ActiGraph and activPAL accelerometer for sedentary time (Ridgers, et al., 2012).

A full and detailed discussion of the differences between the various methodologies is beyond the scope of the current thesis, but the reader is refered to key literature referenced in the present section for more detail.

Table 1. Comparison of the ActiGraph and the activPAL accelerometers

Type of accelerometer	Details	What does it assess	Output	Software Required	Strengths	Weaknesses
ActiGraph GT3X+ Manufacturing Technologies Inc. Health Systems, Fort Walton Beach, Florida	Small (6cm × 3.3cm × 1.5cm, 19g), light-weight (19g) triaxial accelerometer. It is worn on a waist-belt on or slightly above the right hip.	The ActiGraph is an accelerometer able to detect differing levels of intensity (sedentary, light, moderate, vigorous) as it measures acceleration which is proportional to the movement. Can measure activity over several days.	Counts per minute measured at a given epoch setting (15 seconds in the present studies) but can range from 5 seconds to 1 minute. Cut points are used to convert raw data (cpm) into varying physical activity intensities (Evenson cut points used in the present studies)	Actilife required for initialising the monitors and downloading the data	Valid and reliable measure of total physical activity and MVPA, the main outcomes of the study (Evenson et al., 2008).	Cannot accurately measure cycling and needs to be removed during swimming, but these were not issues for the present studies (Trost, 2007). .
activPAL PAL Technologies Ltd. Glasgow, UK.	Small (35 x 53 x 7mm, weight 20g), discrete and lightweight sedentary behaviour and physical activity monitor. It is placed on the right thigh and is kept in place using the manufacturers tape. It can be made waterproof and, therefore, does not need to be removed during swimming.	The activPAL measures time spent in different postures. It records time in: 1. Sitting/lying 2. Standing 3. Walking The activPAL is able to measure these over a several day period.	Time spent in: 1. Sitting/lying 2. Standing 3. Walking The epoch rate is 15 seconds.	The activPAL Professional Research Edition software Excel required for downloading the data.	The activPAL provides an accurate and reliable measure of sitting but this was not a main outcome of the study (Davies, et al., 2012; Janssen, et al., 2014).	Does not measure of physical activity intensity.

3.4.3 ActiGraph cut points

To interpret the ActiGraph output, cut points are typically used to convert the data output (e.g. counts per minute) from the ActiGraph accelerometer into different physical activity intensities (Trost et al., 2011). The use of ActiGraph cut points is a contentious issue, there are multiple cut points available for the child population, which results in varying levels of physical activity being reported (Kim, Beets, & Welk, 2012; Trost et al., 2011). In the pragmatic evaluation and feasibility cluster RCT, the Evenson et al. (2008) cut points were used, which were calibrated in a study of children aged 5-8 years old. Furthermore, given the study design, the choice of cut points was possibly a secondary issue since it would not have affected the ability to detect changes or differences between groups (but would have affected our judgements about the amount of MVPA being accumulated in the play sessions).

Evenson et al. (2008) recruited 33 children (aged 5-8 years) to participate in a lab-based study to determine appropriate cut points for the ActiGraph accelerometer. The children engaged in a range of activities targeting varying physical activity intensities that are typical of their age group including, watching a DVD (sedentary), dribble basketball (moderate intensity) and running (vigorous intensity) among others (Evenson et al., 2008). During the activities, the children wore an ActiGraph accelerometer on their right hip, which measured counts per minute and had their VO_2 and heart rate measured (Evenson et al., 2008). Results indicated that the ActiGraph distinguished well between the different physical activity intensities, which enabled the authors to derive cut points for sedentary, light, moderate and vigorous physical activity (Evenson et al., 2008). Trost et al. (2011) conducted a study comparing different cut points including those proposed by Evenson et al.

(2008). Trost et al. (2011) assessed five different cut points among children aged 5-15 years in a range of sedentary (lying down and computer games etc.) and physical activity behaviours of varying intensities (throwing, catching, basketball, walking, running etc.). The authors concluded that the Evenson et al. (2008) cut points were the most accurate in children and adolescents across all physical activity intensities. In addition, Trost et al's (2011) inclusion of intermittent activities was also a determining factor in choosing the Evenson et al. (2008) cut points for the pragmatic evaluation and feasibility cluster RCT as they are likely to be similar to the movement patterns children generate when engaging in active play. Details on the different cut points used for primary school aged children and the studies used to develop these cut points are described in Table 2.

Table 2. Overview of commonly used ActiGraph cut points

	Age Range and Sample Size	**Details of studies used to develop cut points**	**Cut points**
Evenson et al (2008)	33 children 5-8 years old	Free living activities. For example, walking, stair climbing, basketball dribbling and running	Sedentary ≤ 100 Light> 100 Moderate ≥ 2296 Vigorous ≥ 4012
Freedson and Janz (2005)	80 children aged 6-18 years old	Lab based protocol. Treadmill walk and run.	Age specific- cut points presented are for 12-year olds Sedentary ≤ 100 Light ≥ 100 Moderate ≥ 2220 Vigorous ≥ 4136
Puyau et al (2002)	26 children aged 6-16 year olds	Free living activities. For example, playing a game, walking, jogging and skipping.	Sedentary< 800 Light≥ 800 Moderate≥ 3200 Vigorous≥ 8200

3.4.4 How many days of accelerometry is enough?

Another consideration when using the ActiGraph accelerometer, are the number of hours and days the participants should wear the monitor. It is important to ensure children wear an accelerometer for a sufficient period of time, known as minimum wear time, so that the truest representation of an individual's physical activity levels can be obtained (Trost et al., 2005). It is normal that an individual may engage in more physical activity on some days compared to others; for example, at school, children may engage in more physical activity on days they have physical education compared to days that they do not.

Trost, Pate, Freedson, Sallis and Taylor (2000) found that if children wore the monitor during all waking hours for two to three days (using a CSA 7164 uniaxial accelerometer) the intra-class reliability coefficient was 0.7 and it was 0.8 if children wore the monitor for between four and five days. Suggesting that children aged 7-10 years should wear the monitor during all waking hours for 4 to 5 days to get an accurate representation of their whole day physical activity levels. For the pragmatic evaluation and the feasibility cluster RCT the aim was to get an accurate representation of children's physical activity during an average school day only. In Scotland, children typically attend school for six hours (9-3pm) for five days (Monday-Friday). Given that this is the maximum number of days and hours that could be recorded, it was hypothesized (based on the studies described below) that children had to wear the monitor for $\geq$ 4 hours/school for at least 3 school days to get an accurate representation of their physical activity levels during a typical school week. If a child wore the accelerometer for less than the minimum wear time requirements then their accelerometer data was considered to be not valid and was, therefore, not included in the data analysis. The minimum wear time used in the present studies was similar to that of Kwon, Mason and Welch (2015) who had a minimum wear time of six hours for a minimum of three days. Although, as highlighted in the subsequent sections, for the pragmatic evaluation and feasibility cluster RCT, the majority of participants actually wore the accelerometer for more hours than the minimum wear time.

3.4.5 ActiGraph output data

For the pragmatic evaluation and feasibility cluster RCT, school day physical activity data were collected in 15-s epochs and extracted based on the teacher reported time the monitors were attached and removed each day. The raw data were then converted into total volume of physical activity (counts per minute (cpm)) and physical activity intensities using cut points suggested by Evenson and colleagues (2008): sedentary behaviour (0–100 cpm), light intensity physical activity (101–2292 cpm), moderate intensity physical activity (2293–4008 cpm) and vigorous intensity physical activity (>4008 cpm). Data were then averaged across the school week and reported as percent time in sedentary, light and MVPA.

For the proportion of time spent in MVPA during an Active Play session, the session time was extracted for the school day data and the same process described above was followed.

3.4.6 Summary of measuring physical activity

For the pragmatic evaluation and feasibility cluster RCT, the primary aim was to determine if participating in the Active Play intervention increases school day physical activity levels and a secondary outcome was to assess the proportion of time spent in MVPA during an Active Play session. The ActiGraph accelerometer was chosen because it can be easily attached (on an elastic belt) making it easier for both children and teachers to use (as teachers/children had to attach and remove the monitor at the start and end of the school day). Furthermore, the outcome of most interest was physical activity, in particular, MVPA, which when Evenson cut points are applied, the ActiGraph has been shown to provide a valid and reliable measure of (Evenson et al., 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011).

3.2 Fundamental movement skills

FMS are the basic skills that children should be competent in, and having good FMS increases the likelihood that an individual engages in more complex sports and physical activities (as detailed in Chapter 1, section 5.7) (Lubans et al., 2010; Stodden & Goodway, 2007). For the pragmatic evaluation and cluster feasibility RCT, the Test of Gross Motor Development 2 (TGMD-2) was used to assess children's FMS. It assesses 12 FMS divided into two subtests; locomotor (run, gallop, hop, leap, horizontal jump, side step) and object control (strike, dribble, catch, kick, throw, underhand roll) and each of these 12 skills are assessed on criteria based on a model performance that are divided into 3-5 components of how each skill should be performed (Ulrich, 2000). For each component of the skill the participant achieves they are scored a '1' or a '0' for every component of the skill they do not achieve (Ulrich, 2000). During the assessment, the researcher administering the test demonstrates the skill once and then the participants perform each skill twice while being observed and scored accordingly (Ulrich, 2000). Scores are then adjusted for age and gender to give standard scores and percentiles for the locomotor and object control skills, which are then totalled to give a gross motor quotient score (GMQ- total FMS score) and percentile (Ulrich, 2000). Normative data suggests that children should have a GMQ score of 100, which was based on a sample of 1208 children aged 3-10 years from 1997-1998 from the USA who were tested to provide normative data for the TGMD-2 (Ulrich, 2000). The TGMD-2 also offers a high level of reliability for both subtests (locomotor and object control) across different types of reliability: test-retest (*r* =.96) content sampling (*r* =.91), time sampling (*r* =.96) and scorer (*r* =.98) as well as good validity (goodness of fit index =0.96) (Ulrich, 2000).

The TGMD-2 was chosen to measure children's FMS as it is used widely in research to assess children's FMS and gross motor development, in both surveillance and intervention research (Ulrich, 2000; Okely & Booth, 2004; Morgan et al., 2013). Furthermore, the test is valid, reliable, cost effective and the skills tested are commonly performed by children during play and physical activity (Wiart & Darrah, 2001).

Other motor skills tests have been used in research with children; for example, the Movement Assessment Battery for Children-2 (MABC-2) assesses fine motor skills and some gross motor skills such as catching, throwing, hopping and jumping (Henderson & Barnett, 1992). However, it does not capture the range of gross motor skills that children often engage in during play and physical activity such as running, kicking, side stepping etc., whereas at the TGMD-2 does test these skills (Henderson & Barnett, 1992; Ulrich, 2000). Some common tests of gross motor development are presented in Table 3.

Table 3. Methods of assessing fundamental movement skills

Test	Age Group	Test Information	Purpose	Test Reliability	Strengths	Weaknesses
Test of Gross Motor-2 (TGMD-2) Developed by Ulrich (2000)	3- 10 years	The TGMD-2 assesses 12 FMS divided into locomotor and object control. It takes 15 minutes to administer and can assess several children at a time.	1. Identify children with gross motor development problems 2. Monitor progress 3. Evaluate interventions	*r* ≥ 0.8 in three sources of error: content sampling, time sampling, and inter-scorer differences. (Ulrich, 2000)	1. Equipment is readily available and inexpensive 2. Easy to administer 3. Skills similar to activities children engage in during active play	1. Children's motivation and confidence may affect their performance during the test. 2. Practice required to administer and score the test
Movement Assessment Battery for Children 2 (MABC-2) Developed by Henderson, Sugden and Barnett (1992)	3- <17 years	The MABC assesses both fine and gross motor skills. For example, threading a needle, jumping and catching The test takes 20-40 minutes to administer	1. Identify and monitor progress in children who have movement difficulties	ICC ≥ 0.7 in inter-rater and test-retest reliability. (Wiart & Darrah, 2001)	1. Can be used across a wide age range 2. Scoring system easy to interpret 3. User friendly testing materials to score	1. Time intensive 2. Practice required for administering and scoring
Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) Developed by Bruininks (1978)	4.5-14.5 years	The BOTMP assesses both fine and gross motor skills. It consists of 46 items divided into eight subtests: running speed and agility, balance, bilateral coordination, Strength, upper limb coordination, response speed, visual motor control, and upper limb speed and dexterity. It takes 40-60 minutes to administer	1. Screening and monitoring 2. Evaluation interventions	*r* ≥ 0.77 in inter-rater reliability ICC= 0.86 in test-retest reliability (Wiart & Darrah, 2001)	1. Easy to interpret findings 2. Can be used across a wide age range 3. Simple to score	1. Test is expensive to purchase 2. Time intensive 3. Other tests more reliable

3.3 Inhibition

As detailed in Chapter 1 section 5.8, inhibition is "the ability to withhold actions or modify behaviours" and has been shown to improve through increased levels of physical activity and MVPA (Tomporowski et al., 2015; Hillman et al., 2014). A common and standardised measure of inhibition is a Flanker Test, which is a screen-based test where a central stimulus is 'flanked' by two stimuli on either side and the participant selects a button based on the direction of the central stimulus.

Inhibition was an outcome added for the feasibility cluster RCT and prior to this, during January- March 2017, five 4th year dissertation students working under the supervision of AJ, collected pilot data (to help inform the feasibility cluster RCT) on the Active Play intervention to gain knowledge on and test the inhibition measure. During this pilot phase, a Flanker Test was used on an encrypted university laptop to measure the effect of participating in a single Active Play session on inhibition (whereas the feasibility cluster RCT tested measured inhibition before and after the 10-week programme). Although using a university laptop was a cost-effective method, the encryption meant that there was a delay in the response when participants selected the button, and furthermore, this delay was not consistent among all participants. As reaction time (i.e. how quickly the participants pressed the button) was a key element of measuring inhibition, other methods to administer the Flanker Test that would be more accurate were sought. One solution was to utilise University Apple iPads, which do not require encryption when collecting data; this required an app-based Flanker test developed by an external company

Two apps-based tests were considered, the NIH Toolbox and CANTAB connect, both of which include a battery of tests that measure a range of outcomes one of which is the Flanker Test to assess inhibition. These apps have similar advantages in that they provide Flanker Tests appropriate for children, enable consistency when measuring children across different locations, create and store data that can be downloaded in a simple format ready to be analysed. One major difference between these two products are the cost; CANTAB Connect prices are calculated on quantity per assessment, whereas for the NIH toolbox, an app is purchased once to allow access to all tests in up to 10 iPads. The price for CANTAB connect was quoted to be over >£5000 whereas the NIH Toolbox cost £399 to access the full product.

Therefore, to measure inhibition in the feasibility cluster RCT, the NIH Toolbox Flanker Test was used which requires an Apple iPad Air 2 (Apple Inc., California, USA) to administer the test. For the NIH Toolbox Flanker Test, there is a central stimulus flanked by two stimuli on either side and two buttons pointing left and right and the participants select the button that matches the direction the central stimulus is facing (Weintraub et al., 2013). A mix of congruent trials (stimuli are all facing the same direction) and incongruent trials (the flanking stimuli face the opposite direction to the central stimulus) are presented (Weintraub et al., 2013). Participants were provided an initial four practice trails and had to score at least 3/4 correct or they received an additional four practice trials. They then completed the test which consisted of 20 trials where fish were the stimuli and if they scored 18/20 correct, they then completed another 20 trials where arrows were the stimuli (12 congruent and 8 incongruent trials for both tests) (Weintraub et al., 2013). Participants were given 10 seconds to respond in each trial, if they did not respond within this time limit, the screen moved on to the next trial.

Information on how to process the data is detailed in Chapter 6 section 4.4.6, but briefly practice and non-response trials were removed, and accuracy scores were calculated for the fish test and the arrow test separately. Incorrect trials were removed and reaction time (secs) was averaged for the fish test and the arrow test separately for the congruent and incongruent trials. Finally, the conflict score (the measure of inhibition) was calculated by subtracting the mean reaction time for the congruent trials from the mean reaction time for the incongruent trials for the fish test and the arrow test separately.

The cognition tests in NIH Toolbox has shown to be valid and reliable in children and adolescents aged 3-15 (Weintraub et al., 2013). To assess test-retest reliability, participants completed the seven cognition tests (including the Flanker Test) in the NIH Toolbox and after a period of time they completed the tests again (Weintraub et al., 2013). For convergent validity, each test was matched to a gold standard measurement and Pearson correlations coefficients were conducted to detect differences in test performances (Weintraub et al., 2013). For the inhibition measure, test-retest reliability was high (ICC= 0.95, 95%CI: 0.92, 0.97) in 52 participants (3-15 years old) (Weintraub et al., 2013). For convergent validity, inhibition was significantly correlated to the gold standard (Delis-Kaplan Executive Function System) measure (r =0.7) in 89 participants (3-6 years old) (Weintraub et al., 2013).

Ideally, it would have been preferable to assess both the possible acute and chronic effects of participating in Active Play on children's inhibition. However, this would have been labour intensive, particularly the acute effects, as it would have involved attending a number of Active Play sessions and administering the test to children before and after the sessions, which is not always possible, as the sessions often started either first thing in the morning or just after recess or PE so pre-test data on inhibition could not be collected. When measuring children's inhibition, it is important that they have not participated in physical activity (recess or PE) for approximately 40 minutes as this could influence their scores. Therefore, the possible chronic effects of the intervention on inhibition would be less labour intensive to measure as the participants could be measured at a time of day that was not preceded by a break (recess or lunch) or PE. Furthermore, evidence has also highlighted that physical activity interventions improve inhibition, as discussed in Chapter 1, section 5.8.

3.4 Maths fluency

As detailed in Chapter 1 section 5.8, maths attainment has been shown to improve through increased physical activity and MVPA children (Donnelly et al, 2016; McMorris et al, 2009) and was added as a secondary outcome for the feasibility cluster RCT.

The Wechsler Individual Achievement Test-3rd Edition (WIAT-III) was initially considered; however, this was an expensive and time intensive assessment. After consulting with a senior Educational Psychologist in the School of Psychological Sciences and Health at Strathclyde, it was decided to use a simpler assessment of maths fluency (discussed in section 14.6 of the present chapter). This would give an indication of the potential of the programme in increasing participant's maths scores prior to a definitive cluster RCT, in which, there might be more money available to use a more robust method of assessing math skills.

The WIAT-III can assess an individual's (aged 4-85 years) reading, math, written language and oral language (4 domains-8 subtests) (Breaux, 2009). The assessment is expensive, costing approximately £80 per twenty-five record forms plus additional costs for the manual and scoring book. Furthermore, it is labour intensive as it takes 45-90 minutes to examine one participant across the 4 domains (less time if just maths was being assessed), which would have been difficult to do for the feasibility cluster RCT.

Research into this assessment has highlighted good intra-scorer reliability (ranging from 0.92 - 0.99) and inter-scorer reliability (ranging from 0.94 - 0.98) and internal consistency (0.83 -0.98) across different ages (Breaux, 2009; Donnelly et al., 2013). Furthermore, correlations between the WIAT-III and other achievement tests highlight it has good validity (0.62 - 0.86) (Breaux, 2009; Donnelly et al., 2013). Given the good reliability and validity, it is recommended that the WIAT-III is used in a future definitive RCT, if money allows. It has also been widely used in physical activity and academic achievement research (Donnelly et al., 2013; Lambourne et al., 2013).

To measure participant's Maths Fluency in the feasibility cluster RCT, the One Minute Basic Number Facts Test (1995) was used as it was suggested by a senior Educational Psychologist in the School of Psychological Sciences and Health, is used widely to assess the performance of Australian students and has a test-retest reliability ranging from 0.88 to 0.94 (depending on age level). Furthermore, the test utilises addition and subtraction sums that children are familiar with doing in school. The test can be found in Appendix A.

The One Minute Basic Number Facts Test (1995) has a simple instruction where participants are asked to answer as many addition sums as possible in one minute by writing their answers next to the given sums, the same instruction is repeated for the subtraction element of the test. The correct answers are then totalled for each component of the test (addition and subtraction).

4. Summary of main similarities and differences in methodology between the pragmatic evaluation and the feasibility cluster RCT

The school-based Active Play intervention is a one-hour outdoor active play session incorporating 30 minutes of facilitated games and 30 minutes of free play and is delivered by playworkers from local play charities (described in more detail in section 5 in the present Chapter). Two studies in the present thesis evaluated the Active Play intervention: a pragmatic evaluation (Chapter 5) and feasibility cluster RCT (Chapter 6). The aim of this section is to briefly outline the main similarities and differences between these two studies as the pragmatic evaluation was used to inform the feasibility cluster RCT.

Firstly, the outcomes across these two studies were similar; school day physical activity, the proportion of time spent in MVPA during an Active Play session and FMS were measured in both studies. Inhibition and maths fluency were added in the feasibility cluster RCT and additional information on the feasibility of the trial (consent rate, data lost) and of the intervention (intervention fidelity etc.) was also collected so that findings could inform a future definitive RCT. The methodology for measuring these outcomes improved in the feasibility cluster RCT, which is detailed in the sections below.

The pragmatic evaluation started around September 2015 and ended in March 2016 and involved children from seven schools (eleven classes) in primary 1–5 (mean age =7.0 years; SD =1.1). For the pragmatic evaluation the intervention last 5-months, but this was reduced to 10-weeks for the feasibility cluster RCT. Reducing the duration of the intervention was a decision made by the funders as they agreed to deliver the intervention to 118 schools across Glasgow City Council (one primary 3 or 4 class per school) over a three-year period, which could only be achieved if the intervention was shortened to 10 weeks. The feasibility cluster RCT started in August and ended in December 2017 and involved children from eight schools (one class per school) in primary 3 (mean age =7.1; SD =0.3).

The change in intervention duration also meant that the intervention dosage was the same across all schools for the feasibility cluster RCT (one session per week). For the pragmatic evaluation, the play charities (who deliver the intervention) decided how many sessions per week each class received, which resulted in some schools participating in one session/week and two sessions/week in other schools.

The study design was also improved for the feasibility cluster RCT; in the pragmatic evaluation, classes could not be randomised (because the play charities had already recruited the schools and classes) to the intervention or comparison group. The comparison group was recruited from two schools already participating in the active play programme, but they did not receive the intervention (specific details of the pragmatic evaluation are provided in Chapter 5). Whereas, in the feasibility cluster RCT schools were matched and randomly allocated to either the intervention or control group. Specific details on how the schools were selected, matched and assigned to either the intervention or control group are provided in Chapter 6 (feasibility cluster RCT). Table 4 presents the main similarities and differences between both of these studies.

Table 4. Summary of key similarities and differences between the pragmatic evaluation and the feasibility cluster RCT

	Pragmatic Evaluation	**Feasibility Cluster RCT**
Study Aims	**Primary Aims:** 1. Does school day physical activity and MVPA increase in the intervention group compared to the comparison group? 2. Do FMS improve in the intervention group compared to the comparison group? **Secondary Aim** 1. What is the MVPA content of a Go2Play Active Play session?	The following questions will be answered to help inform a full cluster RCT: • How many children consented to the study from the total population/number of children in the classes? • How many were measured at baseline and follow-up? • Feasibility of delivering the intervention (e.g. were all 10 sessions delivered, were they delivered as intended?) • Feasibility of outcome measures (e.g. how many children provided valid outcome data at baseline and follow-up) **Outcome Measures** *Primary Aims:* 1. Does school day physical activity and MVPA increase in the intervention group compared to the control? 2. Do FMS improve in the intervention group compared to the control? *Secondary Aims:* 1. Does inhibition improve in the intervention group compared to the control? 2. Does maths fluency improve in the intervention group compared to the control? 3. What is the MVPA content of an Active Play session?
Study Design	This study was considered a pragmatic evaluation from the planning stage. This meant that decisions on how many classes, schools and what classes received the intervention were decided by the play charities. Two classes were recruited to act as a comparison but there was no random allocation to intervention and comparison.	This study is a feasibility cluster RCT, in which learnings from the pragmatic evaluation were used to improve most aspects of the feasibility cluster RCT. Eight schools were recruited and matched on a set of criteria and then randomly allocated to intervention or control (more details provided below).
Participant Numbers (inc no of	Eleven intervention classes (from seven schools) were compared to two classes not receiving the intervention (from two schools already participating in the intervention).	Four intervention schools were matched to four control schools (one class per school).

classes and schools)	172 participants in the intervention group consented to evaluation and 24 from the comparison group.	73 participants in the intervention group consented to the trial and 64 from the control group.
Intervention Duration	The intervention lasted 5 months. Schools started the intervention at different times, but baseline measurements were primarily taken in September and October 2015 and follow-up data collection began in February and finished in March 2016(but the intervention continued after follow-up measurements were taken).	The intervention lasted 10-weeks. The schools in the intervention group started the intervention one week apart so that measurements were gathered more easily. This meant that the intervention began in August and September 2017 and finished in November and December 2017.
Intervention Dosage	Classes received either one or two sessions per week (The play charities decided how many sessions per week each class received) The participants who received two sessions/week were measured at true baseline (i.e before the intervention began) and therefore were included in the analysis of changes in physical activity as detailed in Chapter 5.	All classes received one session per week. Inspiring Scotland and Glasgow City Council decided that each school would allocate one class to receive one session per week because of the number of schools they have to deliver the programme to over the three-year period
Age of Participants	Children ranged from P2-4 and had a mean age of 7.0 years in the intervention group and 7.4 years in the comparison group.	All children were in primary 3 and had a mean age of 7.1 (0.3) in the intervention group and 7.0 (0.3) in the control group.
The methodology of outcome measures and timing of measures	1. School day PA Asked to wear monitors for four school days (data was considered valid if children wore the monitor for a minimum of four hours per day for three days) before the intervention began and then again 5-months later (near the end of the intervention). 2. FMS Measured by lead researcher and trained field assistants. FMS was measured within the first few weeks of the intervention beginning and then again 5-months later (near the end of the intervention). 3.MVPA content of an active play session	1. School day PA Asked to wear monitors for five school days, apart from one pair of schools (data was considered valid if children wore the monitor for a minimum of four hours per day for three days), data collected before the intervention began and then again at week 9 of the intervention. 2. FMS Measured by the lead researcher and was measured before the intervention began and then again after the intervention had finished 3. Inhibition Measured in a quiet room using a validated app from the NIH Toolbox on an iPad before the intervention began and then again once the intervention finished.

The proportion of time spent in MVPA during an Active Play session was measured using an the ActiGraph and data were extracted from the session time reported by charities (i.e 13:00-14:00).	4. Maths fluency Measured in a quiet room using a simple test before the intervention began and once the intervention finished. 5. MVPA content The proportion of time spent in MVPA during an Active Play session was measured using an the ActiGraph. The researcher was present at the session to note the time the session started and finished (i.e 13:05-13:58). Additionally, what time the structured part finished, and free play began to determine the time spent in MVPA for each part of the session.

5. Overview and background of the Active Play intervention

The intervention has been explained in detail for the pragmatic evaluation (Chapter 5) and the feasibility cluster RCT (Chapter 6) but more information has been added to this section to provide a more in depth explanation of the theoretical basis of the intervention, its development and aims.

The intervention was developed by Inspiring Scotland (www.inspiringscotland.org.uk/), who manage and fund the intervention, and Agile CIC (www.agilecic.com), who train and support the playworkers. The Active Play intervention was first piloted in 2014 in the community (before the pragmatic evaluation commenced) and was initially an hour of solely free play where children were given a bag of equipment and allowed to choose and explore their own play. Anecdotal evidence from this approach from the play charities and the developers of the intervention observed that when the sessions were solely free play children were unsure of what to play, were not engaging in MVPA and were unlikely to develop a range of FMS. Upon reviewing these observations, the intervention design was altered to 30 minutes of games facilitated by trained playworkers from the play charities and 30 minutes of free play and was delivered in a school setting where more children could be engaged. Although schools are only open for around half of the year, they have access to all children, particularly children who have low levels of physical activity and may not otherwise attend a community-based programme, and it is important to engage these children (Dobbins et al., 2009; Story et al., 2009).

During the school-based Active Play intervention, the playworkers were provided with basic equipment such as balls, beanbags, rackets, skipping ropes, hula hoops and other basic equipment that they used for the session. The facilitated element aimed to develop children's FMS by playing games, introducing a variety of equipment, provide them with ideas of what to play and encourage MVPA. Playworkers were encouraged to facilitate games (examples of games can be found at www.actify.org.uk/activeplay) that would develop a range of FMS (locomotor and object control). For example, if in one session they facilitated games that encouraged children to develop their object control skills (e.g. catching, throwing, kicking), then in the following session the emphasis would be on locomotor skills (e.g. hopping, running, skipping. During the free play element, the children were free to use the equipment to play the games from the facilitated element, create new games, explore their environment and develop their FMS through their own exploration. It might be that participating in the Active Play intervention would increase physical activity beyond the sessions as children are being introduced to a variety of equipment and learning new games.

During the pragmatic evaluation, the play charities provided their own equipment during the sessions, which resulted in each charity offering slightly different equipment, but most provided a range of balls, hockey sticks, tennis racquets, skipping ropes and hula-hoops. Whereas in the feasibility cluster RCT, each charity was provided with the same equipment to ensure a more consistent approach between the play charities. As detailed elsewhere in this chapter, during the pragmatic evaluation the play charities recruited the schools, decided which classes received the Active Play intervention and how many sessions per week they would deliver to each class (either one or two sessions/week). The approach for the feasibility cluster RCT was more consistent; the schools signed up to the intervention at the start of the school year and received a 10-week intervention (one session/week) for one primary 3 class.

The developers of the intervention were influenced by the concept of physical literacy (described in Chapter 1, section 3) when designing the intervention. Physical literacy is ‘the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life’ (International Physical Literacy Association, 2017). Recent emergent research from Canada has highlighted that physical literacy levels are low in children and this is affecting their adherence to the physical activity guidelines (Trembley et al., 2018; Belanger et al., 2018). Furthermore, Trembley et al. (2018) suggested that the low physical literacy scores could be a result of children opting for screen-based activities rather than active play. Play has been suggested as a natural way of developing children’s physical literacy; however, it cannot be developed by play alone. Children, at times, need adults to broaden their experiences and introduce them to a range of FMS and settings (Whitehead, 2010). The Active Play programme was designed with this in mind. The facilitated component encourages children to try new skills, develop their physical competence (FMS) and confidence in a positive environment where the adults (playworkers and teachers) are encouraged to participate in the sessions and model and support the children. The free play component continues their FMS development as children are encouraged to use a variety of equipment to practise a range of skills and create their own games. Their confidence and motivation are also increasing as their skill development improves and they are able to explore their own play and environment and are working at their own level, in a positive and safe environment with their friends.

6. Expanded methodology for the pragmatic evaluation

The aim of this section is to provide more detail on the methodology for the pragmatic evaluation (see Chapter 5), which was published in Preventive Medicine Reports in June 2017.

7. Planning phase for the pragmatic evaluation

Planning for the pragmatic evaluation commenced in mid-August 2015 when funders approached the University to evaluate the Active Play intervention, which gave the research team only three weeks to plan before baseline data collection commenced. This meant that decisions made regarding study design and data collection methods were restricted by limited time and money.

A total of seven schools (eleven classes) were involved in the pragmatic evaluation and a meeting was arranged with each headteacher before evaluation commenced to detail what was involved in the research and what was required of their staff. Three local play charities delivered the Active Play intervention across three local authorities in west, central Scotland. This was the first time the charities were involved in academic research; therefore, they also required a meeting to discuss the research and what was required of them. The play charities had already liaised with the schools and had already scheduled the delivery of the intervention for each of the schools before the evaluation commenced. This meant that the researcher (AJ) could not always measure school day physical activity (results presented in Chapter 5 are based only on classes who could be measured before the intervention started) and FMS before the intervention started or have a say on how many sessions per week the classes should receive (so that all classes were receiving the same dose of intervention). Consent forms were distributed to classes by the play charities and were collected by the lead researcher (AJ) before data collection commenced. The lead researcher did not meet any of the children before the evaluation commenced, but from *n* =306 children who were invited to participate in the evaluation, *n* =196 children provided consent, which was a 64% response rate. Of these children, *n* =257 were from the intervention group and *n* =172 agreed to participate in the research, which was a 67% response rate in the intervention group.

8. Data collection for the pragmatic evaluation

As mentioned in chapter 5, baseline data collection for the pragmatic evaluation was conducted in September and October 2015 and follow-up data collection was February and March 2016. The primary outcomes of interest were school day physical activity (particularly MVPA), the proportion of time spent in MVPA during an Active Play session and FMS, which were measured using an ActiGraph accelerometer and the TGMD-2, respectively. An overview of these methods and a justification as to why these methods were used is provided at the beginning of the present chapter. The procedures for gathering these data will now be explained.

8.1 Procedures for measuring physical activity

Participants were asked to wear the ActiGraph accelerometer for four school days (9.00-15.00). Although children typically go to school for five days (Monday-Friday), participants were asked to wear the ActiGraph accelerometer for four school days so that the accelerometers could be downloaded and initialised every Monday.

On the first day of measurement, the lead researcher (AJ) attended each school to put the monitors on the consenting participants, the next three days the teachers were asked to ensure that the monitors were attached as early as possible and removed just prior to school finishing so that the accelerometers captured as much of the school day as possible. Teachers reported the time (to the nearest 5 minutes) the monitors were attached and removed each day in a class diary (see Appendix B). As expected, accelerometers were not always attached at 9.00 or removed at 15.00; therefore, data were removed if any participants did not wear the monitor for a minimum of 4 hours/ school day for 3 school days in total (minimum wear time is discussed in section 3.1 of the present Chapter) and if they did not have their school day physical activity measured before the intervention started. The average number of hours and days the children wore the ActiGraph is provided in Chapter 5, section 4.6.

The same procedures were followed for measuring school day physical activity at follow-up.

As mentioned, school day physical activity data for the pragmatic evaluation were collected at baseline during September and October 2015 (Autumn) and again at follow-up during February and March 2016 (Spring). Seasonal effects on physical activity have been found to be statistically significant in Scotland ($p < .001$) with physical activity lower during winter and spring compared to summer and autumn; therefore, any possible seasonal effects are likely to attenuate the effect of the intervention (Fisher et al., 2005). Furthermore, as physical activity was measured during the school day, only break times are likely to affect children's physical activity levels.

8.2 Procedures for measuring MVPA during Active Play

The proportion of time spent in MVPA during an Active Play session was measured to determine how active children were during a typical Active Play session. As described above, children wore the ActiGraph accelerometers to measure school day physical activity at follow-up while the intervention was still taking place. On the days the participants attended the Active Play session, the data was extracted by using timeslots reported by the play charities before programme delivery started, for example 13.00-14.00. However, most sessions did not last the full hour as children might be delayed starting the Active Play session or the session might finish early, which may have meant that the data extracted did not solely include the active play session.

A more accurate way of determining the physical activity content of the active play sessions is for the researcher to attend the session and note the time the session (to the nearest minute) begins and finishes, this procedure was used in the feasibility cluster RCT.

8.3 Procedures for measuring fundamental movement skills

FMS was measured in a randomly selected sub-sample (using a random number generator) of consenting children as it was not possible to assess all children who consented. FMS were assessed when the intervention had already started meaning that children's FMS may have already improved before the researcher could measure the participants; however, most participants in the subsample had their baseline FMS assessed within one month of the intervention beginning. The mean duration between which FMS was measured at baseline and follow-up was 4 months (SD =0.4). Participants had their FMS assessed by the lead researcher (AJ) and field assistants in groups of no more than three, as detailed in chapter 5. The same procedures were followed at follow-up data collection in February and March 2016, near the end of the intervention.

9. Data analysis

Details for how the data were analysed are presented in chapter 5, section 4.8.

10. Limitations and lessons learned for the pragmatic evaluation

The major weaknesses of the pragmatic evaluation have been discussed elsewhere in this thesis (Chapter 5, section 6). However, briefly, the schools were chosen by the play charities and, therefore, were not randomised to receive the intervention. The number of children in the comparison group was also much smaller than the number of children in the intervention group and were recruited from two schools who had classes receiving the intervention, but the comparison classes did not receive the intervention. Baseline measurements were not always 'true' baseline, for example, some measurements were taken once the Active Play intervention had started. School day physical activity, in some cases, was measured once the intervention had started but only those with a true baseline were included in the results (Chapter 5, section 5.1) and FMS were assessed in the first few weeks of the intervention, which may have resulted in the intervention improving participant's FMS before they were assessed at baseline. Finally, it would have been desirable to measure whole day physical activity (rather than school day physical activity) to determine if the Active Play intervention increased physical activity beyond the school day. However, due to the number of children and schools involved and the limited number of ActiGraph accelerometers and time constraints to collect baseline data, this was not feasible.

Despite these limitations, there was enough promise in this study (Chapter 5, section, 5) in terms of the proportion of time spent in MVPA during an Active Play session and the effects of the intervention on school day physical activity and FMS, to explore the feasibility and possible impact of the Active Play intervention by conducting a feasibility cluster RCT. Furthermore, as presented below, these limitations were largely addressed in the design of the feasibility cluster RCT.

11. Expanded methodology for the feasibility cluster RCT

As mentioned in Chapter 6, baseline data collection for the feasibility cluster RCT was conducted in August and September 2017 and follow-up data collection in November and December 2017. The aim of this cluster RCT was to determine the feasibility of an Active Play intervention to inform a future definitive RCT. Information on: consent rate, data lost to follow-up, intervention fidelity and number of participants included in the analysis and estimates of the effect for each outcome measure (physical activity, the proportion of time spent in MVPA during an Active Play session, fundamental movement skills, inhibition and maths fluency) was collected.

An overview of these outcomes and a justification as to why these methods were used is provided at the beginning of the present chapter. The following sections will provide an outline of the procedures followed for collecting the main outcome data.

12. Planning Phase of the feasibility cluster RCT

Planning for the feasibility cluster RCT commenced in March 2017 and was informed by the pragmatic evaluation. As previously mentioned, the intervention evaluated in the pragmatic evaluation lasted approximately 5-months, but the intervention was shortened to 10-weeks (but the structure of each session remained the same) so that it could be delivered to 118 schools in Glasgow City over a three-year period (August 2016 to June 2019). Glasgow City Council's Physical Education, Physical Activity and School Sport (PEPASS) were responsible for selecting the 118 schools to receive the intervention.

12.1 Selection of Schools

The selection of schools has been discussed in Chapter 6 (section 4.2), but briefly, Glasgow City Council invited 60 schools to participate in the Active Play intervention during the 2017-18 school year (this is when the feasibility RCT took place). Of these 60 schools, 34 (57%) agreed to participate in the Active Play intervention and a list of these schools was passed to the lead researcher (AJ) divided by location (South and North West). Important information (socio-economic status of the school, percentage of children on free school meals, percentage of children who live in the 20% most deprived areas, school enrolment, number of primary 3 children, percentage of children from ethnic minority groups) on each school was obtained from the Scottish Government (www.gov.scot/Topics/Statistics/Browse/School-Education/Datasets).

Inspiring Scotland aim to work with the most deprived schools, for this reason schools were eligible for the feasibility RCT if ≥70% of their pupils were from the 20% of Scotland's most deprived areas. To avoid contamination, schools were not eligible if they had an existing relationship with any of the play charities that delivered the Active Play intervention or had been involved in the previous pragmatic evaluation. The number of schools excluded based on deprivation, a relationship with the play charities or involved in the previous pragmatic evaluation is detailed in Chapter 6. Once ineligible schools were excluded, five schools remained from the South of the city and six schools from the North West, they were then matched on deprivation (percentage of children who live in the 20% most deprived areas), school enrolment, demographics, and geography. Two schools in the North West and one school in the South of the city were removed and used as contingencies because they were not located near the other schools. Therefore, eight schools were selected for the trial and all eight schools agreed to take part in the trial via their headteachers.

These eight schools (one primary 3 class per school) were matched for deprivation school enrolment, demographics, and geography and each pair of schools were randomised prior to data collection beginning by a researcher unaffiliated to the present trial who used a random number generator to randomly assign each pair of schools to either the intervention or the waiting-list control. Schools allocated to the intervention group received the intervention in August 2017 and the control schools would receive the intervention in April 2018 once the trial was completed.

12.2 Co-ordination of the research with the schools

From May 2017 to June 2017, the lead researcher (AJ) arranged meetings with the headteachers of each school to provide information about the trial. The play charities attended these meetings with the four intervention schools to discuss their involvement in the delivery of the Active Play intervention. Consent forms were distributed at the beginning of the new school year (August 2017) to all children in the primary 3 class for each school. The lead researcher met with each class to provide an overview of the trial.

The next step was to arrange data collection for each pair of schools as they were being measured at the same time point (as detailed in the Table 5). Each pair of schools were measured during the same week to ensure measurements were as similar as possible, for example, if weather was an issue for school day physical activity measurements, it would affect both schools equally. Two weeks were scheduled to collect the data in each pair of schools, the first week for measuring the height and weight (using electronic scales and a stadiometer), FMS, inhibition and Maths Fluency and the second week to measure school physical activity using the ActiGraph accelerometers. The following week, the intervention schools would receive the Active Play intervention for 10 weeks and the control schools would continue their usual routine. Follow-up data collection took place during November and December 2017. The proposed timetable was confirmed with the schools and the play charities.

Table 5. Feasibility cluster RCT data collection timetable

		First Pair (*n* =2)	Second Pair (*n* =2)	Third Pair (*n* =2)	Fourth Pair (*n* =2)
Aug-17	**W/C 21st**	Height/weight, FMS, cognitive & attainment			
	W/C 28th	School day PA measures	Height/weight, FMS, cognitive & attainment		
Sep-17	**W/C 4th**	Active Play session - 1	School day PA measures	Height/weight, FMS, cognitive & attainment	
	W/C 11th	Active Play session - 2	Active Play session - 1	School day PA measures	Height/weight, FMS, cognitive & attainment
	W/C 18th	Active Play session - 3	Active Play session - 2	Active Play session - 1	School day PA measures
	W/C 25th	Active Play session - 4	Active Play session - 3	Active Play session - 2	Active Play session - 1
Oct-17	**W/C 2nd**	Active Play session - 5	Active Play session - 4	Active Play session - 3	Active Play session - 2
	W/C 9th	Active Play session - 6	Active Play session - 5	Active Play session - 4	Active Play session - 3
	W/C 16th	**Glasgow City Council Holiday**			
	W/C 23rd	Active Play session - 7	Active Play session - 6	Active Play session - 5	Active Play session - 4
	W/C 30th	Active Play session - 8	Active Play session - 7	Active Play session - 6	Active Play session - 5
Nov-17	**W/C 6th**	Active Play session - 9 - School day PA measures	Active Play session - 8	Active Play session - 7	Active Play session - 6
	W/C 13th	Active Play session - 10	Active Play session - 9 - School day PA measures	Active Play session - 8	Active Play session - 7
	W/C 20th	FMS, cognitive & attainment	Active Play session - 10	Active Play session - 9 - School day PA measures	Active Play session - 8
	W/C 27th		FMS, cognitive & attainment	Active Play session - 10	Active Play session - 9 - School day PA measures
Dec-17	**W/C 4th**			FMS, cognitive & attainment	Active Play session - 10
	W/C 11th				FMS, cognitive & attainment

13. Data collection for the feasibility cluster RCT

13.1 Procedures for collecting process data

Information on the procedure for collecting process data is detailed in the Chapter 6 (section 4.4.2) but briefly, the lead researcher captured information on the number of participants who consented to the trial and the feasibility of the outcome measures, such as the number of children who provided data at baseline for each outcome and how many were lost at follow-up with reasons.

The playworkers involved in delivering the intervention kept a record of the number of Active Play sessions cancelled, if any session was delivered indoors due to adverse weather conditions, and the duration of each session to determine if the intervention was delivered as intended (i.e. to provide an indication of intervention fidelity). Class teachers were asked to record the attendance of their class at the Active Play sessions to determine how many sessions each participant attended. The lead researcher (AJ) also used an assessment tool developed by Agile CIC (who trained the playworkers) to observe if the playworkers were delivering the intervention as intended. AJ visited one session from each of the four intervention schools to observe the playworkers at week four or six. The assessment tool (found in Appendix C) examined four dimensions: team and individual skills and attributes, knowledge and experience, putting the training into practice and delivery. For each of these four dimensions, there were 4-6 items in which the playworkers were scored out of 5. Results of the assessment tool are presented in Chapter 6 section 5.2 for the feasibility cluster RCT.

13.2 Procedures for measuring school day physical activity

In the feasibility cluster RCT, the number of days the participants were asked to wear the ActiGraph accelerometer increased to five days (9.00-15.00), apart from two schools who wore them for four days, as there was a school holiday during baseline data collection. ActiGraph accelerometers were downloaded and initialised on the Friday evening after they were collected from the school. Details of why the ActiGraph was chosen to measure physical activity is detailed at the beginning of the present chapter. A similar protocol was followed for distributing the monitors in the pragmatic evaluation.

The same procedures were followed for measuring school day physical activity at follow-up, which was measured at week 9 of the intervention. School day physical activity was re-measured in two control schools during January 2018 as they did not wear the monitors as planned in week 9.

Similar to the pragmatic evaluation, given that baseline data collection was during autumn and follow-up was during winter for the feasibility cluster RCT, any possible seasonal effects are likely to attenuate the effect of the intervention (Fisher et al., 2005). Furthermore, as physical activity was measured during the school day, only break times are likely to affect children's physical activity levels and schools were matched their physical activity measured at the same time to reduce the influence of this.

13.3 Procedures for measuring MVPA during Active Play

The data collection of the physical activity content of the Active Play sessions improved from the pragmatic evaluation. During follow-up, when the participants wore the ActiGraph accelerometers to measure their school day physical activity, the lead researcher (AJ) attended the sessions to note the exact time (to the nearest minute) the session started and finished. Furthermore, AJ noted the time the facilitated part of the session finished, and free play started so that the physical activity content of each of the session components could be compared. This method of collecting the data for the physical activity content of the sessions is likely to be a much more accurate way of determining how physically active the participants are during the session.

13.4 Procedures for measuring fundamental movement skills

As per the pragmatic evaluation, the TGMD-2 was used to measure FMS and a justification of why this method was chosen is presented at the start of the present chapter. In the feasibility cluster RCT, FMS was measured before the intervention started so that the participants’ true baseline levels of FMS was captured, which did not happen in the pragmatic evaluation. Children were taken out of class in groups of approximately three to have their FMS assessed outdoors in the playground. It would have been preferable to measure FMS inside as the weather could inhibit their performance (i.e. motivation in cold weather) when measuring the participants outside, but space in some of the primary schools was restricted. The lead researcher (AJ), who has experience in using the TGMD-2 from the pragmatic evaluation, assessed FMS in all participants.

In instances where more than 20 children from a school consented to the trial (n =1 school) 10 male and 10 female participants were randomly selected using a random number generator for FMS measurements. Measuring more than 20 children’s FMS would have been too labour intensive. The same protocol for measuring FMS was followed at follow-up. These measurements were taken one week after the 10-week intervention was completed, but in instances where the test could not be administered because of poor weather conditions, they were measured a few weeks after.

13.5 Procedures for measuring inhibition

A justification as to why inhibition was measured using the NIH Toolbox Flanker Test and an explanation of the measure is detailed in section 3.3 of the present Chapter. Children were taken out of class in groups of no more than three to a quiet room supplied by the school. The test was administered on an Apple iPad Air 2 (Apple Inc., California, USA) and participants were provided with a simple instruction describing the task they had to follow. Participants were presented with the fish test first and if they scored 18/20 correct, they then completed the arrow test.

Inhibition was measured the same week as FMS, either the day before the FMS measure or in the morning prior to, in case the FMS test had an effect on children's inhibition. More information of the procedures for measuring inhibition is detailed in Chapter 6, section 4.4.6. The same procedures were performed at follow-up.

13.6 Procedures for measuring maths fluency

A justification as to why maths fluency was measured using The One Minute Basic Number Facts Test (1995) and an explanation of the measure is detailed in section 3.4 of the present Chapter. For the maths fluency test participants were given one minute to answer as many addition sums as they could and once the allocated time was finished, participants were given another minute to complete as many subtraction sums in the time provided. The same instruction was given to each participant. The same process for measuring maths fluency was followed for follow-up. More information on the procedures for measuring inhibition is detailed in Chapter 6, section 4.4.7.

Inhibition and maths fluency were measured two weeks prior to the intervention beginning and again once the intervention was complete. Participants were taken to a quiet room supplied by the school in small groups to be assessed and the order of these assessments were randomised to minimise order effects. In most instances, the same protocol was completed for follow-up; however, at the start of baseline data collection, there was a delay in obtaining the NIH Toolbox Flanker Test in three schools. This resulted in the researchers arranging to go back and measure these schools on a separate day and inhibition was not assessed on a separate day for follow-up in these three schools.

14. Data analysis

Details for how the data were analysed is presented in Chapter 6, section 4.8.

15. Limitations of the feasibility cluster RCT

Details of important weaknesses in the feasibility cluster RCT are reported in the Chapter 6 (sections 6.1), but briefly the lead researcher who collected the data could not be blinded to group allocation. For most of the outcomes, the researcher could not influence the results. However, for FMS there may have been a bias and/or human error, which was minimised by following standardised procedures and using a researcher (AJ) who has experience in using the TGMD-2. Future studies should consider filming FMS to improve the accuracy of the scores or blind the researcher to group allocation.

Generalisability may also be limited as the eight schools involved in the trial had > 70% or more pupils from 20% of Scotland's most deprived areas. However, of the schools who agreed to participate (*n* =34 schools) in the Active Play intervention, 66% had 50% or more children living in the 20% most deprived areas. The aim of the funder was to provide the Active Play intervention to the most deprived schools in Glasgow.

Similar to the pragmatic evaluation, it would have been desirable to measure physical activity across the whole day (i.e. both inside and outside of school), but due to restraints on time and resources this was not possible.

16. Conclusions

The aim of this chapter was to provide a justification for each outcome measured in the pragmatic evaluation and the feasibility RCT, summarise key differences in methodology between these two studies and provide information on the procedures followed for the pragmatic evaluation and feasibility cluster RCT.

To summarise, practical, valid and reliable methods were used to assess the outcomes of interest in the pragmatic evaluation and feasibility cluster RCT. Although the pragmatic evaluation has some important limitations, these were reviewed and addressed for the feasibility cluster RCT, which was a much more robust study. An additional two outcomes were also added to the feasibility cluster RCT to determine if participating in the Active Play intervention had benefits beyond physical activity and FMS.

Chapter 5 and 6 will now present the papers of the pragmatic evaluation and feasibility cluster RCT.

Chapter 5: Pragmatic evaluation of the Go2Play Active Play intervention on physical activity and fundamental movement skills in children

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1. Preface

Findings from the systematic review (Chapter 3) highlighted that there were gaps in the evidence on the effect of active play interventions on physical activity (particularly MVPA), FMS and other outcomes. The aim of this chapter is to present the published paper, 'Pragmatic evaluation of the Go2Play Active Play intervention on physical activity and fundamental movement skills in children', which was published in Preventive Medicine Reports in June 2017. The paper is presented in the same format as it was published in the journal (note the Active Play intervention is referred to as Go2Play Active Play in this chapter) and, therefore, the referencing system is not APA as is used in the other chapters of this thesis (reference list presented at the end of this chapter).

As mentioned in the previous chapter, AJ planned and conducted the study and was lead author. Two undergraduate students supported AJ in collecting data for the FMS outcome. AH and JJR provided guidance on each aspect and XJ provided training and support for the physical activity outcomes. All authors read and approved of the final manuscript.

2. Abstract

Active play is a novel approach to addressing low physical activity levels and fundamental movement skills (FMS) in children. This study aimed to determine if a new school-based, 'Go2Play Active Play' intervention improved school day physical activity and FMS. This was a pragmatic evaluation conducted in Scotland during 2015–16. Participants (*n* =172; mean age= 7 years) were recruited from seven primary schools taking part in the 5-month intervention, plus 24 participants not receiving the intervention were recruited to act as a comparison group. 189 participants had physical activity measured using an ActiGraph GT3X accelerometer at baseline and again at follow-up 5 months later. A sub-sample of participants from the intervention (*n* =102) and comparison (*n* =21) groups had their FMS assessed using the Test of Gross Motor Development (TGMD-2) at baseline and follow-up. Changes in school day physical activity and FMS variables were examined using repeated measures ANOVA. The main effect was 'group' on 'time' from baseline to follow-up. Results indicated there was a significant interaction for mean counts per minute and percent time in sedentary behavior, light intensity physical activity and moderate-to-vigorous physical activity (MVPA) (all $p < 0.01$) for school day physical activity. There was a significant interaction for gross motor quotient (GMQ) score ($p= 0.02$) and percentile ($p= 0.04$), locomotor skills score and percentile (both $p= 0.02$), but no significant interaction for object control skills score ($p= 0.1$) and percentile ($p= 0.3$). The Go2Play Active Play intervention may be a promising way of improving physical activity and FMS, but this needs to be confirmed in an RCT.

3. Introduction

Systematic reviews have provided high-quality evidence to support the role of physical activity in childhood, more specifically moderate-to-vigorous physical activity (MVPA), on improving health-related behaviors such as weight management; risks of cardiovascular disease, type 2 diabetes and high blood pressure (Janssen and Leblanc, 2010; Timmons et al., 2012). However, most children in western societies are not reaching the recommended 60 min of MVPA per day, with serious consequences on their health in later life (Department of Health, 2011; Basterfield et al., 2008; Healthy Behaviours in School Children (HBSC), 2015; Reilly et al., 2016a). A recent study by Reilly and colleagues suggested that children's physical activity levels decline at five years of age, approximately around the time they begin school (Reilly, 2016).

One neglected area of research is the possible role of active play in increasing children's physical activity. Active play involves children using large muscle groups to expend energy in physical activity which is unstructured, freely chosen and fun (Truelove et al., 2016). It has the potential for population-wide gains in habitual physical activity and MVPA levels if engagement is increased (Janssen, 2014; Tremblay et al., 2014).

Active play often takes place in outdoor settings, and outdoor time is associated with increased habitual physical activity and MVPA levels compared to time spent indoors (Cooper et al., 2010; Gray et al., 2015; King et al., 2011). However, contemporary children are engaging in less outdoor active play, probably due to parental safety concerns and the increasing use of screen-based activities (Veitch et al., 2006; Marshall et al., 2006). Active play may generate higher levels of

MVPA compared to other domains of physical activity such as physical education (PE), recess, active transportation and other sports and physical activities, which have been the subject of more research effort (Hollis et al., 2016; Martin et al., 2016; Brazendale et al., 2015; Brockman et al.,2010; Reilly et al., 2016b). Recent intervention studies have also suggested that active play may improve fundamental movement skills (FMS) (Jones et al., 2011; Adamo et al.,2016; Lai et al.,2014). FMS are important, as they are associated with increased physical activity and MVPA levels; however, FMS are typically poor in contemporary children (Lubans et al., 2010; Fisher et al., 2005a; Hardy et al., 2012; O'Brien et al., 2015). Therefore, facilitated active play sessions may be required for children to increase their physical activity levels and improve their FMS. A school setting provides an ideal opportunity to influence children's physical activity levels and FMS (Lai et al., 2014; Dobbins et al., 2009). Schools have access to all children, including those from at-risk groups, who would otherwise not attend a community-based intervention (Story et al., 2009). A new school-based intervention called ‘Go2Play Active Play’ was facilitated by playworkers, delivered weekly and lasted one-hour in duration. It used a combination of free play and active play to increase children's physical activity levels and improve their FMS. Therefore, the primary aim of this research was to determine if participation in the Go2Play Active Play intervention improved (a) school day physical activity and (b) FMS. A secondary aim was to estimate the intensity of activity during the Go2Play Active Play intervention compared to traditional PE in a comparison group.

4. Methods

4.1 Study design and participants

Fig. 1 presents an overview of the recruitment process and data analysed. This study was a 5-month pragmatic evaluation of a new school-based Go2Play Active Play intervention, in which data were collected at baseline during September and October 2015 and again at follow-up during February and March 2016. Seasonal effects were not likely to affect physical activity during data collection in this study as these have found to be small in Scotland (Fisher et al., 2005b).

Children (*n* =257) from seven primary schools (involving eleven classes from primary grades 1–5) participated in the intervention. A total of 172 children (mean age= 7.0 years; SD= 1.1) provided written consent (via their primary care giver) to participate in the evaluation. Children were eligible for the evaluation if they were apparently healthy and able to participate in normal school activities.

Two of the schools already participating in the evaluation offered an additional two classes, who did not receive the Go2Play Active Play intervention, to act as the comparison group. A total of 24 children (from two classes; primary grades 2–4) provided consent via their primary care giver.

All schools participating in the present study were located in the west of Scotland where children's enrolment is based on area of residence. The consenting participants' demographics are presented in Table 1. Ethical approval was granted by the University of Strathclyde's School of Psychological Sciences and Health Ethics Committee prior to data collection.

Table 1. Demographics of consenting participants

	Intervention	Comparison	Differences between baseline variables
	Mean (SD) or n (%)	**Mean (SD) or n (%)**	***p-value***
Male	82 (48%)	8 (33%)	0.2
Female	90 (52%)	16 (67%)	
Age (years)	7.0 (1.1)	7.4 (0.9)	0.09
BMI z-score	0.4 (1.2)	0.7 (1.2)	0.3
***n*(%) living in top 15% most socio-economically deprived areas of Scotland**	130 (76%)	20 (83%)	0.4

4.2 Pragmatic evaluation

The present study was considered from the planning stage to be a pragmatic evaluation. A pragmatic evaluation involves conducting research in 'real world' scenarios where decisions need to be made on how to best conduct the evaluation with the limited amount of time and resources the researchers may have. In relation to the present study, this meant that we could not control when the intervention began, the number of schools involved or how many Go2Play Active Play sessions and PE classes children engaged in at either baseline or follow-up. We were also unable to randomise schools or classes to the intervention or comparison group. Recruitment of the comparison group was based on convenience sampling as two schools already participating in the intervention offered an additional two classes who did not participate in Go2Play Active Play. Participants were similar in age, BMI z-score and socio-economic status (see Table 1).

4.3 Procedure

Once consent was provided, 189 participants (165 = intervention; 24 = comparison) were asked to wear an ActiGraph GT3X accelerometer for four school days (09:00–15:00) during September and October2015. Due to a lack of time and resources, it was not possible to assess FMS of all consenting children, therefore a sub-sample of 123 children (102= intervention; 21= comparison) were randomly selected from the seven schools to have their FMS assessed using the Test of Gross Motor Development (TGMD-2) (Ulrich, 2000). Most children in the sub-sample had their baseline FMS assessed within one month of the intervention beginning. The participants in the intervention group continued their participation in the Go2Play Active Play intervention (comparison group continued their usual course of PE). At

5-months, the intervention and comparison groups had their physical activity and FMS reassessed just before the intervention finished during February and March 2016. FMS were not assessed while participants were wearing their ActiGraph accelerometer as the FMS assessment may have affected their physical activity levels. The mean duration at which FMS was measured at baseline and follow-up was 4 months (SD = 0.4).

4.4 Intervention

Agile CIC (www.agilecic.com) and Inspiring Scotland (www.inspiringscotland.org.uk) designed the Go2Play Active Play intervention collaboratively and conducted pilot work in 2014 before the independent evaluation began in 2015. The Go2Play Active Play intervention was underpinned by Whitehead's concept of physical literacy (Whitehead, 2001). Physical literacy is the development of physical competencies, motivation and confidence to be physically active throughout an individual's lifespan (Whitehead, 2001). Key to developing physical literacy and therefore increasing physical activity levels is creating an environment that fosters an enjoyment of physical activity from an early age while developing key movement skills. Evidence has suggested that active play achieves both enjoyment and development of FMS thus providing an evidence-based justification as to why active play was the type of physical activity selected for the intervention (Jones et al., 2011; Adamo et al., 2016).

The Go2Play Active Play intervention was outdoors, lasted one-hour in duration, was facilitated by local playworkers (trained by Agile CIC), and combined structured games and free play (30 min each). The first half of the session aimed to introduce children to a variety of FMS by delivering fun, inclusive and active games focussed on improving a specific FMS area (for example locomotor or object control). Each session focussed on one FMS area so that a broad range of skills were covered over the 5-month intervention period. For example, if the first half of the session focused on object control, the playworkers would facilitate games to develop children's catching or throwing ability (examples of the games played can be found at www.activeplay.org.uk). The second half was free play, which allowed children to practise what they learned in the first half of the session and/or to create and play their own games using a variety of traditional equipment such as balls, beanbags, cones, hoops etc. Additional information on the Go2Play Active Play programme can be found at www.inspiringscotland.org.uk/our-funds/go2play.

During the intervention, four classes participated in two; one-hour Go2Play Active Play sessions per week and the remaining seven classes participated in one, one-hour session per week for 5-months. The comparison group participated in their usual PE classes (described in Table 2).

4.5 Anthropometrics

All consenting participants had their height and weight measured (to the nearest 0.1 cm/kg) using a portable stadiometer and digital scales (both Seca, Hamburg, Germany). Weight status is presented as a BMI z-score relative to 1990 UK reference data; healthy weight (BMI z-score b 1.04); overweight (BMI z-score 1.04–1.64); obese (BMI z-score N 1.64). Postcode data were collected to describe the participant's area-based socio-economic status (SES) using the Scottish Index of Multiple Deprivation (SIMD) (The Scottish Government, 2016).

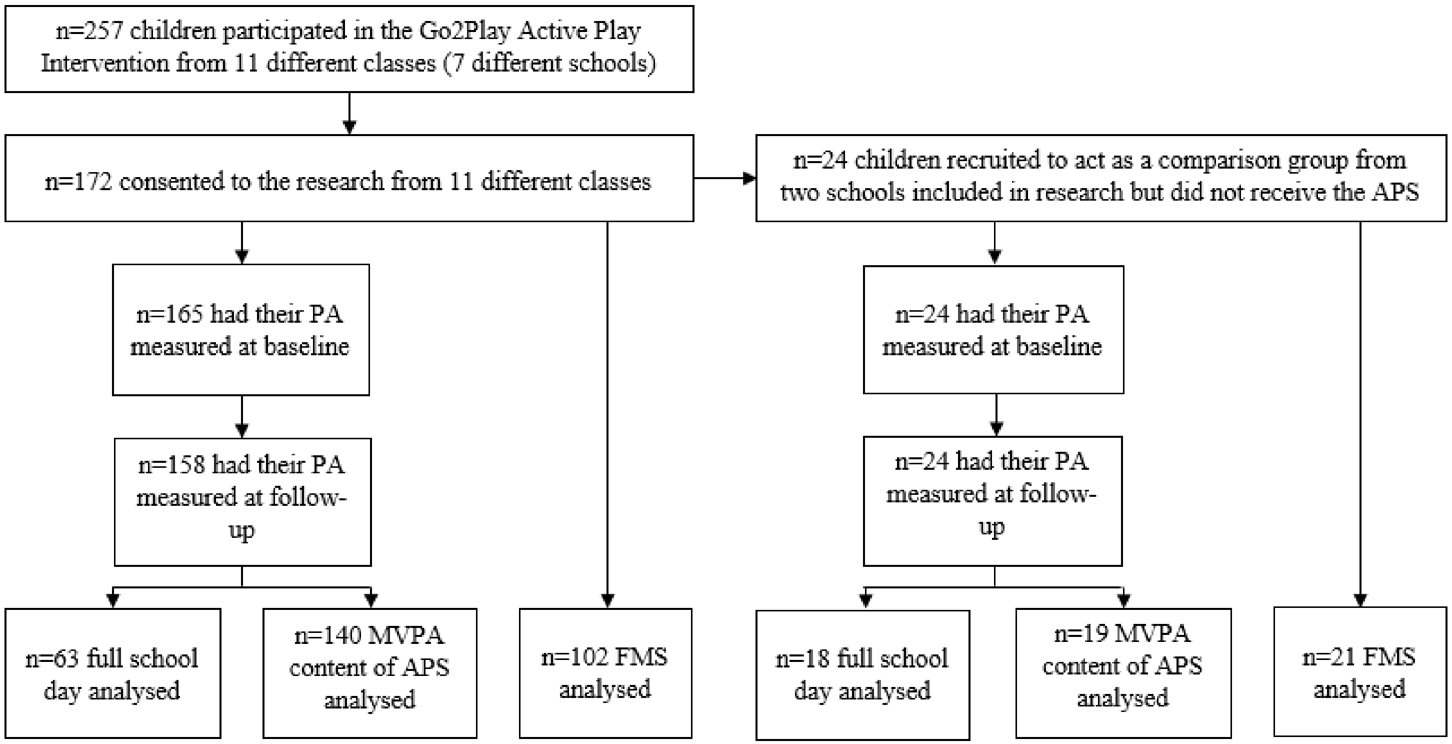

Figure. 1 presents a flow diagram to highlight the participants involved in the evaluation, number recruited and number analysed for each of the variables.

Abbreviations: PA=Physical Activity, MVPA, Moderate to Vigorous Physical Activity, FMS= Fundamental Movement Skills, APS=Active Play Session, PE=Physical Education.

4.6 Physical activity

Participants wore an ActiGraph GT3X accelerometer (Pensacola, Florida, USA) for four school days (09:00–15:00), attached to an elastic waist belt and worn around the participant's waist so that the accelerometer was on or slightly above their right hip (Evenson et al., 2008). It was not feasible to measure physical activity during the after-school period. Data were collected in 15-s epochs and converted into total volume of physical activity (counts per minute, cpm) and physical activity intensities using cut points suggested by Evenson and colleagues, which have evidence of reliability and validity (Evenson et al., 2008). These cut points are sedentary behavior (0–100 cpm), light intensity physical activity (101–2292 cpm), moderate intensity physical activity (2293–4008 cpm) and vigorous intensity physical activity (>4008 cpm).

4.6.1 School day

Data were accepted if the participants wore the monitor for a minimum of three school days (09:00–15:00) and if school-day physical activity was measured before the intervention started (n = 63). Evidence suggests a minimum wear time of three days for 6 h/day has acceptable reliability (Basterfieldetal.,2011); in the present study, children wore the accelerometer on average for 4 days for 6 h/day (09:00–15:00) at baseline and follow-up. Intervention participants meeting the above criteria (n = 63) were from two schools (four classes, primary 2–4) and were compared to the comparison group (n = 18) who were recruited from the same two schools, but did not receive the intervention (two classes, primary 2–4). Variables analysed were percent time in sedentary behavior, light intensity physical activity and MVPA.

Table 2 describes the duration and frequency of Go2Play Active Play and PE sessions engaged in during the measurement week at baseline and follow-up.

4.6.2 Go2Play Active Play sessions

Go2Play Active Play sessions and PE sessions (for the comparison group) were extracted from the participants' follow-up physical activity data. Participants in the intervention group were included in the data analysis if they participated in one full Go2Play Active Play session (*n* =140) or one full PE class for the comparison group (n = 19) during the follow-up measurement week. If they participated in two Go2PlayActive Play or PE sessions (for the comparison group) during the measurement week an average was taken. Variables analysed were counts per minute and percent time in sedentary behavior, light intensity physical activity and MVPA to correct for the different duration of the PE andGo2Play Active Play sessions.

4.7 Fundamental movement skills

FMS were measured by the same field staff and researcher at baseline and follow-up using the TGMD -2, which is a valid, reliable and cost-effective method for assessing FMS (Wiart and Darra, 2001). The researcher trained field staff prior to data collection according to the TGMD-2 manual. They were given practise opportunities to administer and score the test with children to ensure they were competent at measuring FMS.

The TGMD-2 assesses 12 skills and is split into two subtests; locomotor (run, gallop, hop, leap, horizontal jump, slide) and object control (strike, dribble, catch, throw, kick, roll). Each of the 12 skills is divided into a number of components that make up the skill. For the assessment, the field staff demonstrated the skill first, and then the child performed the skill twice and was observed and scored accordingly

(Ulrich, 2000). If the child being assessed completed the component of the skill as written in the TGMD-2 manual they scored, a ‘1’ and a ‘0’ if they did not.

Participants were included in the data analysis if they had their FMS assessed at both baseline and follow-up: 102 children in the intervention group and 21 children in the comparison group (total n = 123). Variables examined were gross motor quotient (GMQ) score and percentile s, which is a summary score of all FMS that adjusts for age and gender and is the recommended variable for interpretation as it is the most reliable indicator of FMS competency (Ulrich, 2000). Standard scores and percentiles were also used for interpretation of each subtest (locomotor and object control), which are not as reliable as the GMQ score but are a useful interpretation of both subtests (Ulrich, 2000).

4.8 Data analysis

All statistical analyses were conducted using SPSS v 22.0 (SPSS Inc., Chicago, IL). Tests for normality were run prior to data analysis to check for normal data distribution (skewness and kurtosis <|2.0|). Descriptive statistics were run to present means and standard deviations for relevant variables for both physical activity and FMS. Baseline differences in demographics, physical activity and FMS variables between the intervention and comparison group were assessed using an in dependent samples t -tests, chi square test or Mann Whitney U test (demographic differences are presented in Table 1). The two primary aims of improvement in FMS variables and school day physical activity were examined using repeated measures ANOVA. The main effect was ‘group’ (intervention and comparison) on ‘time’ from baseline to follow-up.

Table 2. Overview of Active Play and PE sessions included in the measurement of school day physical activity at baseline and follow-up in the intervention and comparison groups

School	Class	Number of children	Baseline		Follow-up	
			Number of Go2Play Active Play Sessions	Number of PE Classes	Number of Go2Play Active Play Sessions	Number of PE Classes
Intervention (n =63)						
A	1	8	0	2x1hr	2x 1hr	0
	2	25	0	2x1hr	2x 1hr	1x 1hr
B	3	20	0	2x50mins	2x 1hr	0
	4	10	0	1x50mins	2x 1hr	0
Comparison (n =18)						
A	5	10	0	1x1hr	0	1x50mins
B	6	8	0	1x1hr	0	1x40 mins, 1x1hr

5. Results

5.1 Objectively measured physical activity

5.1.1 School day physical activity

At baseline, the intervention and comparison group were similar in percent time in sedentary behavior and light physical activity, but the comparison group had a higher mean counts per minute (p =0.03) and percent time in MVPA (p =0.02). Table 3 presents the changes in school day physical activity from baseline to follow-up in the intervention and comparison group.

There was a significant interaction between ‘time’ and ‘group’ for mean counts per minute ($F(1,79) = 53.9$, $p< 0.01$) and percent time in: sedentary behavior ($F(1,79) = 45.3$, $p< 0.01$), light intensity physical activity ($F(1,79) = 22.6$, $p< 0.01$) and MVPA ($F(1,79) = 23.0$, $p< 0.01$).

The intervention group showed a decrease in percent time in sedentary behavior (− 18.6%), an increase in total physical activity (+258 cpm) and percent time in light intensity physical activity (+15.7%) and MVPA (+ 2.8%, $p< 0$ .01 for all). The comparison group showed a decrease in mean counts per minute (− 65 cpm, $p= 0.1$), an increase in percent time: in sedentary behavior (0.1%, $p= 1.0$) and light physical activity (1.7%, $p= 0.5$), and a decrease in percent time in MVPA (− 1.8%, $p= 0.04$)

5.1.2 Intensity of physical activity during Go2Play Active Play and PE sessions

Means and standard deviations for the intensity of physical activity during Go2Play Active Play for the intervention group and PE for the comparison group are presented in Table 4

Table 3. School day physical activity at baseline and follow-up in intervention and comparison groups (changes are presented as an average day)

	Intervention (*n* =63)				Comparison (*n* =18)			
	Baseline	**Follow-up**	**Mean Change (95% CI)**	***p-value***	**Baseline**	**Follow-up**	**Mean Change (95% CI)**	***p-value***
Counts Per Minute	610 (137)	868 (180)	258 (217 to 300)	<0.01	741 (220)	676 (164)	-65 (142 to 13)	0.1
Sedentary Time (%)	52.2 (5.9)	33.6 (11.6)	-18.6 (-21.2 to -16.0)	<0.01	49.5 (7.9)	49.5 (12.6)	0.1 (-4.8 to 4.9)	1.0
Light PA (%)	39.8 (5.0)	55.5 (11.7)	15.7 (13.0 to 18.5)	<0.01	39.8 (5.5)	41.6 (12.1)	1.7 (-3.4 to 6.9)	0.5
MVPA (%)	8.0 (2.6)	10.8 (4.0)	2.8 (1.9 to 3.7)	<0.01	10.7 (4.3)	8.9 (2.5)	-1.8 (-3.5 to -0.1)	0.04

Data Presented as mean (SD). Abbreviations: PA= Physical Activity, MVPA= Moderate-to-vigorous Physical Activity

Table 4. Intensity of **p**hysical activity during Active Play sessions and PE in intervention and control groups

	Intervention (*n* =140)	**Comparison (*n* =19)**
Counts Per Minute	1716 (523)	1314 (381)
Sedentary Time (%)	19.1 (12.2)	33.2 (8.1)
Light PA (%)	50.8 (12.7)	45.8 (7.7)
MVPA (%)	30.1 (12.4)	21.1 (7.2)

Data presented as mean (SD). Abbreviations: PA= Physical Activity, MVPA= Moderate-to-vigorous physical activity

5.2 Fundamental movement skills

At baseline, the intervention and comparison group were similar in all FMS variables. Table 5 presents the changes in FMS variables from baseline to follow-up in the intervention and comparison group

5.2.1 GMQ

There was a significant interaction between 'time' and 'group' for GMQ score ($F(1,121) = 5.9$, $p= 0.02$) and GMQ percentile ($F(1,121)=4.4$, $p= 0.04$).

The pairwise post hoc comparison indicated that the intervention group had a statistically significant increase in both their GMQ score and their GMQ percentile (both $p< 0.01$). In the comparison group, there was an increase in the GMQ score ($p= 0.15$) and GMQ percentile ($p= 0.13$), but neither were statistically significant.

5.2.2 Locomotor and object control skills

There was a significant interaction between 'time' and 'group' for locomotor skills score ($F(1,121) = 5.4$, $p= 0.02$) and locomotor percentile ($F(1,121) = 5.2$, $p=$

0.02. There was no significant interaction between 'time' and 'group' for object control skills score ($F(1,121) = 2.5$, $p = 0.1$) and object control percentile ($F(1,121) = 0.9$, $p = 0.3$).

The pairwise post hoc comparison indicated that the intervention group had a statistically significant increase in their locomotor skills score and percentile and their object control skills score and percentile (all $p < 0.01$). The comparison group's locomotor skills score ($p = 0.59$) and percentile ($p = 0.64$), and their object control skills score ($p = 0.08$) and percentile ($p = 0.05$) also increased, but the increases were not statistically significant.

6. Discussion

The present study suggested that a 5-month Go2Play Active Play intervention significantly improved physical activity and FMS variables compared to the comparison group, who received their usual PE. However, since this was a pragmatic evaluation, it was not possible to randomly allocate classes to intervention and comparison groups and the size of the comparison group was small.

Recent research has suggested that children's physical activity levels decline around the age they start school (Reilly, 2016). School hours are often very physically inactive periods of the day; and therefore, a critical time where improvements need to be made (van Stralen et al., 2014; Nettlefold et al., 2011; Belton et al., 2016). Much of the research aimed at increasing physical activity levels during school has focussed on PE, recess and active transportation, all of which have shown limited improvements (Hollis et al., 2016; Martin et al., 2016; Reilly et al.,2016b). School-based interventions utilising active play are limited and tend to focus on recess interventions (Reilly et al., 2016b; Verstraete et al., 2006). These studies have shown limited improvements compared to the findings in the present study where percent time spent in light physical activity and MVPA during the school day improved by 15.7% and 2.8%, respectively.

After-school is an important period of the day where children engage in even less physical activity than du ring school hours (Brockman et al., 2010; Belton et al., 2016). Although the present study only focussed on the effect of the intervention during the school day, it highlights the need to objectively measure physical activity after school to determine the true effect of the intervention. The influence on physical activity may be greater in the present study because children are learning to play with limited involvement from adults, and equipment that is readily available in most homes. It is thought that active play has the potential to generate higher levels of MVPA compared to other types of physical activity (Janssen,2014; Brazendale et al., 2015). In the present study, children spent, on average, 30.1% of the Go2Play Active Play session in MVPA compared to the comparison group who spent 21.1% of their PE class in MVPA. Brazendale and colleagues found the MVPA content of an hour of free play was 35%, which is similar to Go2Play Active Play (Brazendale et al., 2015). International recommendations suggest that children should spend 50% of their time in MVPA during PE (Association for Physical Education, 2008). Although the MVPA content of Go2Play Active Play sessions did not achieve the 50% recommended time in MVPA, it appears that active play in the present study may generate higher levels of MVPA compared to traditional PE.

Table 5. FMS at baseline and follow-up intervention and comparison groups

	Intervention (*n* =102)				Comparison (*n* =21)			
	Baseline	**Follow-up**	**Mean Change (95% CI)**	***p-value***	**Baseline**	**Follow-up**	**Mean Change (95% CI)**	***p-value***
GMQ Score	83.2 (11.6)	93.3 (11.1)	10.1 (7.9 to 12.3)	<0.01	86.6 (11.2)	90.1 (10.9)	3.6 (-1.3 to 8.4)	0.15
GMQ Percentile	18.9 (17.8)	36.1 (23.8)	17.2 (13.2 to 21.2)	<0.01	23.4 (19.8)	30.2 (20.3)	6.9 (-2.0 to 15.7)	0.13
Locomotor Score	7.5 (2.1)	9.1 (2.4)	1.6 (1.1 to 2.1)	<0.01	7.5 (1.6)	7.8 (1.6)	0.3 (-0.7 to 1.3)	0.59
Locomotor Percentile	24.6 (18.8)	40.4 (25.5)	15.9 (11.1 to 20.6)	<0.01	23.0 (13.7)	25.6 (14.9)	2.5 (-8.0 to 13.0)	0.64
Object Control Score	6.9 (2.4)	8.7 (2.1)	1.8 (1.3 to 2.3)	<0.01	8.0 (2.7)	9.0 (2.4)	0.9 (-0.1 to 1.9)	0.08
Object Control Percentile	21.5 (20.0)	36.7 (23.3)	15.2 (10.7 to 19.7)	<0.01	30.0 (25.9)	39.9 (25.2)	9.9 (0.0 to 19.7)	0.05

Data Presented as mean (SD); GMQ, gross motor quotient

FMS need to be improved as they are low in children from western nations and are associated with increased physical activity and MVPA levels (Fisher et al., 2005a; Hardy et al., 2012). Interventions aimed at improving children's FMS have been successful in a range of settings including, early years, school and community-based studies (Logan et al.,2012). Two school-based interventions, which focused on sports, provided improvements in some FMS skills but in general, the overall improvements in these studies were small compared to the present study (Lai et al., 2014; Barnett et al., 2009; Salmon et al., 2008). However, recent interventions that utilised active play to improve FMS have shown improvements in pre-school aged children and are more consistent with findings in the present study (Jones et al., 2011; Adamo et al.,2016). The mean GMQ score at baseline in our study was 83.2 (18.9th percentile) and significantly improved to 93.3 (36.1st percentile) in the intervention group. These scores, even at follow-up, are lower than the norm-referenced value of 100 presented by Ulrich (Ulrich,2000). In fact, it is widely thought that FMS are generally poor in con-temporary children and worse in those with low socioeconomic status (Hardy et al., 2012; O'Brien et al., 2015). In the present study, 76% of the participants in the intervention group were from Scotland's most socio-economically deprived areas. While the present study had some limitations, discussed below, it tentatively suggests that the Go2PlayActive Play intervention may be effective improving FMS. The mix of facilitated FMS games and child-led free play may create an environment that fosters natural curiosity in a child to practise FMS by themselves in an enjoyable way.

The present study was a pragmatic evaluation of a school-based active play intervention delivered by three local charities in central Scot-land. Despite potentially promising findings, and this study being a novel attempt to evaluate an active play intervention as a means of improving both FMS and physical activity, it had some important limitations. Firstly, this study was a pragmatic evaluation meaning certain important elements of study design were out of the researcher's control. These included, when the Go2Play Active Play intervention began, the number of schools who participated in the intervention and how many active play sessions and PE classes they engaged in at both baseline and follow-up. The sample size was determined by the number of participating schools; therefore, a power calculation was not carried out and our ability to detect any change in the comparison group (e.g. in FMS) was probably limited due to the small number of children in this group. Second, the schools could not be randomised to the intervention or control group as schools were already selected before the research was underway. Third, the effect of active play on habitual physical activity (i.e. including time spent out of school) needs further exploration to determine the true potential of active play on increasing overall physical activity. Results obtained should be helpful in developing a randomised controlled trial (RCT) to provide a more definitive evaluation of Go2Play Active Play in the future.

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Chapter 6: An active play intervention to improve physical activity and fundamental movement skills in children of low socio-economic status: feasibility cluster randomised controlled trial

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1. Preface

Thus far, the present thesis has highlighted that the evidence base for active play interventions is small (Chapter 3) and more research is needed to determine their impact on physical activity, FMS and cognition. Chapter 5, the pragmatic evaluation aimed to add to the field, but it has some important limitations.

The aim of this chapter is to present the submitted manuscript; 'An active play intervention to improve physical activity and fundamental movement skills in children of low socio-economic status: feasibility cluster randomised controlled trial', which was informed by the pragmatic evaluation. This paper was submitted to the Journal of Pilot and Feasibility Studies in September 2018. This paper is presented in the same format as was submitted the journal and, therefore, the referencing system is not APA as is used in the other non-published chapters in this thesis (reference list presented at the end of this chapter).

As mentioned in the previous chapter, AJ planned and conducted the study and was lead author. Seven undergraduate students, supervised by AJ, supported the data collection across all outcomes. AH advised on the design of the study and supported the analyses, JB advised and supported on the inhibition and maths fluency outcome, LB advised and supported analysis of the inhibition outcome and JJR and ADH supported all aspects of the study. All authors read and approved the final manuscript.

2. Abstract

Introduction: Active play is a novel approach to addressing low physical activity levels and fundamental movement skills (FMS) in childhood and new interventions must be developed and evaluated.

Aim: This study aimed to determine the feasibility of a 10-week school-based ‘Active Play’ intervention, and present preliminary findings on four outcomes: physical activity levels, FMS, inhibition, and maths fluency.

Methods: This was a feasibility cluster RCT in which eight schools (one primary 3 class per school) were matched and randomly allocated to either the 10-week intervention (*n* =4) or waiting-list control (*n* =4). The Active Play intervention consisted of a 1-hour outdoor physical activity session per week, incorporating 30 minutes of facilitated games and 30 minutes of free play. Physical activity was measured using an ActiGraph GT3X accelerometer, FMS were assessed using the Test of Gross Motor Development-2 (TGMD-2), inhibition was measured using a Flanker Test and maths fluency was assessed using the One Minute Basic Number Facts Test.

Results: 66% of eligible children (*n* =137) agreed to participate in the research. No schools withdrew from the study and three participants were lost to follow-up. Compliance to the intervention was high- none of the participants missed more than two of the 10 scheduled Active Play sessions. Data lost to follow-up were minimal; most were lost (14%) for school day physical activity. Active play sessions were shorter than planned on average by 10 minutes, and participants spent a mean of

39.4% (14.2) of the session time in moderate-to-vigorous-intensity physical activity (MVPA). Preliminary findings suggested that there was no significant intervention effects on MVPA (p= 0.13; d= 0.3), FMS score (p= 0.06; d= 0.4), inhibition (fish trial: p= 0.35; d=0.1, arrow trial p= 0.74; d= 0.1) or maths fluency (addition: p= 0.13; d= 0.3, subtraction: p= 0.6; d= 0.1).

Conclusion: The Active Play intervention was feasible and benefitted from a relatively high MVPA content; however, preliminary findings suggest the intervention had no significant effect on the outcomes. Having more Active Play sessions per week and/or extending the duration of the intervention may increase the effects and should be tested in a future definitive cluster RCT.

Trial Registration: This trial was registered on the International Standardised Randomised Controlled Trials Number register (ISRCTN) in August 2017 (ISRCTN11607781)

Key words: Active Play; Physical Activity; Moderate-to-Vigorous Physical Activity; Fundamental Movement Skills; Inhibition; maths fluency.

3. Introduction

It is recommended that UK school-aged children and adolescents (5-18 years) should engage in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (1). In Canada, new ‘24-hour movement guidelines’ encourage a whole day approach to movement by recommending that children should engage in four behaviors: ‘sweating, stepping, sleeping and sitting’, at optimal levels to gain the associated health benefits (2). Specifically, for primary school-age children, a healthy 24 hours would include 9-11 hours of sleep, 60 minutes of MVPA, several hours of structured and unstructured physical activity, screen time use of no more than 2-hours and a limited amount of time spent sitting (2). Achieving the UK or Canadian guidelines should bring health benefits, including reducing the risk of some cancers, type 2 diabetes, cardiovascular disease, obesity, mental wellbeing and poor bone health (2-4). However, children in Scotland and in other high-income countries are typically not achieving the recommended 60 minutes of MVPA per day (5, 6).

Recent systematic reviews into the contribution of active commuting to school, recess and physical education (PE) on children's physical levels have suggested that they make a small contribution to helping children achieve the physical activity guidelines (7-9). A recent systematic review found that interventions to promote active play have received little attention in physical activity research to date (10), but the potential of Active Play for increasing physical activity levels may be substantial given that it can be engaged in before, during and after school, 365 days of the year (11). Active play is "a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner" (12). It is often engaged in outdoors, which is associated with higher habitual physical activity and MVPA levels and is suggested to be one of the factors explaining the higher levels of physical activity in low-middle income countries compared to high-income countries (6, 13-15). Furthermore, in high-income countries, those from a lower socioeconomic status (SES) typically engage in less active play than those from a higher SES (16, 17).

In addition to increasing physical activity levels, active play also has the potential to improve fundamental movement skills (FMS) (18-20). FMS are a set of skills, which children should be competent in (such as throwing catching, running and jumping) and competency in these skills is associated with higher physical activity levels (21-23). Furthermore, research has suggested a possible link between MVPA and improved executive function (i.e. inhibition) and maths attainment (24). Inhibition is the ability to suppress actions and modify behaviour, which is implicated in many areas of life and learning. Active play has been suggested as a potentially good way of achieving both increased MVPA and improved inhibition (25, 26).

The UK MRC Framework for complex interventions recommends feasibility and pilot research before a definitive RCT is undertaken (27). The authors of the present study conducted a pragmatic evaluation of the Active Play intervention (ne Go2Play Active Play) on physical activity and FMS in a non-randomised group of participants (18). This pragmatic evaluation was sufficiently promising to develop the intervention and evaluation in the form of the present study.

Therefore, the aim of this cluster RCT was to determine the feasibility of an Active Play intervention to inform a future definitive RCT. Information on: consent rate, data lost to follow-up, intervention fidelity and number of participants included in the analysis and estimates of the effect for each outcome measure (physical activity, fundamental movement skills, inhibition and maths fluency) was collected.

4. Methodology

4.1 Trial design

The present study was a two-arm parallel feasibility cluster RCT involving eight primary schools (one primary 3 class per school) located in Glasgow, Scotland. Glasgow City Council and the funders of the program (Inspiring Scotland) chose pupils in primary 3 (aged 7 years) to receive the intervention because this age group receive the least amount of additional physical activity opportunities compared to other age groups. Schools were matched based on relevant criteria and then randomly assigned either to the intervention group or waiting-list control (described in more detail below). Baseline data were collected in August and September 2017 and follow-up data were collected in November and December 2017.

This trial was registered on the International Standardised Randomised Controlled Trials Number register (ISRCTN) in August 2017 (ISRCTN11607781) and follows the CONSORT guidelines for reporting pilot and feasibility trials (28). Ethical approval was granted by Glasgow City Council's Education Services and the University of Strathclyde's School of Psychological Sciences and Health Ethics Committee prior to data collection.

4.2 Procedures

In April 2017, Glasgow City Council invited 32 schools from the South and 28 schools from the North West of Glasgow to participate in the Active Play intervention during the 2017-18 school year. 34 of the 60 schools agreed to participate in the intervention, and a list of these schools was sent to the lead researcher who divided the schools by location (South and North West). A profile of each school was created by obtaining information held by the Scottish Government (www.gov.scot/Topics/Statistics/Browse/School-Education/Datasets) on socio-economic status of the school as measured by the Scottish Index of Multiple Deprivation (SIMD) score, percentage of children on free school meals, percentage of children who live in the 20% most deprived areas, school enrolment, number of primary 3 children, percentage of children from ethnic minority groups and if the schools had an existing relationship with the charities delivering the Active Play intervention.

The aim of the funders, Inspiring Scotland, was to implement the Active Play intervention in the most deprived schools in Glasgow, for this reason, schools were eligible for this study if at least 70% of pupils from the school were living in the 20% most deprived areas of Scotland. Of the 34 schools who agreed to participate in the intervention, 66% (*n* =22) schools had 50% or more children living in the top 20% most deprived areas. Schools (*n* =3) were also excluded if they had an existing relationship with any of the charities that delivered the Active Play intervention (to avoid contamination) or had been involved in the previous pragmatic evaluation (18). Once the schools not meeting these criteria were excluded, five schools remained from the South of the city and six schools from the North West, at which point they were matched on deprivation (based on the percentage of children who live in the 20% most deprived areas), school enrolment, demographics (percentage of children from ethnic minorities) and geography (located close to each other). Two schools in the North West and one school in the South of the city were removed and kept for contingencies because they were not located near the other schools. Therefore, 8 schools were selected for the study and all 8 schools agreed to take part in the study via their headteachers.

The schools were matched, and each pair of schools were randomised prior to data collection beginning. A researcher unaffiliated to the present study used a random number generator to randomly assign each pair to either the intervention or the waiting-list control. Schools allocated to the intervention group were informed they would receive the intervention starting in August 2017 and the control schools would receive the intervention in April 2018 once the research was completed. Eight schools were involved in the study due to limitations on time and resources; this was considered sufficient for a feasibility trial as previous studies have also used a similar number of clusters (29).

Information and consent forms were distributed to all children in the primary 3 class of each school and were collected in early August 2017, data collection began one week later. Participants were eligible if they were apparently healthy and able to participate in Active Play unaided. Participants' weight status, SES using the SIMD (30), FMS, inhibition, and maths fluency measured two weeks before the intervention began, and physical activity was measured one week before the intervention began. At week 9 of the intervention, physical activity was measured again, and the other outcome measures were assessed once the intervention was completed.

4.3 Intervention

Inspiring Scotland (www.inspiringscotland.org.uk, Edinburgh) and Agile CIC (www.agilecic.com, Glasgow) developed the Active Play (ne Go2Play Active Play) intervention in 2014. In the present study, the intervention was delivered by playworkers from two local play charities who were trained by Agile CIC. The intervention has been detailed previously (18), but briefly, it is underpinned by the concept of physical literacy. Physical literacy is "the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" (31). Key to establishing a foundation of good physical literacy is developing children's physical competency (i.e. FMS) and ensuring they have a positive experience of physical activity from an early age

(32-34). Increasing levels of MVPA and improving fundamental movement skills are the main aims of the present intervention.

The Active Play intervention was delivered to one primary 3 class per school for 10-weeks (one session per week). The intervention was planned to consist of a one-hour outdoor physical activity session: 30 minutes of facilitated games plus 30 minutes of free play. The play charities were supplied with a standard set of basic equipment, which included a range of balls, tennis racquets, hockey sticks, skipping ropes among other items to enable them to deliver both elements of the intervention. During the facilitated section of the session, the playworkers led and joined in on games designed to develop participants' FMS and other components of physical literacy (examples of games can be found at https://www.actify.org.uk/activeplay). During the free play section of the session, the equipment was provided, and participants were free to choose what they wanted to play. The playworkers and teachers were encouraged to participate fully in the sessions with the children. The delivery principles of the Active Play sessions are that they should be Fun, Inclusive and Active (F.I.A), which should encourage high levels of MVPA and FMS development (18).

Although participants only received one session per week, the intervention might increase physical activity levels beyond the session as the equipment is basic, inexpensive and readily available at home or school, children are learning to play which may encourage play outside intervention time and improving FMS and other aspects of physical literacy might facilitate physical activity (22, 23).

4.4 Outcomes

4.4.1 Anthropometrics

All consenting participants had their height and weight measured at baseline only (to the nearest 0.1cm/kg) using a portable stadiometer and digital scales (both Seca, Hamburg, Germany). Weight status is presented as a BMI z-score relative to 1990 UK reference data; healthy weight (BMI z-score <1.04); overweight (BMI z-score 1.04-1.64); and obese (BMI z-score >1.64).

4.4.2 Process measures

The lead researcher captured information on the number of children who consented from the total sample available, which was provided by the class teacher who provided them with the total number of children in each class.

Feasibility of the outcome measures was also captured by the lead researcher who kept a record of the number of children who provided data at baseline for each outcome measure, and the number, with explanations, that were lost to follow-up (for example, moved school, no longer wanted to participate in research, data not valid).

To determine if the intervention was delivered as intended, the playworkers kept a record of the number of sessions they delivered, if any sessions were delivered indoors due to adverse weather conditions, how long the sessions lasted and if any child was injured because of participating in Active Play. Additionally, the lead researcher observed the playworkers delivering one session per school at week four or six of the intervention to determine if they were delivered as intended. To support observations, an assessment tool was developed by Agile CIC, which assessed four key dimensions to delivering a successful session: team/individual skills and attributes (for example, demonstrates confidence and enthusiasm), knowledge and experience (for example, demonstrates experience in leading play and physical activity sessions), putting the training into practice (for example, plans and delivers appropriate session for age group), and delivery (for example, session incorporates a range of FMS and are Fun, Inclusive and Active). For each of these four dimensions, there were 4-6 items in which the playworkers were scored out of 5. Class teachers were asked to record attendance at the Active Play sessions to determine how many sessions each participant attended.

4.4.3 School day physical activity

Physical activity was measured using an ActiGraph GT3X accelerometer (Pensacola, Florida, USA), which is a small and unobtrusive monitor attached to an elastic waist-belt worn over the participant's right hip (35-37). Data were collected in 15-s epochs and raw physical activity data were converted to total volume of physical activity (counts per minute- cpm) and time (minutes/school day) spent in sedentary (0 - 100 cpm), light (101 – 2292 cpm) and MVPA (≥ 2293 cpm) intensities using Evenson cut points (35). Evenson cut points have evidence of validity and reliability for children and adolescents across varying physical activity intensities (35, 38).

Participants were asked to wear the ActiGraph accelerometer for five school days (9.00 – 15.00), except for one pair of schools who wore the monitors for four school days. Class teachers reported the time the monitors were attached and removed each day and these times were used to extract the raw data from the monitors. Participants had to wear the monitors for a minimum of four school hours and for at least three days for the data to be valid, the same criteria used in our previous study and in other school-based studies (18, 39). The average actual wear time during school-time was 5.4 hours per day and 4.5 days at baseline and 5.3 hours per day and 4.3 days at follow-up.

Each pair of schools had their physical activity measured during the same week at baseline and follow-up and were measured the week prior to the intervention beginning at baseline and during week 9 of the intervention for follow-up. However, one intervention school was measured at week 8 of the intervention as their first session was cancelled and two control schools had to be measured again in January 2018, as they did not wear the monitors during week 9 (i.e. November and December 2017) as planned.

4.4.4 Physical activity content of Active Play

During the follow-up physical activity data collection week which took place on week 8 (n =1 school) or 9 (n =3 schools) of the intervention, the lead researcher attended the intervention sessions to note the time (to the nearest minute) the session started, finished and when the facilitated games part finished, and free play began. These times were then used to accurately extract accelerometer data to determine the physical activity content of the sessions in terms of percent time spent in sedentary behavior, light intensity physical activity, and MVPA.

4.4.5 Fundamental movement skills

FMS were assessed using the Test of Gross Motor Development-2 (TGMD-2), which is divided into two subtests: locomotor (run, gallop, hop, leap, horizontal jump, sidestep) and object control (strike, dribble, catch, kick, throw, underhand roll) (40). Each skill is comprised of 3-5 components based on a model performance of how the skill should be performed. If the participant performed each component as described they were scored a ‘1’, or a ‘0’ if they did not (40).

FMS were assessed, predominately outdoors, by the same lead researcher prior to the intervention beginning and after the intervention had finished. During the assessment, the lead researcher demonstrated the skill once and then participants performed each skill twice while being observed and scored accordingly (40). Scores were then adjusted for age and gender to give standard scores and percentiles for the locomotor and object control skills, which are then totalled to give a gross motor quotient score (GMQ- total FMS score) and a percentile (40). In instances where more than 20 children consented from a school (*n* =1 school), 10 male and 10 female participants were randomly selected using a random number generator to have their FMS assessed due to time restrictions.

4.4.6 Inhibition

Inhibition was measured using the NIH Toolbox Flanker Test, which was administered on an Apple iPad Air 2 (Apple Inc., California, USA). The Flanker test consisted of a mix of congruent (all stimuli facing in the same direction) and incongruent trials (the middle stimulus is facing in the opposite direction to the flanker stimuli) and participants were asked to select the button on the screen that matched the direction of the middle stimulus (41). Participants were given four practice trials and if they got >1 one trial incorrect they received a further four practice trials. The test consisted of 20 trials where the stimuli were fish and if they scored 18/20 correct, they then completed another test involving 20 trials where arrows were the stimuli (12 congruent and 8 incongruent trials for both tests) (41). Participants were given a maximum of 10 seconds to respond in each trial, if they did not respond within this timeframe then the screen moved on to the next trial.

Practice and non-response trials were removed, and accuracy scores were calculated for the fish test and the arrow test separately (average accuracy score). Trials with incorrect responses were then removed and reaction time (secs) was averaged for the fish test and the arrow test separately for the congruent and incongruent trials. Finally, the mean reaction time for the congruent trials was subtracted from the mean reaction time for the incongruent trials for the fish test and the arrow test separately to calculate the conflict score (i.e. the measure of inhibition) for the fish test and the arrow test for each participant.

4.4.7 Maths fluency

Maths fluency was measured using the One Minute Basic Number Facts Test (1995), which was a simple pencil and paper test that assessed participants' addition and subtraction abilities (42). Participants were asked to answer as many addition sums as possible in one minute by writing their answers next to sums (42). The same protocol was then followed for the subtraction element of the test (42). The number of correct answers was then totalled separately for the addition and subtraction component of the test (42).

Inhibition and maths fluency were measured two weeks prior to the intervention beginning and again at follow-up once the intervention was complete. Participants were assessed in small groups in a quiet room supplied by each school and the order of assessments conducted was randomised to minimise order effects; for example, if one group completed the inhibition measure first, the following group completed maths fluency first. The same protocol was followed in most instances at follow-up; however, at the start of baseline data collection, there was a delay in obtaining the NIH Toolbox Flanker Test, which resulted in the researchers arranging to go back and measure schools (*n* =3) on a separate day. We did not measure inhibition on a separate day for follow-up in these three schools.

4.5 Blinding

Standardised procedures were followed for each outcome measured at baseline and follow-up. The lead researcher was not blinded to any of the outcome measures; however, the lead researcher could not influence the physical activity, inhibition and maths fluency measures. For the FMS outcome, the same researcher assessed each participant at both baseline and follow-up following standardised procedures.

4.6 Data analysis

Statistical analyses were completed using SPSS v 23.0 (SPSS Inc, Chicago, IL). Initial tests for normality were conducted to determine if data were normally distributed (skewness and kurtosis $<|2.0|$). Baseline demographics of the intervention and control group were compared using independent samples t-tests and chi-square tests and are presented in Table 1.

For normally distributed data (physical activity, fundamental movement skills and Maths fluency), the effect of the intervention on the primary and secondary outcomes (defined as baseline minus follow-up) were assessed using general linear modelling techniques where a p-value of <0.05 for the predictor variable would indicate a significant effect. For non-normally distributed data (inhibition), the effect of the intervention was assessed using the Kruskal-Wallis test where a p-value of <0.05 for the predictor variable would indicate a significant effect. Post-hoc comparisons were conducted to assess the change from baseline to follow-up within each group and effect sizes were calculated using Cohen's d.

We analysed data at the participant level because schools were matched based on key criteria before baseline data collection commenced. The statistical analysis was completed by the lead author and supported by an experienced statistician.

5. Results

5.1 Baseline characteristics

Figure 1 shows the flow of schools and participants through the study. As Figure 1 highlights, a total of 207 children from the primary 3 class of each school were invited to take part in the research (two participants were not eligible as they had a disability which may have affected their ability to engage in active play). A total of 137 children (intervention *n* =73; control *n* =64) consented to participate in the study, a consent rate of 66%. Table 1 presents the baseline characteristics of the consenting participants in the intervention and control group.

As presented in Table 1, there were no statistically significant differences between the intervention and control group for baseline characteristics.

Table 1. Demographics of consenting participants

	Intervention (*n* =73)	Control (*n* =64)	Differences between groups
	Mean (SD) or n (%)	**Mean (SD) or n (%)**	***p-value***
Male	34 (47%)	24 (38%)	0.28
Female	39 (53%)	40 (62%)	
Age (years)	7.1 (0.3)	7.0 (0.3)	0.32
BMI z-score	0.7 (1.2)	0.5 (1.3)	0.31
***n*(%) living in top 20% most socio-economically deprived areas of Scotland**	49 (72%) 5 missing	51 (85%) 4 missing	0.08

*indicates statistical significance

5.2 Process evaluations

Figure 1 shows that no schools were lost to follow-up and three children moved from their schools during the study period (*n* =2 from the intervention group and *n* =1 from the control group). The number of participants providing data for each outcome at baseline and lost to follow-up is also presented in Figure 1. Data lost to follow-up were minimal in most instances, and when data were lost to follow-up, this was predominantly due to pupil absences on measurement days for each of the outcomes. Most data were lost (14%; *n* =3 for the intervention group and *n* =16 for the control group) for the school day physical activity outcome, which was largely due to participants not wearing the monitor for the minimum wear time as specified in the Methods section. Physical activity was measured at baseline during August and September and follow-up during November and December; however, physical activity had to be re-measured in two control schools during January 2018, as they did not wear the monitors during week 9 as planned.

All schools received 10-weeks of the intervention; however, one school had a session cancelled during week one, which meant (as previously stated) physical activity measurements were taken at week eight and this school received two sessions during the final week. One school purchased the services of one play charity to provide more active play opportunities throughout their school during the research period, which involved a combination of recess games and play leadership on one day of the week. The primary 3 class from this control school did not receive any play leadership but might have engaged in activities during recess on the day the play charity provided activities.

Attendance at the Active Play sessions was high, only four participants missed two sessions and no participants missed more than two sessions. All sessions took place outdoors but tended to be shorter than the one-hour by 10 minutes on average due to class teachers bringing the participants to the sessions late because they had to walk from their class to where the session was being delivered in the playground.

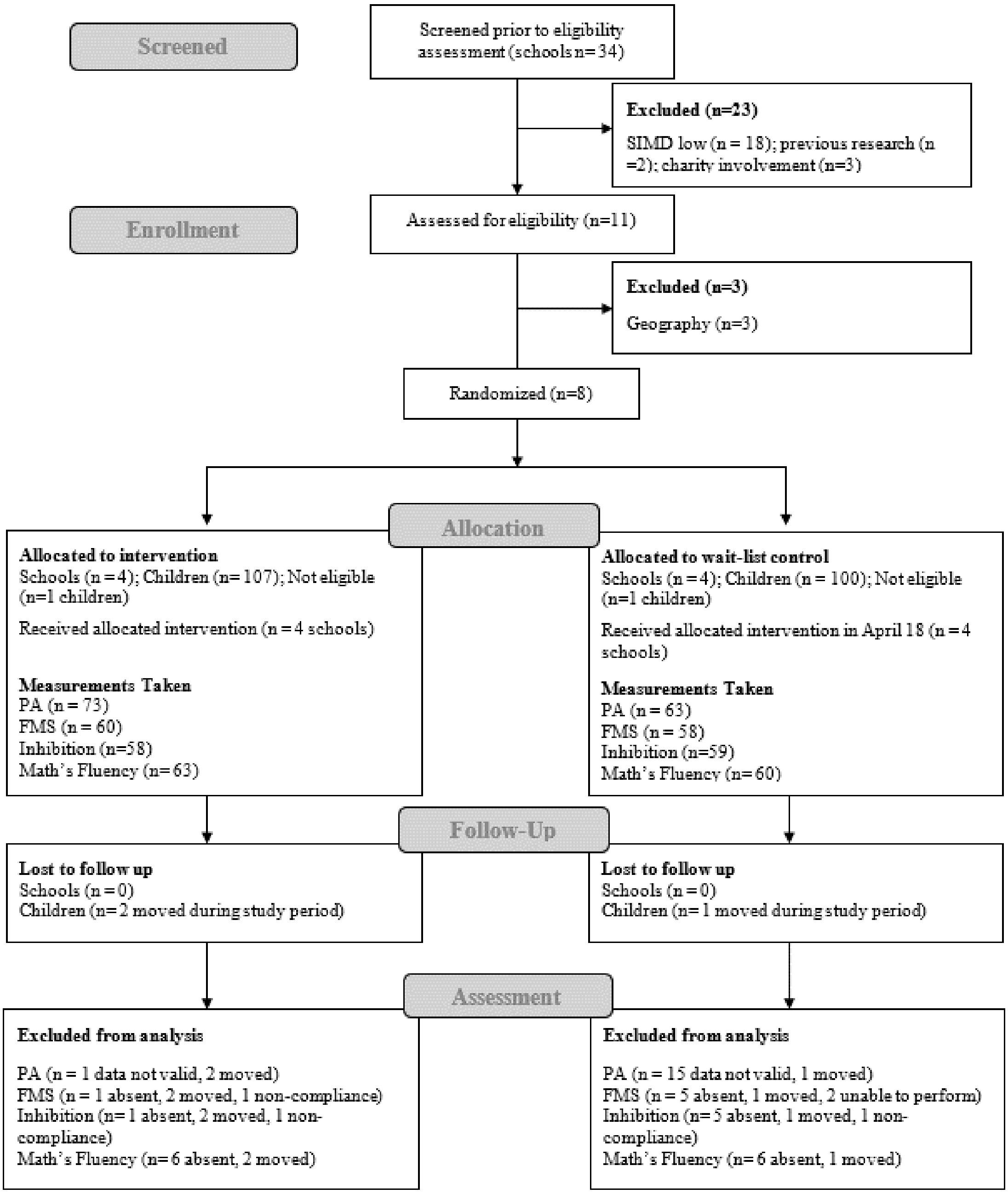
Playworkers from both play charities scored highly in the assessment tool, with play charity A scoring 3.6 and play charity B scoring 4.7 out of 5. The main area where playworkers needed to improve was in the delivery aspect of the assessment tool. The sessions would have been further enhanced if the playworkers increased their confidence through expanding their knowledge of the intervention and greater practice of facilitating the sessions. See Table 2 for each charity's score on the assessment tool.

Table 2. Assessing capacity of play charities to deliver Active Play

	Charity A	Charity B
Team/individual skills and attributes	3.8	5.0
Knowledge and Experience	3.6	4.6
Putting the training into practice	3.7	4.8
Delivery	3.2	4.4
Total	3.6	4.7

*Scores out of 5; see appendix one for a copy of the blank assessment

Figure 1: CONSORT diagram showing the flow of schools and participants through each stage of the cluster RCT.



5.3 School day physical activity

Table 3 presents the results of the between and within-group effects of the intervention.

There was no evidence of significant differences between the intervention and control group for the change in percent school time in sedentary behavior (*p*= 0.62; d= 0.1) light intensity physical activity (*p*= 0.16; d= 0.3) or MVPA (*p*= 0.13; d= 0.3).

The post-hoc analyses showed that the intervention group had a significant decrease in percent time in sedentary behavior (- 2.1%; 95% CI: -3.7, -0.6; *p*= 0.008; d= 0.3) and a significant increase in percent school time in MVPA (+ 1.4%; 95% CI: 0.8, 2.0; *p*< 0.001; d= 0.5). However, there was no significant increase in percent time in light intensity physical activity (+ 0.7; 95% CI: -0.5, 2.0; *p*= 0.2; d= 0.2). The control group had a significant decrease in percent time in sedentary behavior (- 2.7%; 95% CI: -4.6, -0.8; *p*= 0.005; d= 0.4) and a significant increase in light intensity physical activity (+ 2.1 %; 95% CI: 0.6, 3.6; *p*= 0.006; d= 0.4); with no significant increase in percent time in MVPA (+ 0.6; 95% CI: -0.1, 1.4; *p*= 0.12; d= 0.3).

5.4 Physical activity content of Active Play

Means and standard deviations for the percent time spent in sedentary, light and MVPA during an Active Play session measured at week 8 or 9 of the 10 10-week intervention are presented in Table 4.

Participants spent an average of 39.4% (14.2) of their time in MVPA during the full session, and 37.6% (12.3) and 41.3% (20.8) of their time in MVPA during the facilitated games and free play component, respectively.

Table 3. Percent of school day spent in sedentary behavior, light intensity physical activity, and MVPA at baseline and follow-up in the intervention and control group

	Intervention (*n* =70)			Control (*n* =48)			Difference between groups for the change	
	Baseline Mean (SD)	**Follow-up Mean (SD)**	**Within group change Mean; *p*-value; *d***	**Baseline Mean (SD)**	**Follow-up Mean (SD)**	**Within group change Mean; *p*-value; *d***	**Mean (95% CI)**	**p-value; *d***
Sedentary %	51.2 (8.6)	49.1 (8.9)	-2.1; 0.008*; 0.3	55.1 (8.9)	52.4 (9.0)	-2.7; 0.005*; 0.4	0.6 (-1.8, 3.1)	0.62; 0.1
Light %	40.0 (6.5)	40.7 (6.7)	+0.7; 0.2; 0.2	38.5 (7.2)	40.6 (7.8)	+2.1; 0.006*; 0.4	-1.4 (-3.3, 0.6)	0.16; 0.3
MVPA %	8.8 (3.4)	10.2 (3.9)	+1.4; <0.001*; 0.5	6.4 (3.3)	7.0 (3.0)	+0.6; 0.12; 0.3	0.8 (- 0.2, 1.8)	0.13; 0.3

*indicates statistical significance

Table 4. Percent time spent in sedentary behavior, light intensity physical activity, and MVPA during the Active Play session

Intervention (*n* =68)	Full Session Mean (SD)	Facilitated Games Mean (SD)	Free Play Mean (SD)
Sedentary %	13.2 (7.8)	16.9 (8.0)	10.5 (9.7)
Light %	47.4 (10.6)	45.6 (9.6)	48.1 (16.1)
MVPA %	39.4 (14.2)	37.6 (12.3)	41.3 (20.8)

5.5 Fundamental movement skills

Table 5 presents the results of the between- and within-group effects of the intervention.

5.5.1 GMQ

There was no evidence of significant differences between the intervention group and control group for the change in GMQ score (*p*= 0.06; d= 0.4) and percentile (*p*= 0.11; d= 0.3).

The post-hoc analyses showed that the intervention group had a significant increase in GMQ score (+ 3.1; 95% CI: 0.9, 5.3; *p*= 0.007; d= 0.4) but did not significantly improve their GMQ percentile (+ 4.3; 95% CI: -0.3, 8.8; *p*= 0.07; d= 0.3). There was no significant increase in GMQ score (0.0; 95% CI: -2.4, 2.3; *p*= 0.96; d= 0.0) or GMQ percentile (- 1.1; 95% CI: -5.9, 3.7; *p*= 0.7; d= 0.1) in the control group.

5.5.2 Locomotor and object control skills

There was evidence of significant differences between the intervention and control group for the change in locomotor score (p= 0.03; d= 0.4) and percentile (p= 0.03; d= 0.4). There was no evidence of significant differences between the intervention group and control group for the change in object control score (p= 0.51; d= 0.1) and percentile (p= 0.63; d= 0.1).

The post-hoc analyses showed that the intervention group did not significantly increase their locomotor skill score (+ 0.4; 95% CI: -0.1, 0.9; p= 0.13; d= 0.2) or locomotor percentile (+ 3.8; 95% CI: -1.8, 9.3; p= 0.18; d= 0.2). However, there was a significant increase in their object control score (+ 0.6; 95% CI: 0.2, 1.1; p= 0.008; d= 0.4) and object control percentile (+ 5.1; 95% CI: 0.7, 9.5; p= 0.02; d= 0.3). The control group did not significantly increase their locomotor skill score (- 0.4; 95% CI: -1.0, 0.1; p= 0.14; d= 0.2), locomotor percentile (- 5.2; 95% CI: -11.0, 0.7; p= 0.08; d= 0.2), object control score (+ 0.4; 95% CI: -0.1, 0.9; p= 0.1; d= 0.2) or object control percentile (+ 3.5; 95% CI: -1.1, 8.2; p= 0.13; d= 0.2).

Table 5. Fundamental movement skills scores at baseline and follow-up in the intervention and control group

	Intervention (*n* =56)			Control (*n* =50)			Difference between groups for the change	
	Baseline Mean (SD)	Follow-up Mean (SD)	Within group change Mean; *p*-value; *d*	Baseline Mean (SD)	Follow-up Mean (SD)	Within group change Mean; *p*-value; *d*	Mean (95% CI)	p-value; *d*
GMQ Score	87.7 (12.8)	90.8 (10.5)	3.1; 0.007*; 0.4	92.0 (12.1)	92.0 (10.1)	0.0; 0.96; 0.0	3.2 (- 0.1, 6.4)	0.06; 0.4
GMQ Percentile	26.5 (23.6)	30.8 (20.1)	4.3; 0.07; 0.3	34.3 (23.5)	33.2 (19.9)	-1.1; 0.7; 0.1	5.4 (- 1.3, 12.0)	0.11; 0.3
Locomotor Score	8.6 (2.5)	9.0 (1.9)	0.4; 0.13; 0.2	9.2 (2.5)	8.7 (1.8)	-0.4; 0.14; 0.2	0.8 (0.1, 1.6)	0.03*; 0.4
Locomotor Percentile	34.7 (25.3)	38.5 (21.0)	3.8; 0.18; 0.2	40.7 (26.1)	35.5 (19.7)	-5.2; 0.08; 0.2	8.9 (0.9, 17.0)	0.03*; 0.4
Object Control Score	7.3 (2.6)	7.9 (2.3)	0.6; 0.008*; 0.4	8.2 (2.3)	8.6 (2.0)	0.4; 0.10; 0.2	0.2 (- 0.4, 0.9)	0.51; 0.1
Object Control Percentile	24.4 (20.9)	29.5 (21.4)	5.1; 0.02*; 0.3	32.0 (22.1)	35.5 (19.8)	3.5; 0.13; 0.2	1.6 (- 4.8, 8.0)	0.63; 0.1

*indicates statistical significance

5.6 Inhibition

Table 6 presents the results of the between and within group effects of the intervention.

There was evidence of significant differences between the intervention and control group for the change in accuracy score for the fish trials (*p*= 0.02; d= 0.4). There was no evidence of significant differences between the intervention and control group for the change in accuracy score for the arrow trials (*p*= 0.20; d= 0.3). The post-hoc analyses showed that the intervention group did not have a significant increase in their accuracy score for the fish trials (*p*= 0.47; d= 0.0) but did have a significant increase in their accuracy score for the arrow trials (*p*= 0.01; d= 0.4). The control group did have a significant increase in their accuracy score for the fish trials (*p*= 0.003; d= 0.4) but did not have a significant increase in their accuracy score for the arrow trials (*p*= 0.57; d= 0.1).

There was no evidence of significant differences between the intervention and control group for the change in conflict score for the fish trials (*p*= 0.35; d= 0.1) or the arrow trials (*p*= 0.74; d= 0.1).

The post-hoc analyses showed that the intervention group did not have a significant improvement in conflict score for the fish trials (*p*= 0.40; d= 0.1) or the arrow trials (*p*= 0.05; d= 0.3). Whereas the control group did have a significant improvement in conflict score for the fish trials (*p*= 0.02; d= 0.3) but not for the arrow trials (*p*= 0.06; d= 0.3)

Table 6. Inhibition scores at baseline and follow-up in the intervention and control group

	Intervention (fish *n* =54; arrow *n* =51)			Control (fish *n* =52; arrow *n* =45)			Difference between groups for the change
	Baseline Median (IQR)	**Follow-up Median (IQR)**	**Within group change Median; *p*-value; *d***	**Baseline Median (IQR)**	**Follow-up Median (IQR)**	**Within group change Median; *p*-value; *d***	***p*-value; *d***
Fish Accuracy	100% (100, 100%)	100% (96, 100%)	0%; 0.47; 0.0	100% (94, 100%)	100% (100, 100%)	0%; 0.003*; 0.4	0.02*; 0.4
Arrow Accuracy	100% (94, 100%)	100% (100, 100%)	0%; 0.01*; 0.4	100% (96, 100%)	100% (100, 100%)	0%; 0.57; 0.1	0.20; 0.3
Fish Trials Conflict Score	0.13 (-0.01, 0.28)	0.12 (0.05, 0.2)	-0.05; 0.40; 0.1	0.17 (0.08, 0.32)	0.08 (0.01, 0.21)	-0.07; 0.02*; 0.3	0.35; 0.1
Arrow Trials Conflict Score	0.24 (0.11, 0.46)	0.15 (0.10, 0.30)	-0.08; 0.05; 0.3	0.38 (0.10, 0.74)	0.21 (0.01, 0.46)	-0.18; 0.06; 0.3	0.74; 0.1

*indicates statistical significance

5.7 Maths fluency

Table 7 presents the results of the between- and within-group effects of the intervention.

There was no evidence of significant differences between the intervention and control group for the change for addition scores (p= 0.13; d= 0.3) or subtraction scores (p= 0.61; d= 0.1).

The post-hoc analyses highlighted that the intervention group had a significant increase in addition scores (+ 3.6; 95% CI: 2.7, 4.5; p< 0.001; d= 1.0) and subtraction scores (+ 3.4; 95% CI: 2.6, 4.3; p< 0.001; d= 1.2). The control group also had a significant increase in addition scores (+ 2.6; 95% CI: 1.6, 3.5; p< 0.001; d= 0.8) and subtraction scores (+ 3.1; 95% CI: 2.3, 4.0; p< 0.001; d= 0.9).

Table 7. Maths fluency: addition and subtraction scores at baseline and follow-up in the intervention and control group

	Intervention (*n* =57)			**Control (*n* =53)**			**Difference between groups for the change**	
	Baseline Mean (SD)	**Follow-up Mean (SD)**	**Within group change Mean; *p*-value; *d***	**Baseline Mean (SD)**	**Follow-up Mean (SD)**	**Within group change Mean; *p*-value; *d***	**Mean (95% CI)**	***p*-value**
Addition	8.8 (5.0)	12.4 (5.9)	3.6; <0.001*; 1.0	8.2 (4.4)	10.8 (5.5)	2.6; <0.001*; 0.8	1.0 (-0.3, 2.3)	0.13; 0.3
Subtraction	5.9 (4.4)	9.3 (4.3)	3.4; <0.001*; 1.2	4.2 (3.3)	7.3 (4.3)	3.1; <0.001*; 0.9	0.3 (-0.9, 1.5)	0.61; 0.1

*indicates statistical significance

6. Discussion

The present study was a feasibility cluster RCT designed to inform a future definitive cluster RCT; therefore, the sample size was not designed to detect intervention effects. The study benefitted from a relatively high pupil consent rate of 66%, a 100% school retention rate, and the loss of only three pupils (as they moved school) at follow-up. Compliance to the intervention was high, only four participants from the intervention group missed two sessions and none missed more than two. Compliance to the outcome measures was also high; 14% (n =3 for the intervention group and n =16 for the control group) of data were lost for the school day physical activity outcome, which was predominately due to participants not wearing the monitor for the minimum wear time as specified in the Methods section. Furthermore, two control schools had physical activity re-measured in January 2018. The playworkers who implemented the intervention scored highly in the assessment tool, but confidence could have been higher in the delivery of sessions. Furthermore, the sessions were often shorter than intended by approximately 10 minutes per session, which equates to a total of 1-hour and 40 minutes over the 10-weeks. Sessions were shorter because teachers brought the children late to the sessions, particularly when an Active Play session followed afternoon recess. The low levels of participants lost to follow-up, data lost to follow-up and high compliance to the intervention might be partly explained by the benefits of delivering the intervention and collecting outcome data in a school setting.

The Active Play intervention benefits from a collaborative approach in which local play charities deliver the sessions to enable teachers to participate, learn and then embed the intervention beyond the 10-weeks. Furthermore, utilising charities who are experts in play might increase the likelihood that children will continue playing at home and in their communities, particularly as the equipment provided is likely to be similar to what children might have access to at home.

The Active Play intervention was promising in terms of the MVPA content, with participants spending on average 39.4% of the session in MVPA. Interestingly, the participants engaged in slightly more MVPA during the free play component of the session compared to the facilitated games component (41.3% of time in MVPA on average versus 37.6%). The previous study conducted by Johnstone et al. (18) found that the participants spent 30.1% of their time during an active play session in MVPA and Brazendale et al. found that during a one-hour session of solely free play, participants spent 25% of that time in MVPA (43). To put this in context, a recent systematic review suggested that during physical education, participants of primary school-age children typically spend as little as 11% of their time in MVPA, despite the recommendation that 50% of time in PE should be MVPA (7, 44).

Preliminary findings of the outcome measures from the present study suggested that the intervention did not have a significant effect on physical activity levels, FMS, inhibition or maths fluency. It should be noted that for all outcome measures, these findings are preliminary. This study was not sufficiently powered to demonstrate significant intervention effects but to help power a future definitive cluster RCT as noted above.

This present study follows on from a pragmatic evaluation of the ‘Go2Play Active Play’ intervention conducted by the authors of the present study (18). Our previous study was a pragmatic evaluation (with a non-randomised small comparison group) of the intervention which lasted 5 months and involved two sessions per week

(18). The intervention tested in the present study used the same format (i.e. 30 minutes of facilitated games and 30 minutes of free play); however, the frequency of the sessions and the duration of the intervention were reduced to 10-weeks, one session per week so that it could be delivered to a larger number of schools. The previous evaluation of the Active Play intervention found a 16% increase in light intensity physical activity and a 3% increase in MVPA in the intervention group during an average school day (18). However, in the present study, light intensity physical activity only increased by 0.7% in the intervention group and by 1.7% in the control group during an average school day. Percent time spent in MVPA increased by 1.4% (4.2 minutes) in the intervention group and by 0.6% (1.7 minutes) for the control group during an average school day. A recently published systematic review from the authors of the present study also highlighted that active play interventions to date have had no effect on MVPA levels during school hours when two studies were pooled, which was similar to findings of the present study (10), though the evidence base is very limited in quality and quantity (9). Goldfield et al in a play-based intervention in Canada found an average increase in MVPA by 11.8 minutes/ school day for the intervention group and by 5.3 minutes/ school day for the control group (19). This was a 6-month study which involved encouraging more active and outdoor play opportunities for pre-school aged children (19).

Physical activity is underpinned by competency in FMS as it has been suggested that children who have a higher competency in FMS are more likely to be physically active (22, 23). Baseline FMS in the present study were poor, participants in the intervention group had a mean GMQ score of 87.7 and 92.0 in the control group; it is recommended that children should be scoring at least 100 (40). GMQ score did not significantly increase in the intervention group compared to the control (*p*= 0.06; d= 0.4), but the control group had no increase in their score whereas the intervention group had an increase of 3.1 (95% CI: 0.9, 5.3). These findings were similar to those reported by Adamo et al., who conducted a 6-month preschool intervention aimed at providing more active and outdoor play opportunities (20). They found that the intervention group increased their GMQ score by 4.2 (95% CI: 0.5, 7.9) and the control group had a small decrease of - 1.53 (- 4.82 to 1.77) (20). The previous study conducted by Johnstone et al found much larger increases in GMQ Score (+10.1; 95% CI: 7.9, 12.3) for the intervention group and a small increase in the comparison group (+ 3.6 -1.3 to 8.4), but the participants had lower baseline scores than the present study and the duration of the intervention was 5-months.

The present study also found that there was a significant intervention effect on locomotor score (+0.8; 95% CI 0.1, 1.6, *p*= 0.03; d= 0.4) and percentile (+8.9; 95% CI 0.9, 17.0, *p*= 0.03; d= 0.4) in the intervention group compared to the control. Adamo et al. found marginally larger increases for locomotor score (+1.2; 95% CI 0.2, 2.2, *p*= 0.02) and percentile (+12.6; 95% CI 2.0, 23.2, *p*= 0.02) compared to the present study (20). There were no significant intervention effects for object control score or percentile, but the intervention group did have a significant increase in their object control score (+ 0.6; 95% CI: 0.2, 1.1; *p*= 0.008; d= 0.4) and object control percentile (+ 5.1; 95% CI: 0.7, 9.5; *p*= 0.02; d= 0.3) from baseline to follow-up.

Recent research has suggested a possible link between MVPA and cognitively engaging activities (i.e. activities which target FMS) and improved executive function (inhibition) and attainment (particularly maths related outcomes) (24, 26).

The present study found evidence for a significant intervention effect for the fish accuracy scores (p= 0.02; d= 0.4); however, there was a ceiling effect with participants in both the intervention and control group scoring >95% on the fish and arrow trials. There was no significant effect on conflict scores (the measure of inhibition) for the fish trials (p= 0.35; d= 0.1) or the arrow trials (p= 0.74; d= 0.1) in the intervention group compared to the control group. The present study also found no significant intervention effect on children's maths fluency scores. However, there was a significant improvement in addition and subtraction scores in both the intervention and control group. These scores are likely to have improved through daily maths lessons over the study period and there might potentially have been a practice effect.

There is some evidence of the impact of physical activity interventions on children's inhibition and maths achievement. In the Medical College of Georgia randomised controlled trial, overweight (>85th percentile) participants were recruited and assigned to either low dose exercise (20 minutes/day), high dose exercise (40 minutes/day), or a control condition (educational component). The exercises focused on fun, inclusion and intensity, and participants wore heart rate monitors to measure the intensity of physical activity. Executive functions (planning, attention etc.) and maths attainment were assessed, and the authors found a dose-response relationship with planning (p= 0.015), but not math's achievement (p= 0.06). There were no significant intervention effects for other executive functions, but the authors did find significant effects on maths fluency (p= 0.01).

A study conducted by Donnelly et al aimed to determine the effects of a three-year physical activity intervention, consisting of 90 minutes of academic active lessons throughout the school week, on participants' maths fluency using the WIAT II (45). They found significant improvements in maths achievement in the intervention group compared to the control by approximately seven points (45). Findings from the Georgia Trial and Donnelly et al. suggest that the present Active Play intervention requires a higher frequency of delivery per week and/or a longer duration. However, the play intervention sessions in the present study were characterised by relatively high levels of MVPA and cognitively engaging activities, suggesting improvements in inhibition and maths fluency might be likely if more sessions were delivered per week. A future study may also benefit from utilising a more comprehensive method of assessing maths achievement, such as the WIAT II, rather than solely maths fluency; although, there are practical advantages of using a simpler measure. Furthermore, a future study should consider measuring social and emotional outcomes as these might be other important benefits of the intervention, these factors are thought to be important mediators for the relationship between physical activity and cognition (46). Anecdotally, teachers have reported that the active play sessions improved friendships among children, improved happiness and general mental wellbeing.

6.1 Study Limitations

The present study was a feasibility cluster RCT aimed at informing a future definitive trial. Although this study had a high consent rate, low attrition, was well organised and had a strong design necessary for the development of a future definitive RCT (27), it had some important weaknesses.

Firstly, the lead researcher who collected most of the data could not be blinded to group allocation. It is unlikely that this impacted the physical activity, inhibition and maths fluency outcomes as the researcher could not influence these findings; however, there may have been a bias and/or human error for the FMS scoring. These were minimised by using a researcher with extensive experience in using the TGMD-2 and following standardised procedures. Future studies should either blind the researcher to the intervention and control groups, or film participants performing the FMS test and score using the recordings to improve the accuracy of the scores, which would improve intra and inter-rater reliability.

The schools which agreed to participate in the intervention had a predominately low SES, which may have limited the generalizability of the present study. The aim of the funder was to provide Active Play to the most deprived schools in Glasgow and for this reason, schools were eligible for this study if 70% or more pupils were from the 20% of Scotland's most deprived areas. However, the majority (66%) of the schools who agreed to participate in the intervention had 50% or more children living in the 20% most deprived areas. A future definitive RCT of this intervention might consider a wider cross-section of schools.

Finally, due to time and cost the authors did not include additional outcomes to determine if there were any unintended intervention effects on participant's social and emotional development. A future definitive trial should consider additional outcomes (including qualitative measures) to determine if there are any unintended intervention outcomes.

7. Conclusions

The present study suggests that an Active Play intervention focused on outcomes of physical activity, FMS, educational and cognitive outcomes is feasible in primary school children. Although there was no evidence of a significant intervention effect on the outcome measures, the high MVPA content suggests that the intervention might be promising if delivered for a longer duration and/or higher dosage (for example, at least two sessions per week).

8. Supplementary Material- power calculation

Not presented in the submitted manuscript

This was a feasibility RCT and, therefore, the sample size was small, which limits the likelihood that an intervention effect would be detected. Based on findings from the feasibility cluster RCT, a sample size calculation was performed for the school day MVPA outcome to help inform a future definitive cluster RCT. A sample size calculation was conducted using standard formulas for a two-sided t test where clusters would remain equal and α =0.05 and β =80%. Mean group difference for the change in percent of school day spent in MVPA =0.8 and the SD =3.0. This resulted in a conservative estimate of n =221 children for the intervention group and n = 220 children for the control group. The sample size was corrected for the design effect where m =21 children per cluster (factoring in consent rate and data lost) and ICC =0.04, which was taken from the protocol paper by Bundy et al. (2011), which was the protocol for Engelen et al. (2013)- a study included in the systematic review, Chapter 3. The resulted in a total of 798 participants (399 in each arm) would be required to detect a 0.8%. improvement in school day MVPA in the intervention group compared to the control group. This equates to around 19 schools in each arm, based on 21 children per cluster.

Based on the findings, it is recommended that at least two active play sessions per week be delivered; therefore, a power calculation was also conducted for two sessions per week. It was assumed that the effect of the intervention would be doubled for school day MVPA (1.6%) and the SD would remain the same (3.0), this resulted in a conservative estimate of n =55 children for the intervention group and n = 55 children for the control group. Once the sample size was corrected for the design effect where m =21 children per cluster and ICC =0.04, a total of 210 participants (105 in each arm) would be required to detect a 1.6% improvement in school day MVPA in the intervention group compared to the control group. This equates to around 5 schools in each arm, based on 21 children per cluster.

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Chapter 7: Utilising active play to improve children's health and wellbeing and educational attainment

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1. Preface

The present thesis has highlighted the gaps in the research of active play interventions on improving children's physical activity levels and FMS (Chapter 3). The pragmatic evaluation (Chapter 5) and the feasibility cluster RCT (Chapter 6) have aimed to add to the evidence base for active play interventions in a school-based setting. The aim of this chapter is to summarise key findings and implications of these three studies and provide recommendations for schools on how to encourage more active play. This manuscript was submitted to the Scottish Educational Review for their special issue on 'Play in Scotland' in November 2018.

This paper is presented in the same format as was submitted to the journal and, therefore, the referencing system is not APA as is used in the other non-published chapters in this thesis (reference list presented at the end of this chapter).

AJ was lead author of this study and JJR and AH supported and advised on the content. All authors read and approved the final manuscript.

2. Abstract

Active play is 'a form of gross motor or total body movement in which children exert energy in a freely chosen, fun, and unstructured manner'; active play has huge potential in increasing physical activity levels, particularly moderate-to-vigorous (MVPA) intensity physical activity, which is desired to improve health,

wellbeing and cognition (important for learning). However, many modern children in high-income countries are not engaging in enough active play.

This paper will reflect on lessons learned from active play interventions including the evaluation of the ‘Active Play’ intervention delivered in Scotland. Recommendations for schools on how to encourage more active play will also be provided. Research suggests that promoting active play during school break times, in the after-school period and participating in the ‘Active Play’ intervention are promising ways of increasing children’s MVPA and enhancing their health and wellbeing.

3. Introduction

Active play is ‘a form of gross motor or total body movement in which children exert energy in a freely chosen, fun, and unstructured manner’ (Truelove et al., 2017). Active play provides children with a range of social, physical, emotional and cognitive benefits, all of which are important for health and wellbeing and for present and future success in life (Janssen & Leblanc, 2010; Timmons et al., 2012). In the Scottish Curriculum for Excellence, Health and Wellbeing is one of the three priority areas, with play mentioned as an important way of enhancing children’s social, physical and mental health (Scottish Government, 2008).

Active play can be promoted in a variety of ways, across a number of settings including at home, in the community and during school (Scottish Government, 2013). In Scotland, active play provision is provided through increased outdoor time, the expansion of outdoor childcare and by public and third sector organisations facilitating more active play (relevant examples are provided at the end of the present paper). It has also been suggested that Scotland has a much more favourable environment for outdoor active play, in terms of accessibility and safety than might be expected, but still not ideal (Reilly et al., 2016a). In Scotland, 91% of parents reported that their children had at least one place to play and 64% of parents reported that they thought it was very or fairly safe for their children to play at a park with 2 or 3 friends (Scottish Household Survey, 2015). However, parental safety concerns were greater in areas of deprivation with 12% of parents living in the most deprived areas reporting that they are less likely to think it was safe for their child to play at the park with two or three friends compared to the Scottish average (64%) (Scottish Household Survey, 2015).

Given the benefits of active play and its relevance to the Scottish Curriculum, interventions may be required to provide children with more active play opportunities. The authors of the present study have worked closely with Inspiring Scotland (www.inspiringscotland.org.uk) to evaluate a school-based 'Active Play' intervention to determine if participating increased children's physical activity levels and improved their fundamental movement skills (FMS), inhibition and maths fluency (Johnstone et al., 2017; Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018). Findings of the evaluation proved promising in terms of the amount of moderate-to-vigorous physical activity (MVPA) children engaged in during the active play sessions and improvement in physical activity levels and FMS, suggesting a larger study is required to determine the true potential of the intervention (Johnstone et al., 2017; Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018). This intervention expanded to three local authority areas in Scotland with the longer-term ambition of delivering the intervention in other local authorities.

The present paper aims to present the range of benefits of engaging in active play, summarise the authors work on active play interventions, with particular focus on schools, summarise findings and implications of a Scottish school-based 'Active Play' intervention, and highlight some promising working examples in which active play is being delivered in Scotland.

4. Making the case for active play

Engaging in active play provides children with a range of social, physical, emotional and cognitive benefits, all of which are important to the health and wellbeing of children (Janssen & Leblanc, 2010; Timmons et al., 2012). Increasing levels of physical activity is one of the main benefits of promoting active play, given that active play is relatively unrestrictive in nature (i.e. it can be engaged in every day of the year) and has been suggested to be one of the best ways of providing population wide gains in children's physical activity levels (Janssen, 2014). In the UK, it is recommended that children and adolescents (5-18 years) should be achieving at least 60 minutes of MVPA per day every day and minimise amount of time spent in sedentary behaviour (Department of Health, 2011). Sedentary behaviour is defined as "any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017) and MVPA is defined as physical activity with an energy cost of >2.9 but <6.0 times resting energy expenditure (Department of Health, 2011). MVPA is particularly important as it provides a range of immediate and longer-term benefits including, reduced risk of cancer, overweight and obesity, depression and diabetes (Janssen &Leblanc, 2010; Timmons et al., 2012). However, most children in Scotland are not reaching the recommended minimum amount of physical activity (McCrorie, Mitchell & Ellaway, 2018; Reilly et al., 2016a). It might be that increasing the amount of time in active play would enable more children to achieve the recommended amount of physical activity (Janssen, 2014). Active play is often engaged in outdoors and outdoor time is consistently associated with increased levels of physical activity compared to time indoors, particularly MVPA, the most health enhancing intensity of physical activity (Brussoni et al., 2015; Gray et al., 2015; Cooper et al., 2010). However, in a global context, it is not known how much time children typically spend in active play per day. In a study comparing the physical activity behaviours of 38 countries, only 17 of these countries were able to provide data on the prevalence of active play (Tremblay et al., 2016) and the quality of the measures of active play was quite limited in many of the countries. This study also suggested that active play makes an important contribution to the relatively high levels of physical activity among children from low-income countries, where children typically spend more time each day playing outside and accumulating more MVPA compared to high-income countries where physical activity levels of children tend to be lower (Tremblay et al., 2016). Furthermore, active play interventions have also suggested that increased time spent in active play does lead to overall increases in physical activity (Johnstone et al., 2017, Adamo et al., 2016).

Related to physical activity are FMS, which have also been suggested to be improved by active play (Johnstone et al., 2017, Adamo et al., 2016). FMS are the basic skills children should be competent in such as throwing, catching, running, and skipping and underpin physical activity levels (Lubans et al., 2010; Stodden & Goodway, 2007). If children are competent at these skills then they are more capable of engaging in higher levels of physical activity compared to children who have not acquired these skills (Lubans et al., 2010; Stodden & Goodway, 2007). FMS are typically poor in children from high-income countries (Hardy et al., 2012), including Scotland (Johnstone et al., 2017), which might partly explain the low levels of physical activity among Scottish children (McCrorie, Mitchell & Ellaway, 2018; Reilly et al., 2016a). The FMS data in Scottish children, which is the only of its kind, was measured in *n* =229 children (across two studies) in children aged 7 years and the authors found that children were scoring lower than average for their age (Johnstone et al., 2017),

Engaging in active play in the early years is important for developing FMS, with active play been suggested as a good way of improving children's FMS (Johnstone et al., 2017; Adamo et al., 2016) and might be an enjoyable way of doing so (Roach & Keats, 2018).

A combination of high intensity physical activity and development of FMS has been hypothesised (see Figure 1) to improve children's executive functions (particularly inhibition) an important precursor to raising attainment (specifically maths), and active play is a good way of achieving these outcomes (McMorris, Tomporowski & Audiffren, 2009). Executive functions are, "the capacity to think before acting, retain and manipulate information, reflect on the possible consequences of specific actions, and self-regulate behaviour"; examples include inhibition, planning and attention among others. Inhibition has been defined as "the ability to withhold actions or modify behaviours" and is implicated in many areas of learning including, maths, literacy, reading and science (Tomporowski, McCullick & Pesce et al., 2015).

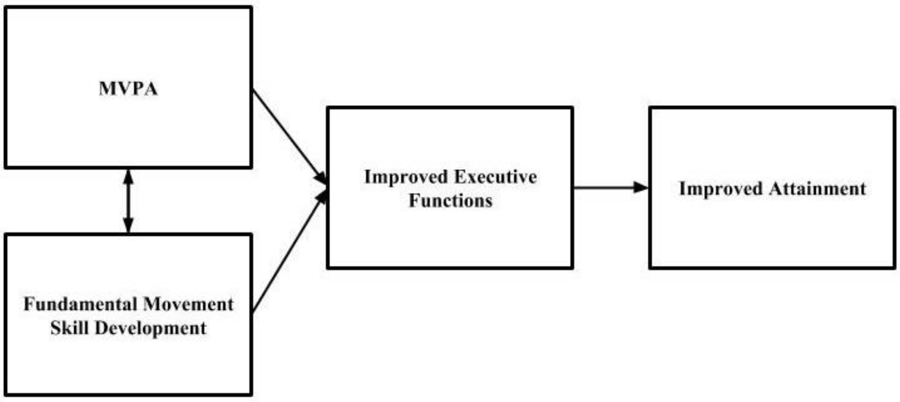

Figure 1. Diagram highlighting how a combination of high intensity physical activity and FMS development (or motor skills) can enhance children's executive functions (redrawn from Tomporowski et al., 2015).

The Georgia Trial was a seminal randomised controlled intervention trial in which US children (*n* =222) age 7-11 year-olds were randomly allocated to receive either 20 minutes/day or 40 minutes/day of fun physical activity after school, or continued as normal (control group) over a 13-week period. The intervention was intended to maximise MVPA while providing cognitive stimulus (e.g. the games involved children using cognitive functions such as shifting/rule changes) (McMorris, Tomporowski & Audiffren, 2009; Tomporowski, McCullick & Pesce et al., 2015). This study found that engaging in the intervention enhanced inhibition and maths fluency (McMorris, Tomporowski & Audiffren, 2009) and subsequent studies have found similar findings (Donnelly et al., 2013; Hillman et al., 2014). Recent research has suggested that active play might be particularly beneficial for enhancing primary school aged children's inhibition and attainment, particularly if active play is engaged in outdoors, which might typically provide greater cognitive stimulus than play indoors (Pesce et al., 2016; Tomporowski, McCullick & Pesce et al., 2015).

Active play has also been suggested to have social and emotional benefits. When children play, they often engage in this behaviour with friends (Veitch et al, 2008) and when children play together they naturally socialise, work together and navigate conflict. It mirrors many of the situations they will experience as they mature into adulthood, which enhances problem solving, cooperation and communication (Burdette & Whitaker, 2005; LeMoyne & Buchanan, 2011; Schiffrin et al, 2014). Finally, children who are not given opportunities to play often exhibit higher levels of depression and anxiety as they mature into adulthood (Burdette & Whitaker, 2005).

In summary, engaging in daily active play provides children with a range of social, physical, emotional and cognitive benefits, all of which are important for children's health and wellbeing, and which should also translate into improved academic attainment. Given that health and wellbeing is one of three priority areas in the Scottish curriculum, more active play opportunities should be provided, and active play interventions might be a good way of achieving this.

5. Active play interventions- what do we know so far

The authors of the present study conducted a systematic review, which aimed to determine if active play interventions increased children's (3-12 years) physical activity levels and improved their FMS, cognition and weight status (Johnstone et al., 2018). After searching relevant databases, only four eligible studies of controlled active play interventions (described in 5 published papers) were found (Johnstone et al., 2018). This is a very small body of evidence that suggests that active play as an intervention has been overlooked by researchers and policymakers in health and education.

These four eligible studies in the review were all from high-income countries, three of the studies were pre-school or school-based interventions (O'Dwyer et al., 2012; Tortella et al., 2016; Adamo et al., 2016; Goldfield et al., 2016; Engelen et al., 2013) and the final study was community based (O'Dwyer et al., 2012). This highlights the need to implement active play interventions in other settings such as in the home or community, which might provide additional opportunities to increase children's physical activity levels. The interventions differed across the four studies and targeted different levels of the 'Socio-ecological Model' for Health (Dahlgren & Whitehead, M., 1991). This model, as presented in Figure 2, has four interconnecting sections: policy, physical environment, social environment, individual lifestyle factors and a centre which describes characteristics that cannot be changed (such as ethnicity). Each level of the Socio-ecological Model should be targeted to increase active play opportunities (Sallis, Owen, & Fisher, 2008).

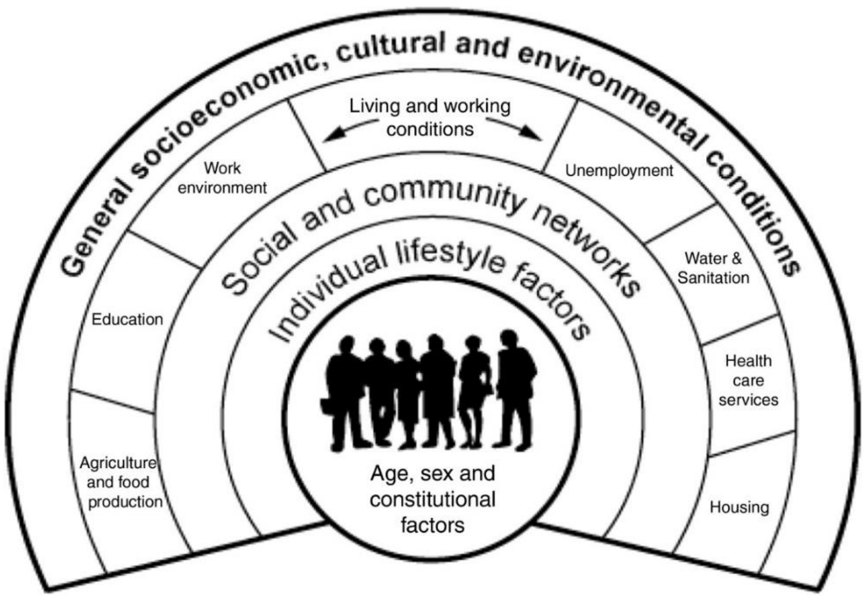

Figure 2. Dahlgren and Whitehead's Socio-ecological Model for Health

The study conducted by Adamo et al. (2016) and Goldfield et al. (2016) targeted pre-school aged children in a child care centre, in which staff provided more outdoor active play opportunities and attended workshops designed to increase their knowledge on the benefits of active play. Engelen et al. (2013) utilised a playground setting in a primary school to provide loose parts equipment designed to encourage more active play. Tortella et al. (2016) also utilised a playground setting but children from a kindergarten were taken to a local playground where they were provided with opportunities to develop their FMS and provided with time to free play. Finally, the community-based study conducted by O'Dwyer et al. (2012) was a parent and child active play intervention consisting of educational workshops for parents and active play sessions for both parent and child. The intervention duration ranged in the four eligible studies from 10-weeks (Tortella et al., 2016; O'Dwyer et al., 2012), 13-weeks (Engelen et al., 2013) and 6-months (Adamo et al., 2016; Goldfield et al., 2016).

Findings from this systematic review suggested the active play interventions had no effect on MVPA when two studies were pooled (Engelen et al., 2013; Goldfield et al., 2016). However, total physical activity (light physical activity and MVPA combined) increased in the intervention group compared to the control groups in two of three studies (Goldfield et al., 2016; O'Dwyer et al., 2012). Two of the studies found significant improvements in FMS in the intervention group compared to the control group (Adamo et al., 2016; Tortella et al., 2016). No studies examined the effects of participating in active play on cognition and one study examined the effect on weight status, which was non-significant (Goldfield et al., 2016), so the evidence from randomised controlled studies on the benefits of active play interventions for obesity prevention or cognitive/educational improvement, other than the Georgia Trial mentioned above, is somewhat limited at present.

In summary, active play interventions have the potential to improve physical activity levels and FMS, and this may have the 'co-benefit' of improved cognition and educational attainment; however, the evidence base is small and needs to be further enhanced (Johnstone et al., 2018). Over recent years, an 'Active Play' intervention has been delivered in predominately Glasgow schools, which will now be discussed with focus on describing the intervention, main findings from our evaluation of the intervention and future directions.

6. An 'Active Play' intervention in Scotland- a useful contribution to children's physical activity levels and FMS

6.1 Description of the Active Play intervention

The 'Active Play' intervention is a collaborative approach involving a number of partners. Inspiring Scotland (www.inspiringscotland.org.uk) manage the programme, Agile CIC (www.agilecic.com) provide training and support to the playworkers and class teachers, and a number of play charities in each location deliver the intervention. Since it began in 2014, the intervention has been delivered in a number of Local Authorities across Scotland and presently it is being delivered in Glasgow, Inverness and Dundee. Much of the research thus far has been conducted in Glasgow, with Possibilities for Each and Every Kid (PEEK) Project, Jeely Piece Club and Family Action in Rogerfield & Easterhouse (FARE) currently delivering the intervention to 118 primary schools across three school years (2016-19).

The intervention has been described elsewhere (Johnstone et al., 2017), but briefly it consists of a one-hour outdoor active play session involving 30 minutes of facilitated games and 30 minutes of free play (Johnstone et al., 2017). During the facilitated section of the session, the playworkers lead and join in on games designed to develop children's FMS and during the free play section, children are free to use the equipment provided to choose what they want to play (Johnstone et al., 2017). The delivery principles of the Active Play sessions are that they should be Fun, Inclusive and Active (F.I.A), which should encourage high levels of MVPA and FMS development. Teachers are encouraged to participate in the sessions with the children and the playworkers, with the aim of the teachers continuing to deliver the intervention beyond the intervention period. The one-hour session benefits from utilising basic equipment (such as, balls, bean-bags, skipping ropes, balls etc.), is simple and inexpensive to deliver. It might also increase physical activity levels outside of the sessions as children may play the games learned during the intervention at break times and outside of school.

6.2 Pragmatic evaluation of the Active Play intervention

The pragmatic evaluation was published in Preventive Medicine Reports in June 2017 (Johnstone et al., 2017). The pragmatic evaluation involved a 5-month school-based intervention in which baseline data were collected during September and October 2015, and follow-up data were collected during February and March 2016 in children aged 7 years from deprived schools in central Scotland (delivered by three play charities) (Johnstone et al., 2017). During the intervention children participated in 2x1 hour Active Play sessions per week for 5-months. The aim of the pragmatic evaluation was to determine if participating in the intervention increased children's physical activity levels (measured objectively by accelerometry) and fundamental movement skills (measured using the Test of Gross Motor Development-2) (Ulrich, 2000).

Findings suggested a decrease in sedentary behaviour (-19%; 56 minutes/school day) and an increase in light intensity physical activity (+16%; 55 minutes/school day) and MVPA (+3%; 10 minutes/school day) during an average school day for the intervention group. The comparison group (i.e. children in this group did not receive the intervention) showed no change in these behaviours from baseline to follow-up. Total FMS score (also known as Gross Motor Quotient) increased by 10 points for the intervention group and by 4 points for the comparison group. However, even at follow-up the intervention group's total FMS score was 93 on average (36th percentile), which, based on normative data is lower than the recommended value of 100 (Ulrich, 2000). This is the only data of its kind in Scotland and it highlights the low level of FMS competency in Scottish children living in areas of deprivation (Johnstone et al., 2017).

The pragmatic evaluation found that the intervention was promising in terms of improving physical activity levels and FMS but due to limitations with the study design, it required further testing.

6.3 Feasibility cluster RCT of the Active Play intervention

The pragmatic evaluation had some limitations because not all measurements could be taken before the intervention began, the number of children in the comparison group was small and the groups could not be randomised to either the intervention or the control condition. Findings from the pragmatic evaluation was used to inform the second study, a feasibility cluster RCT (submitted to a peerreviewed journal) which is a stronger design as it addressed the limitations of the pragmatic evaluation (Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018). For the feasibility cluster RCT, the intervention was reduced to 1x1hour active play session per week for 10-weeks so that more schools could receive the intervention.

Although the intervention is being delivered in 118 schools over a three-year period in Glasgow, only eight schools were recruited for the study (for practical reasons). These eight schools (one primary 3 class per school) were matched based on deprivation, school size and demographics and were randomised (intervention = 4 schools; control= 4 schools) prior to data collection. Baseline data collection took place during August and September 2017 and follow-up during November and December 2017. The aim of this study was to determine if the intervention was feasible to deliver in school and as a trial, plus if participating in the intervention increased children's physical activity levels (measured objectively) and improved their FMS, inhibition and maths fluency. The MVPA content of the active play sessions was also collected (also measured objectively by accelerometry).

One of the primary findings of this study was the high proportion of MVPA children engaged in during an Active Play session. Findings indicated that children spent 39% (21 minutes) of the active play session in MVPA; furthermore, they spent 38% (9 minutes) in MVPA during the facilitated games section and 41% (12 minutes) in MVPA during the free play section. This means that each Active Play session is providing a relatively high amount of children's MVPA and contributing to achievement of guidelines, at least on days when they receive the active play session. To put this into context, systematic reviews of research on other physical activity domains have found that active commuting typically contributes around 17 minutes of MVPA per school day, recess typically equates to around 12 minutes of MVPA and a typical PE session contributes only around 12 minutes of MVPA (Martin et al., 2016; Reilly et al., 2016b; Hollis et al., 2016).

Other findings of the feasibility cluster RCT highlighted that there was no improvement in percent time in sedentary behaviour, light physical activity and MVPA during an average school day in the intervention group compared to the control group. The intervention group had a decrease in percent time in sedentary behaviour (- 2.1%; -6 minutes/school day) and an increase in percent time in light intensity physical activity (+ 0.7; +2 minutes/school day) and MVPA (+ 1.4%; +4 minutes/school day) during an average school day. There was also no improvement in total FMS score in the intervention group compared to the control group. The intervention group had a 3 point (+ 4.3 percentile points) increase in total FMS score, whereas the control group had no increase. Similar to the pragmatic evaluation, even at follow-up the intervention group's total FMS score was 91, which is below the recommended value of 100 (Ulrich, 2000). Finally, there was also no improvement in inhibition or maths fluency for the intervention group compared to the control group.

Overall, the feasibility cluster RCT found that the intervention had no effect on school day physical activity levels, FMS, inhibition and maths fluency but the intervention only involved one Active Play session per week for 10 weeks, which, as the results suggest, is not enough to improve these outcomes (Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018). However, since each Active Play session provides 21 minutes of MVPA, it is possible that if more active play sessions were delivered each week and/or for longer than 10 weeks the intervention may have a bigger effect on these outcomes.

Active Play is an hour session, delivered outdoors and is additional to PE. During the 10-weeks delivery, findings from the feasibility cluster RCT found that all sessions were delivered outdoors as intended but getting the full-hour for the Active Play intervention would be difficult as teachers often brought their class to the sessions late due to getting children ready or transitioning between classes or break times. Sessions tended to last approximately 50 minutes, this meant that over the course of the 10-weeks, an hour and 40 minutes of valuable delivery time was lost, and this could have minimised the effect of the intervention. Furthermore, children appeared to enjoy these sessions as only four missed two sessions and no child missed more than two sessions.

6.4 Impact of the Active Play on teachers

A key aim of the intervention is to encourage teachers to continue to deliver the intervention beyond the 10-weeks. Anecdotal information collected by Agile CIC and Inspiring Scotland highlighted that teachers had initial concerns about fitting the Active Play intervention into the curriculum, when they have other aspects of the curriculum to teach. However, a few weeks into the intervention, the teachers begin to see the value of the intervention in terms of its contribution to the children's Health and Wellbeing experiences and outcomes and as an intervention they should continue. An evaluation conducted by Inspiring Scotland found that 78% of teachers involved in year two (*n* =40 schools) of the Glasgow Active Play intervention planned to continue the intervention beyond the 10-weeks (FMR Research, 2018). Furthermore, they observed a range of benefits from the Active Play intervention among the children in their classes. Fifty three percent of teachers cited improved relationships with children, in particular with children who often disengage from a classroom-based setting, as these are often the children who thrive during the Active Play intervention (FMR Research, 2018). The children also improved their relationships with each other, and enhanced their resilience, conflict resolution and communication, as cited by the playworkers and class teachers (FMR Research, 2018).

The funders, Inspiring Scotland, are keen to ensure that the Active Play intervention is delivered beyond the charity input to sustain health and wellbeing outcomes in children. Teachers provided suggestions on how they will continue the intervention beyond the 10-weeks of charity input. Some teachers stated that they could only afford 30 minutes each week with others comfortable with the full-hour. This poses an important question on how to best implement an active play intervention in a school setting. A hybrid model where the intervention is initially delivered in school to work with the teachers and the children and then moves to the after-school period where there might be more scope to offer the intervention more than once a week. This might work by providing two sessions per week for the first 5-weeks and then moving one of the sessions to the after-school period for the next 5-weeks, where any children is free to attend, and beyond the 10-week period it becomes a predominately after school intervention. The benefit of this approach is that there may be scope to offer more sessions per week, whilst still upskilling the teachers and engaging with children who might not usually attend after school clubs. Additionally, weekends and school holidays might also provide a useful time to offer this Active Play intervention, and increasingly schools are open during the school holidays in many areas of Scotland. The Active Play intervention encourages high levels of MVPA during the sessions and if more sessions can be provided each week, the more it will benefit the children participating. At one session per week, the intervention is adding an additional 4 minutes/school day of MVPA. If the intervention was delivered two times per week this could increase to 8 minutes/school day, or 12 minutes/school day for three sessions per week, which is a more substantial contribution to the recommended 60 minutes of MVPA per day and may also lead to improvements in FMS, inhibition and maths fluency.

Another consideration is the ability of the teachers to deliver the intervention once the charities have delivered the 10-weeks. These play charities are experts in providing play opportunities for children and are able to deliver high quality and high intensity sessions. The teachers who have already received the intervention exhibit varying levels of confidence and ability, with many requiring additional training to improve their delivery. Thirteen percent of class teachers were still lacking confidence in delivering the intervention at the end of the 10-weeks (FMR Research, 2018). In Glasgow, Agile CIC has offered two CPD opportunities per school year and a website (https://www.actify.org.uk/activeplay) where teachers can access related resources to enhance their ability to deliver the intervention beyond the 10-weeks. Further training and resources may be needed to increase the likelihood that teachers are able and confident to delivering the intervention beyond the 10-weeks.

6.5 Summary of Active Play intervention

The Active Play intervention benefits from a collaborative approach, bringing together a number of partners: Inspiring Scotland (funders and strategic managers), Agile CIC (training and development) and a number of play charities, PEEK, Jeely

Piece Club, FARE (Glasgow), Care And Learning Alliance (CALA- Inverness) and Smart Play Network (Dundee). The intervention provides a high percentage of time spent in MVPA during the session, higher than a typical PE session for example. The effect of the intervention on physical activity levels and FMS was bigger in the pragmatic evaluation when the intervention was longer in duration (5-months) and delivered twice a week (Johnstone et al., 2017); however, findings should be interpreted with caution as this study had some limitations. The feasibility RCT, which was a 10-week intervention delivered once a week, found much smaller effects of the intervention on physical activity levels, FMS, inhibition and maths fluency (Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018). However, the sessions are providing children with much needed MVPA on the day they are participating in Active Play and if the intervention was delivered twice or three times a week there might be bigger improvements. Moving forward, thought needs to be given to whether the intervention can be delivered twice or three times per week, in addition to PE and the training and support provided to teachers to continue to deliver the intervention beyond the play charity's input.

7. Discussion

The evidence base for active play interventions needs to increase to determine how best to realise the potential they may have on improving children's health, wellbeing, and educational attainment. Effects of active play on physical activity, FMS, cognition (important for attainment) are likely, but still have to be demonstrated in robust study designs like RCTs. Evidence from other high-income countries has suggested that active play interventions might be promising in increasing children's physical activity levels and improving their FMS (Johnstone et al., 2018), though a number of gaps in the evidence exist and how best to implement active play and embed it in Scottish schools is unclear, but suggestions have been provided throughout this text.

Active play interventions in other high-income countries have targeted a range of settings (school, community and home) across varying levels of influence (policy, physical environment, social environment, and individual factors). Examples include, changes to policy to encourage more active outdoor play opportunities in a pre-school setting (Adamo et al., 2016; Goldfield et al., 2016); providing loose-parts play equipment in a primary school setting to change the physical environment to foster more active play during break times and increase children's physical activity; and utilising a community setting to deliver a family based intervention that encourages more active play.

Schools are a great setting to provide children with more active play opportunities and increase physical activity levels as all children (particularly those with low levels of physical activity) can be targeted; however, they are only open on around half of the days of the year, which presents a challenge. However, if schools can provide access to the entire school and preschool age population, and with suitable facilities, they could be 'active play hubs' for during and out of school time.

Other school based physical activity domains, including, recess, physical education and active commuting make a useful contribution to children's physical activity levels, but only small amounts of MVPA are achieved in these domains so the scope to increase physical activity, particularly MVPA, is small (Martin et al., 2016; Reilly et al., 2016b; Hollis et al., 2016). Active commuting contributes to 17 minutes of MVPA per school day, recess equates to 12 minutes and PE equates to 12 minutes (Martin et al., 2016; Reilly et al., 2016b; Hollis et al., 2016). Given that children only attend school half of the year, this would equate to a small contribution of MVPA per day when averaged over the entire year (active commuting= 8 minutes; recess= 6 minutes and PE= 6 minutes). Promoting active play could provide an additional way of increasing children's MVPA levels during school but after school clubs should also be considered to provide additional opportunities. For example, schools could provide the facilities and support with recruiting families and work collaboratively with local play charities to deliver an active play intervention.

In Scotland, the 'Active Play' intervention being delivered in Scotland might make a useful contribution to improving children's physical activity levels (particularly MVPA), FMS, cognition and attainment. Although the pragmatic evaluation found more substantial intervention effects on the outcomes (as the intervention period was longer and involved two sessions/week), it had some limitations compared to the feasibility cluster RCT and, therefore, should be interpreted with caution. Furthermore, it was used to inform the feasibility cluster RCT. The high levels of MVPA engaged in during the Active Play sessions were of particular interest because it meant that on average it contributed to one-third of children's daily MVPA recommendations (21 minutes). If the intervention was delivered more times a week (twice or three times) it would be more likely to increase average school day physical activity, FMS, inhibition and attainment.

The Active Play intervention benefits from being a simple, low-cost, collaborative intervention that provides children with additional opportunities to be physically active during school hours. Further efforts should be made to fit the intervention into the curriculum and to sustain it in the long-term.

8. Recommendations and take-home messages- embedding active play in schools

Based on the main themes discussed in the present paper, this section will aim to provide recommendations on how more active play opportunities can be provided to children and some working examples currently being delivered in Scotland.

Firstly, ensure that break times are protected; they should not be cut short to increase teaching time and, furthermore, children should be encouraged to play outside when the weather is poor, which, anecdotally, many schools opt to keep children indoors when the weather is poor. For every time children are kept indoors during break times, on average they are missing around 12 minutes of MVPA per school day which is a small but useful contribution to meeting physical activity guidelines (Reilly et al., 2016b). Schools can also provide additional active play interventions (as described above). These can be as simple as affording children more time outside and outdoor time is associated with increased levels of physical activity (Adamo et al., 2016; Goldfield et al., 2016) or providing additional 'loose parts play equipment' in the playground to encourage more active play (Engelen et al., 2013). In Scotland, Inspiring Scotland have developed a 'Loose Parts Toolkit' aimed at providing schools with simple advice on how to make their school break times more playful. The Active Play intervention described in the present paper might also provide a useful contribution to children's MVPA during the school day. Further improvements of the intervention such as, more sessions per week, delivered over a longer period and a parental element may also bring further increases to children's physical activity levels and improvements in FMS, inhibition and maths attainment (Johnstone et al., submitted to Journal of Pilot and Feasibility Studies in September 2018).

It is also important to look beyond the school day and provide additional active play opportunities outside of school hours, particularly to engage with parents and children together, as parents are key influencers of children's behaviour. An educational component to describe the benefits of play complemented with time for children and adults to play together may be important here. Schools could be central to enabling this by delivering the intervention after school, using school facilities and utilising their expertise in engaging parents.

Currently in Scotland, there are a number of play charities providing children with active play opportunities, during and outside of school hours. PEEK Project (www.peekproject.org.uk) is a play charity based in the East End of Glasgow who aims to promote active play through a variety of strategies. A large part of their work involves, 'street play' where playworkers visit predominately deprived locations across Glasgow to encourage children to reclaim their communities (streets, playgrounds and open spaces) for play. The playworkers take a variety of equipment and loose parts, such as, balls, racquets, skipping ropes, den building among other things which the children can use to create their own games and actively play. PEEK also work in collaboration with a number of schools to provide a range of opportunities throughout the school day and after school period for children. They facilitate breakfast clubs, break times and after-school clubs to provide children with more active play opportunities by playing games and taking basic equipment that the children can use. They also regularly deliver play training to parents, community workers and school staff to promote the importance of play for children and to support others to champion the child's right to play.

Finally, they have also offered school holiday clubs for children and their parents/carers to provide them with a range of opportunities including active play where both children and parents are provided time and space to play together. The school holidays can be a very difficult time for the children and families that PEEK works with and their outreach and playful approach helps some of the most marginalised families in the communities they work in. The strategies PEEK Project use highlight how active play opportunities can be effectively promoted, before, during and after school, and when schools are not open.

To conclude, providing children with plenty of active play opportunities throughout the day could be an important way of supporting their health and wellbeing, and at the same time potentially encouraging improved cognition and academic attainment.

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Chapter 8: Thesis Discussion and Conclusions

1. Background

The present thesis aimed to explore the role of active play interventions on improving children's physical activity levels and fundamental movement skills (FMS). The introduction and literature review (Chapter 1) explored topics related to active play interventions, physical activity, moderate-to-vigorous physical activity (MVPA) and FMS. Chapter 1 highlighted that children and adolescents are not achieving the recommended minimum amount of 60 minutes of MVPA per day despite the contribution of other physical activity domains (McCrorie et al., 2018; Reilly et al., 2016a; Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016b). This resulted in the discussion of active play as a way of increasing children's physical activity, MVPA and FMS given that it can be engaged in 365-days of the year and is often engaged in at a high intensity of physical activity (i.e. MVPA) (Janssen, 2014).

Chapter 2 was a methodology chapter that complemented the systematic review (Chapter 3), which was published in BMC Public Health in June 2018. The aim of the systematic review was to determine the effect of active play interventions in increasing children's physical activity levels and improving FMS, and to characterise the interventions used. The systematic review confirmed the findings from the literature review in that active play interventions are an under researched area, with only four studies (representing five papers) included in the review.

Chapter 4 presented a detailed methodology of two studies: a pragmatic evaluation (Chapter 5) and a feasibility cluster RCT (Chapter 6) of a school based 'Active Play' intervention. The pragmatic evaluation was published in Preventive Medicine Reports in June 2017 and aimed to evaluate the effects of the intervention on school day physical activity and FMS. The pragmatic evaluation was used to inform the feasibility cluster RCT which aimed to determine the feasibility of a 10-week school-based 'Active Play' intervention, and present preliminary findings on four outcomes: physical activity levels, FMS, inhibition, and maths fluency. The feasibility cluster RCT was submitted to the Journal of Pilot and Feasibility Studies in September 2018.

The final paper (Chapter 7) was submitted to the Scottish Education Review in November 2018 and aimed to present the benefits of engaging in active play, summarise the findings from the systematic review (Chapter 3), pragmatic evaluation (Chapter 5) and feasibility cluster RCT (Chapter 6), and highlight some promising working examples in which active play is being delivered in Scotland. The audience for this paper was those working in the Education setting in Scotland and, therefore, was a more narrative piece.

The aim of the present chapter is to summarise and discuss the key findings from the present thesis, the strengths and limitations of the research, and provide recommendations for policy and future research.

2. Summary of Thesis Findings

Three main themes emerged from the thesis: a) active play is an under researched area that needs greater focus, b) the school-based Active Play intervention is promising and a future definitive cluster RCT is required, and c) children from Scotland have poor FMS.

Currently, most children from high-income countries are not doing enough physical activity and efforts to increase physical activity levels through active commuting, recess, physical education (PE) and sport have contributed only small amounts (McCrorie et al., 2018; Reilly et al., 2016a). This has led to the emergence of active play as a neglected but promising way of increasing children's MVPA levels; however, active play is an under-researched area and active play interventions are limited (Janssen, 2014). The primary aims of the systematic review (Chapter 3) were to determine the effect of active play interventions in increasing children's physical activity levels and improving FMS. The secondary aims were to determine the effect of active play interventions on improving cognitive performance and weight status in children. After searching four databases and rigorously removing articles that did not meet the inclusion criteria, only four cluster RCT studies (representing five papers) were found to be eligible, highlighting the small evidence base for active play interventions. In comparison, systematic reviews looking at the potential to increase MVPA via other physical activity domains have been subject to more research; for example, recess (*n* =9 studies), primary school PE (*n* =13 studies) and active commuting (*n* =32 studies) (Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016b).

Of the four eligible studies in the systematic review of active play interventions, three were (pre)school based and only one was community-based, highlighting the need for more community and home-based interventions in the future. However, the four interventions did target varying levels of the Socio-ecological Model for Health (policy, physical, social and individual) (Sallis, Owen, & Fisher, 2008). These interventions have been described in Chapter 3 (section 5.2), but briefly, O'Dwyer et al (2012) delivered a parent and child 10-week active play intervention in the community where parents received a 20 minute educational component and then 40 minutes of active play for both parent and child. Adamo et al.

(2016) and Goldfield et al. (2016) utilised child-care centres and conducted two-three hour workshops for the care providers to encourage more active and outdoor play for the children. Engelen et al. (2013) provided ‘loose parts’ (e.g. tyres, crates, recycled plastic and fabric) for children to utilise in a school playground and, finally, Tortella et al. (2016) divided the playground into motor skill specific areas where the children played for 10 minutes each and the remaining 30 minutes was free play. When designing future active play interventions, the Socio-ecological Model for Health should be considered so that multiple levels of the model are targeted (as discussed in Chapter 7, section 8) (Sallis, Owen, & Fisher, 2008). Furthermore, future active play interventions should also consider a parental component, particularly as parental safety concerns might be limiting children’s playing and this is even more likely in more deprived areas in Scotland (Scottish Household Survey, 2015).

Although it was difficult to draw conclusions on only four eligible studies included in the systematic review, findings suggested that there was no significant effect (p =0.71; MD= 1.12, 95%CI: -4.83, 7.06) on school day MVPA when two studies were pooled (Goldfield et al., 2016; Engelen et al., 2013). A meta-analysis was not possible on the other outcomes, but two of three studies found significant improvements in total physical activity. In the study conducted by O’Dwyer et al. (2012), the intervention group increased their total physical activity compared to the control group by 5 minutes (95% CI: 3, 9) during the weekday and by 10 minutes (95% CI: 2, 18) during the weekend. Similarly, Goldfield et al. (2012) found a 19 minute (95% CI: 9, 30) increase in physical activity during an average preschool day, whereas the control group decreased their physical activity by 3 minutes (95% CI: -12, 6). Two studies included in the systematic review also looked at the effects of active play interventions on FMS, which both showed significant improvements in the intervention group compared to the control group (Adamo et al., 2016; Tortella et al., 2016). None of the eligible studies examined cognitive effects and one examined the effect on weight reduction, which did not find a significant intervention effect (Goldfield et al., 2012).

In summary, the systematic review was of high methodological quality and aimed to evaluate active play interventions with strong study designs. However, only four studies (representing five papers) were included and these were rated as low to moderate quality based on the Effective Public Health Practice Project (EPHPP) tool. Studies were typically rated weak for the 'selection bias', 'study design' and 'blinding' categories. More active play interventions are required and should be tested in high quality studies.

The present thesis evaluated a school based 'Active Play' intervention (known as Go2Play in Chapter 5) through two study designs: an initial pragmatic evaluation (Chapter 5) and a more robust feasibility cluster RCT (Chapter 6). The pragmatic evaluation was published in Preventive Medicine Reports in June 2017 and aimed to determine the effect of the intervention on school day physical activity, FMS and the proportion of time spent in MVPA during Active Play (Johnstone et al., 2017). The pragmatic evaluation had some important limitations (discussed in Chapter 5, section 6) which were addressed for the feasibility cluster RCT (Chapter 6). The feasibility cluster RCT was submitted to the Journal of Pilot and Feasibility Studies in September 2018 and aimed to determine the feasibility of the Active Play intervention and present preliminary findings on the effect of the intervention on school day physical activity levels, FMS, inhibition, and maths fluency.

The initial pragmatic evaluation found significant intervention effects on school day physical activity (sedentary, light and MVPA all $p < 0.01$) and FMS in the intervention group compared to the comparison group. However, the classes could not be randomly allocated to either the intervention or the comparison group and the study was not specifically powered to detect intervention effects, therefore, the findings should be interpreted with caution. Children spent a mean of 30.1% of the Active Play session in MVPA; however this was based using the playworkers reported session times to extract the data and may have included times when children were not engaging in Active Play.

Following from the pragmatic evaluation, a feasibility cluster RCT (Chapter 6) was conducted to determine if the intervention was feasible to implement in schools and provided preliminary findings on school day physical activity levels, FMS, inhibition, and maths fluency. The funders reduced the intervention to one session per week for 10-weeks. The intervention was found to be feasible; there was a relatively high consent rate of 66%, 100% school retention rate, only three pupils (as they moved school) were lost at follow-up. Data lost was minimal across outcomes, school day physical activity was the highest (14%; n =3 for the intervention group and n = 16 for the control group), which was predominately due to participants not wearing the monitor for the minimum wear time (as specified in Chapter 4). Compliance to the intervention was high as only four participants missed two sessions, and none missed more than two. The intervention was implemented to a high quality as highlighted in the findings from the playworker assessment tool (Chapter 6, section 5.2) and by the proportion of time spent in MVPA during Active Play. Participants spent on average 39.4% (facilitated =37.6%; free play =41.3%) of the session in MVPA, which was higher than the figure reported in the pragmatic evaluation (30.1%), which might be because the researcher was present at the session to note the start and end time to the nearest minute. One final finding for the process measures was the session duration time, which tended to be shorter by 10 minutes on average. This means that over the 10-week period, approximately 1-hour and 40 minutes of session time was lost.

Outcome data was also collected to determine if the intervention improved school day physical activity, FMS, inhibition and maths fluency; however, the study was not adequately powered to detect intervention effects. Therefore, findings presented are designed to report preliminary outcome results only. For school day physical activity, there were no significant differences between the intervention group and control group for the change in percent school time in sedentary behaviour (p =0.62; d =0.1) light physical activity (p =0.16; d =0.3) or MVPA (p =0.13; d =0.3). There were also no significant differences between the intervention group and control group for the change in GMQ score (p =0.06; d =0.4) and percentile (p =0.11; d =0.3). Two additional outcomes were also added to the feasibility cluster RCT trial: inhibition and maths fluency. Findings highlighted that there were no significant differences between the intervention group and control group for the change in inhibition (fish trials p =0.35; d =0.1 and arrow trials p =0.74; d =0.1) in the intervention group compared to the control group. Similarly, there were no significant differences between the intervention group and control group for the change in addition scores (p =0.13; d =0.3) or subtraction scores (p =0.61; d =0.1) in the intervention group compared to the control group.

Active play has been suggested to provide population wide gains on physical activity and MVPA given that it can be engaged in 365-days of the year and is often engaged in at a high intensity of physical activity (Janssen, 2014). Percent time spent in MVPA in the intervention group increased by 2.8% in the pragmatic evaluation, double the amount compared to the feasibility cluster RCT (+ 1.4%; 4.2 minutes/school day). This might be because the pragmatic evaluation involved two active play sessions per week compared to one session per week in the feasibility cluster RCT. Findings from the pragmatic evaluation and feasibility cluster RCT were lower than that reported in Goldfield et al. (2016), a study included in the systematic review (Chapter 3), which reported an increase of 11.8 minutes of school day MVPA in the intervention group. However, this was a longer study lasting 6-months in which care providers offered more active and outdoor play opportunities in childcare settings (Goldfield et al., 2016). The high proportion of time spent in MVPA during an Active Play session (39.4%, equivalent to 21 minutes on average) highlights that if the intervention was delivered twice or three times per week, then the intervention might be more promising in increasing school day physical activity, as well and inhibition and maths fluency, as these have been found to be particularly sensitive to MVPA (McMorris et al., 2009; Tomporowski et al., 2015).

A power calculation was conducted based on the school day MVPA outcome and added to Chapter 6, section 8 as supplementary material. If the intervention was to remain as one session per week, 19 schools in each arm would be required for a definitive RCT and 5 schools in each arm would be needed if the number of sessions were to increase to two times per week. A further consideration is the way school-based physical activity interventions are analysed. For the pragmatic evaluation and feasibility cluster RCT, and in line with other active play interventions, school day physical activity is averaged across the week to capture a 'typical school day'. However, this means that at follow-up the effect of the intervention is diluted (as it is averaged across the measurement days). In the feasibility cluster RCT, the proportion of time spent in MVPA during an Active Play session was 39.4% (21 minutes). This is a higher proportion of time spent in MVPA compared to other physical activity domains (Hollis et al., 2016; Martin et al., 2016; Reilly et al., 2016b) and, additionally, contributed to one third of their physical activity guidelines on the day they participated in the Active Play intervention. However, as there were no significant intervention effects on school day MVPA, it could result in assuming the intervention 'did not work'. Future studies may wish to consider a more transparent method of analysing physical activity outcomes of interventions, such as reporting both the average (as completed in the pragmatic evaluation and feasibility cluster RCT) and the day effect of the intervention or ensuring the MVPA content of the intervention is reported, depending on the intervention.

The final theme of the present thesis was the apparent low levels of FMS in the participants measured. It has been suggested that FMS competency increases the likelihood an individual will be more physically active throughout their life course (Stodden & Goodway, 2007). It is recommended, based on normative data from the TGMD-2 used to measure FMS, that children's GMQ score should be at least 100 to be classified as 'average' (Ulrich, 200). At follow-up in the pragmatic evaluation, the intervention group scored 93.3 (11.1) and the control group scored 90.1 (10.9) and for the feasibility cluster RCT, the intervention group scored 90.8 (10.5) and the control group scored 92.0 (10.1). Findings appear to be similar to other high-income countries. In a large study of Australian children and adolescents (*n* =6917, 7-14 years), Hardy et al. (2012) assessed seven FMS and found that the percentage of children and adolescents who had low competency in all FMS ranged from 46% in boys aged 14 years to 98% of girls aged 9 years. These poor FMS scores were lower in children from a low socioeconomic status (SES) (Hardy et al., 2012).

The FMS data collected during the pragmatic evaluation and feasibility cluster RCT is the only of its kind in Scotland and highlights the need to develop interventions aimed at improving children's FMS given that it has implications on physical activity. Encouraging more active play and the school-based Active Play intervention might be a novel and promising way of developing children's FMS, whilst possibly enhancing other elements of physical literacy such as confidence and motivation (Trembley et al., 2018).

In summary, active play is an under researched area and more active play interventions targeting different settings and different levels of the Socio-ecological Model for Health are required. The school-based Active Play intervention aimed to add to this evidence base and proved promising in terms of the proportion of time spent in MVPA during a typical session. However, this is an example of another school-based intervention when, as outlined in Chapter 1 of this thesis, one of the main arguments for active play as an intervention is it that it can be implemented on 365 days a year potentially, and is not restricted to school days. Although schools provide a good opportunity to promote physical activity and reach a large number of children, in particular, those who might not otherwise engage in physical activity in other settings, more thought should be given on how a school setting and community setting could work together (Dobbins et al., 2009; Story et al., 2009). One suggestion from the final paper (Chapter 7) in the present thesis, is to collaborate with schools to create ‘active play’ hubs where they can provide more active play opportunities during school hours and implement a ‘hybrid’ version of the Active Play intervention. This may involve initially working with a number of classes in the school to deliver the programme twice per week over a 5-10 week period, the intervention would then taper off during school hours and be offered as an after-school club. This provides a greater opportunity to offer more sessions per week and to have more influence over children’s physical activity levels outside of school hours. This hybrid model benefits from engaging with schools to upskill teachers and work with children who would not normally attend afterschool clubs. Furthermore, the initial intervention during school hours would be used to recruit children to attend the after-school intervention with the assumption that this would increase the number of children attending. Thought also needs to be given to incorporating a parental component given that there is evidence of parents limiting their child’s active play (Scottish Household Survey, 2015; Veitch et al., 2006). Finally, as schools are increasingly open during summer holidays in many areas of Scotland, this might also provide a useful time to offer the Active Play intervention, particularly as evidence has suggested children’s fitness and physical activity levels often decline during this period (Carrel et al., 2007).

3. Thesis Strengths and Limitations

3.3 Strengths

The present thesis aimed to look at a novel research area. As Chapter 3 (the systematic review) indicates, there is limited research into the potential of active play interventions on improving children’s physical activity levels, MVPA, FMS, cognition and attainment. The three unique publications (the systematic review, pragmatic evaluation and feasibility cluster RCT) aimed to contribute and enhance the small body of research into the effect of active play interventions on these outcomes.

The systematic review implemented strong and robust methodology, which was highlighted by the fact it was published in a well-regarded journal (BMC Public Health). The pragmatic evaluation had some limitations (for example, the intervention group and comparison group could not be randomised), but the intervention proved promising. Furthermore, many of these limitations were addressed in the feasibility cluster RCT. The feasibility cluster RCT was of a strong design in which eight schools were recruited and randomly assigned to the intervention or waiting-list control. For this study, there was a high pupil consent rate (66%), school retention rate (100%), and the loss of only three pupils (as they moved school) at follow-up. Compliance to the outcome measures was also high; 14% (*n* =3 for the intervention group and *n* =16 for the control group) of data were lost for the school day physical activity outcome, which was due to participants not wearing the monitor for the minimum wear time. Both the pragmatic evaluation and feasibility cluster RCT used valid and reliable methods to assess physical activity and FMS.

Finally, the collaborative nature of the Active Play intervention was a strength despite, at times, resulting in decisions being made that were out of the research teams' control. Researching a real-world intervention and working collaboratively with external organisations who are delivering active play enhances knowledge exchange opportunities that might not happen otherwise.

In summary, with the limited time and resources, the present thesis implemented strong designs in each of the three studies and used valid and reliable methods to measure outcomes.

3.4 Limitations

Despite important strengths, the present thesis also has some important limitations that need to be highlighted. Firstly, the systematic review only included randomised study designs, which limited the number of eligible studies included (*n* =4). The reason for only including randomised studies was so that only strong designs (i.e. studies with low risk of bias) were included; however, according to the EPHPP tool three of the four eligible studies were rated as 'weak' quality and one was rated 'moderate'. They were typically rated weak for the 'selection bias', 'study design' and 'blinding' categories, highlighting the need to enhance the quality of these categories in future RCTs.

The pragmatic evaluation had a number of limitations; firstly, the lead researcher (AJ) could not control when the intervention started, meaning that FMS was assessed after the intervention began. The play charities also decided how many sessions each school received, which resulted in schools receiving either one or two sessions per week. Finally, the schools were recruited by the charities, which meant that they could not be randomised to an intervention and control group and participants in the comparison group were conveniently sampled from two schools already participating in the Active Play intervention.

These limitations in the pragmatic evaluation were addressed for the feasibility cluster RCT, but this study also had some important limitations. Firstly, the lead researcher (AJ) could not be blinded to the group allocation though this was unlikely to influence most outcome measures apart from FMS. Standardised procedures were followed for assessing FMS at baseline and follow-up, but human error or bias may have occurred. This could have been corrected by filming the FMS test or ensuring researchers were blinded to the group allocation. Generalisability may also be limited as most schools had a low SES (66% of the schools had 50% or more children living in the 20% most deprived areas), which is the aim of the funder to work with the most deprived schools. A future definitive RCT should recruit a wider cross section of schools. Lastly, additional outcomes such as those that would assess potential social and emotional benefits could not be added due to time and resources. Greater insights into the process of the intervention and the perceptions of the intervention from key stakeholders (teachers, play workers, children and parents) would also have been possible if qualitative work had been undertaken, but that was beyond the scope of this thesis.

For both the pragmatic evaluation and feasibility cluster RCT, only school day physical activity could be measured due to constraints on time and resources. It might be that participating in the Active Play intervention increased physical activity beyond the school day and, therefore, a future definitive trial should consider measuring the whole day.

In summary, most limitations were due to a lack of resource (unfunded other that AJs stipend) and the nature of many of the decisions regarding the pragmatic evaluation and feasibility cluster RCT being out of my control. For example, in the feasibility cluster RCT, it was advised to the funders that schools should be receiving two sessions per week and ideally a 2 session/week x10 week Active Play intervention was what would have been evaluated if the decision could be made by the lead researcher.

4. Recommendations

4.3 Policy Implications

In 2013, the Scottish Government published the first policy document specifically related to play, which highlighted the importance of promoting play opportunities at home, in school and in the community (The Scottish Government, 2013). The present thesis has added to the evidence base for active play interventions, in particular, a school-based intervention that is delivered in Scotland. Findings suggest that the intervention might be a promising way of increasing children's physical activity levels, particularly MVPA (given the MVPA content of the sessions) if more sessions are delivered per week. These findings also align with the Active Scotland's Outcome Framework (Appendix D) which presents six key outcomes related to increasing the population's physical activity. The outcome most related to active play is, 'develop physical confidence and competence from the earliest age' (Scottish Government, 2017). Evidence from the pragmatic evaluation and feasibility RCT suggests that participating in the active play intervention may improve children's FMS (Chapter 5 and 6). The importance of active play on achieving this Active Scotland Outcome and increasing physical activity levels was recently detailed in the Scottish Government's Physical Activity Delivery Plan (Scottish Government, 2018).

In a Global context, the WHO published their Ending Childhood Obesity report (2016) which recommended that addressing low levels of MVPA is central to improving the levels of overweight and obesity. Evidence presented in this thesis has suggested that active play is a neglected domain of physical activity that may have the greatest potential for increasing children's MVPA and physical activity levels. The importance of active play in increasing children's physical activity levels was also reinforced in the WHO's (2018) Global Action Plan on Physical Activity which provided a range of relevant recommendations to ranging from improving access, providing interventions across multiple settings that target parents and enhancing school-based programmes.

In summary, the active play research conducted in the present thesis contributes to national and global policy and should be utilised to inform more active play opportunities.

4.4 Future Research

During the process of conducting the research for the present thesis, gaps in the evidence base for active play were identified, which researchers may wish to consider for future research.

Firstly, when conducting the systematic review, it became apparent that the definition of active play (presented throughout the thesis) might be problematic. Key elements of the definition of active play used in this thesis are 'free' and 'unstructured'; however, many of the eligible studies in the systematic review and the Active Play intervention evaluated in the present thesis have varying levels of adult involvement and so were structured to some degree. Adult involvement may be required to increase active play opportunities, but researchers should ensure that their interventions fit with key elements of the definition. It is recommended that a more comprehensive definition of active play is developed with the possibility of creating related sub-definitions such as, 'facilitated active play'.

Secondly, more active play interventions should be developed and evaluated in a range of settings and target multiple layers of the Socio-ecological Model for Health. Schools could be ‘active play’ hubs where interventions are co delivered in both the school setting and community (after school hours using school grounds) and any possible intervention should consider a parental component.

Finally, a future definitive cluster RCT of the school-based Active Play intervention should be delivered at a minimum of two sessions per week for 10-weeks, with more frequent delivery if possible, to enhance the effect of the intervention or be improved by following recommendations detailed in Chapter 7. Additional outcomes, such as social and emotional benefits should also be added to determine the extent of which the school based Active Play intervention enhances children’s wider health and wellbeing.

5. Conclusions

This thesis aimed to determine the potential of active play interventions on improving children’s physical activity levels, FMS and additional outcomes. The studies presented in the thesis have achieved this and, additionally, have contributed and enhanced the small evidence base on active play interventions.

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Appendix A: Copy of the One Minute Basic Number Facts Test (1995)

One Minute Tests of Basic Number Facts

Addition	Subtraction
2 + 1 =	2 – 1 =
1 + 4 =	5 – 1 =
2 + 2 =	3 – 2 =
4 + 2 =	5 – 3 =
3 + 4 =	6 – 2 =
2 + 3 =	2 – 2 =
5 + 2 =	6 – 4 =
4 + 5 =	7 – 2 =
3 + 5 =	6 – 1 =
2 + 8 =	7 – 3 =
4 + 4 =	8 – 2 =
2 + 5 =	7 – 5 =
3 + 3 =	6 – 6 =
1 + 8 =	8 – 3 =
6 + 4 =	7 – 4 =
3 + 7 =	9 – 3 =
6 + 3 =	8 – 5 =
5 + 5 =	9 – 5 =
1 + 5 =	9 – 9 =
6 + 2 =	10 – 4 =
2 + 7 =	9 – 4 =
4 + 6 =	10 – 3 =
5 + 7 =	11 – 2 =
8 + 3 =	10 – 6 =
4 + 9 =	12 – 3 =
7 + 6 =	12 – 6 =
6 + 6 =	15 – 5 =
8 + 6 =	11 – 5 =
9 + 8 =	13 – 3 =
6 + 9 =	12 – 9 =
8 + 7 =	14 – 6 =
9 + 5 =	17 – 8 =
9 + 7 =	16 – 9 =

Appendix B: Physical activity diary

Teacher Handbook

Using the Physical Activity Monitors

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1. INTRODUCTION

1.1 Purpose of the Study

The health benefits of being physically active are vast, however levels of physical activity in most Scottish children are low. Children are now spending more time in recreational screen time than playing, therefore play has the potential to increase physical activity levels in Scottish children. One promising way to improve physical activity levels is to involve children in organised active play programmes in schools, but it isn't yet clear whether such play programmes are effective.

The aim of the study is to find whether the active play programme:

a. Increases children's physical activity levels.
b. Improves children's fundamental movement skills
c. Improves children's learning ability and attainment

1.2 Purpose of this Handbook

During August and September 2017, children (with consent) will be asked to wear an activity monitor attached to an elastic waist belt for five school days. They will then be asked to wear the activity monitors again approximately 9-weeks later to see if there have been any changes in the children's physical activity levels.

The purpose of this handbook is to ensure that all children have the correct monitors and the researcher builds an understanding of what the children are doing during school hours.

2. ACTIVITY MONITORS

2.1 Wearing the activity monitors

Children should put on the activity monitors, with the support of the teacher and researcher during registration and removed at the end of the school day. The following steps should be followed;

Fig.1

1. Each child will be assigned a specific monitor (denoted by a number displayed on the monitor) which **must** be the same each day. The monitor record sheet on the following page will help you with this.
2. The monitor **must** be worn around the waist, on or slightly above the **right** hip. It can either be under or on top of their clothes (whichever the child is most comfortable with), and the screw on the monitor should be at the top (see fig.1).
3. The monitor should remain on the child for the remainder of the day unless they are; sleeping, showering, swimming.
4. Pupils should continue to wear the monitor during PE unless they are participating in swimming.
5. If the child does not wish to wear the monitor then please remove it and score their name off the register on the following page.
6. At the end of each day, please place the monitors in the box provided and lock in a cupboard for security (the monitors are expensive).
7. If you have any questions regarding these monitors; (a) check the frequently asked questions page or (b) contact Avril via email or telephone.

2.2 Monitor Record

While the children are wearing the monitors it is vital that we know (a) what time they put them on in the morning, (b) when they take them off before they leave school, (c) if they were absent and (d) if there were any other reasons why the monitors had to be removed.

Below is a monitor record sheet which should cover all aforementioned areas. Please write the time in ‘hrs:mins’, to the nearest 5 minutes (e.g. 09:35)

<u>Monitor Record Sheet</u>

		Monday		Tuesday		Wednesday		Thursday		Friday	
Pupil Name	**Monitor No**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**

		Monday		Tuesday		Wednesday		Thursday		Friday	
Pupil Name	**Monitor No**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**	**Start Time**	**Finish Time**

3. ADDITIONAL INFORMATION

3.1 Break/ Lunch Times

For the research it is really useful to know when children have their break and lunch times. Additional comments can be used if there was any bad weather which prevented children from going outside or any other relevant information.

		Break		Lunch	
Date	**Day**	**Finish Time**	**Start Time**	**Start Time**	**Finish Time**
e.g. 21/08/17	***Monday***	***10:30***	***10:45***	***12:15***	***13:00***
	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				

3.2 Physical Education and Other Activities

Use space provided to detail children's PE classes.

PE				
Date	**Day**	**Start Time**	**Finish Time**	**Additional Comments**
e.g. 21/08/17	***Monday***	***11:00***	***12:00***	
	Monday			
	Tuesday			
	Wednesday			
	Thursday			
	Friday			

It is also important that we know of anything else that may be un-typical of a school day. For example, were there any school trips, did children receive a reward which allowed them to spend time out of class? Please use the space provided to add any relevant information.

Activity					
Date	**Day**	**Start Time**	**Finish Time**	**Details**	**Additional Comments**
	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				

3.3 Security

Please ensure monitors are kept in the box provided and locked in a cupboard. The monitors are durable and should not break, however, if any monitors break while a child is wearing them, please let us know, but do not penalise children for losing or breaking a monitor! These things are sometimes unavoidable. If the monitors unscrew at the top then use a coin or fingers to twist back into place.

4. FREQUENTLY ASKED QUESTIONS

Q. How do I fix the screw at the top that has come loose?
A. *The screw prevents water from entering the monitor, it should be easily twisted into place with your fingers, a small coin or a screwdriver if available.*

Q. What should I do if a pupil has accidentally broken a monitor?
A. *The monitors are robust and only in rare circumstances will they break. If they do break then remove it from the child and place in the box. Please contact Avril so she can make a decision as to whether the child can get a new one.*

Q. It is taking a lot of time to get the monitors on in the morning
A. *Ask pupils to put the monitor on themselves and you can check to see if they are fitted correctly. If this problem persists, contact the researcher ASAP to arrange further support.*

Q. Should I alter my class's behaviour so they are more active?
A. *No. Please continue to work in the same manner as you would if the children were not wearing the monitors*

If there are any additional questions the please contact the researcher.

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Appendix C: Assessing ability to deliver Active Play

Developed by Agile CIC

Team/individual skills and attributes

	1	2	3	4	5	Comment
Leadership (with staff team and/or participants)						
Confidence						
Communication						
Engagement						
Enthusiasm/ energy						
Physical literacy						

Knowledge and Experience

	1	2	3	4	5	Comment
Understands the concept of free play						
Demonstrates experience of leading play sessions						
Understands the role of FMS/physical literacy in supporting children to be more active						
Demonstrates experience of leading physical activity sessions						

Putting the training into practice

	1	2	3	4	5	Comment
Demonstrates evidence of using the planning tool						
Plans appropriate activities to deliver the FMS (which demonstrates understanding of the FMS)						
Plans are appropriate for the delivery setting						
Plans appropriate to age group						
Has an appropriate session plan which follows the guideline (skills/free play split)						

Delivery

	1	2	3	4	5	Comment
Session incorporates target FMS						
Session is fun						
Session is inclusive						
Session is active						
Team can respond to/change delivery format to respond to the children and/or environment						

Appendix D: Active Scotland Outcomes Framework

As published by the Scottish Government (2017)