Evaluating the role of specialist FMS instruction to support Irish school children's fundamental movement skill development

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Abstract

Background: Fundamental movement skills (FMS) are an important precursor to enjoyment of, and regular engagement in lifelong physical activity (PA). These skills ideally should be learned between the ages of 3- and 8-years old. In Irish primary schools, Physical Education (PE) is typically taught by non-specialist teachers who may not feel confident to deliver all aspects of the PE curriculum equally. This may be a missed opportunity to support children's FMS development.

Purpose: This research aimed to determine if specialist FMS instruction should be incorporated into primary PE lessons to support Irish school children's FMS development.

Methods: Study one established FMS proficiency levels among 414 school children from the midlands of Ireland. Study 2 involved the design, implementation and evaluation of an 8-week school-based intervention programme focusing on specialist FMS instruction. A cluster cross-over design study was used to examine the immediate and long-term effectiveness of the intervention on FMS proficiency levels of 255 1st and 2nd class children. Finally, a teacher questionnaire was designed to examine teachers' perceptions, attitudes and perceived confidence to teach PE. This study aimed to identify how the quality of PE lessons could be improved to assist children in learning a broad range of FMS during the primary school years.

Findings: Less than 40% of children achieved mastery across 15 different skills, with males performing significantly better than females in ball skills and non-overweight children outperforming overweight/obese children. The intervention programme led to significant improvements in locomotor subtest, ball skills subtest and overall FMS scores immediately following the intervention, and FMS scores remained significantly higher than baseline values at 13-month follow-up. Mainstream teachers in Ireland have positive attitudes towards PE but most feel that their pre-service training did not adequately prepare them to teach PE. However, teachers who completed in-service training with an FMS focus reported higher levels of perceived confidence to teach PE, compared to teachers who completed in-service training without an FMS focus.

Conclusion: Irish children are failing to master a broad range of FMS, however, engaging in lessons delivered by professionals with specialist FMS content and pedagogical knowledge may support children's FMS development.

Authors Declaration

I hereby declare that the material included in this thesis for the award of Doctor of Philosophy is my own work, and that I have exercised care to ensure the work is original and does not to the best of my knowledge breach any law of copyright. Where appropriate, credit has been given where reference has been made to the work of others. This work has not been submitted to any other higher education institution or for any other award with this institution.

Signed ___________________ (Candidate)   **Date** ___________________

Lisa Kelly

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List of abbreviations

BMI	Body Mass Index
BOT-2	Bruininks-Oseretsky Test of Motor Proficiency-2
CI	Confidence Interval
CRF	Cardiorespiratory Fitness
CSPPA	Children's Sports Participation and Physical Activity
FMS	Fundamental Movement Skills
ICC	Intraclass Correlation
KTK	Körperkoordinationtest für Kinder
LM	Locomotor
MOT 4-6	Motoriktest für Vier- bis Sechjärige Kinder
Movement-ABC	Movement Assessment Battery for Children
OC	Object-Control
PA	Physical Activity
PASS	Physical Activity and Skills Study
PDMS	Peabody Development Scales
PDST	Professional Development Service for Teachers
POMP	Percentage of Maximum Possible
PE	Physical Education
SD	Standard Deviation
SPANS	Schools Physical Activity and Nutrition Survey
TGMD	Test of Gross Motor Development

Glossary of terms

Fundamental Movement Skills: These are described as the basic observable patterns of movement that create a foundation for the development of more advanced skills required for activities of daily living and both recreational and competitive forms of physical activity. They can be categorised into locomotor, object-control or stability skills (Gallahue et al., 2012).

Physical Activity: Bodily movements produced by skeletal muscles that require energy expenditure above resting levels (WHO, 2015)

Physical Education: A subject in the Irish primary school curriculum that aims to contribute to the holistic development of the child through the medium of athletics, dance, aquatics, outdoor and adventure, games and gymnastics (Department of Education and Skills, 1999).

Test of Gross Motor Development: A process-oriented assessment tool for measuring FMS proficiency levels by assigning scores based on the presence or absence of pre-defined behavioural components for each skill (Ulrich, 2000).

Mastery, Near Mastery, Poor Mastery: When assessing FMS, mastery is assigned when all skill criteria are correctly performed over two trials. Near mastery is assigned when all but one skill criteria are correctly performed over two trials and poor mastery is given when more than one skill criteria are incorrect or absent over two trials (Van Beurden et al., 2002)

Moderate to Vigorous Physical Activity: Physical activity that requires a moderate to a large amount of effort that increases heart rate and breathing rate. Moderate intensity physical activity can include brisk walking and dancing whilst running, heavy lifting and team sports are examples of vigorous intensity physical activity (WHO, 2010).

Sedentary Behaviour: Any waking behaviour that expends up to 1.5 metabolic equivalent units of energy, is classified as sedentary behaviour. Examples include sitting, lying down and screen-based entertainment (Pate, O'Neill and Lobelo, 2008, p174).

List of publications

Peer-reviewed journal articles

Kelly, L., O'Connor, S., Harrison, A. J. and Ní Chéilleachair, N. J. (2019). Does fundamental movement skill proficiency vary by sex, class group or weight status? Evidence from an Irish primary school setting. *Journal of Sports Sciences*, 37(9), 1055-1063.

Kelly, L., O'Connor, S., Harrison, A. J. and Ní Chéilleachair, N. J. (2020). Effects of an 8-week school-based intervention programme on Irish school children's fundamental movement skills. *Physical Education and Sport Pedagogy*, (Accepted September 2020).

Oral presentations

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2016). Fundamental movement skills among primary school children: Is there a gender divide? FSEM Thirteenth Annual Scientific Conference 2016. Royal College of Surgeons in Ireland. Dublin. September 16th. (Runner-up award: best oral presentation)

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2016). Fundamental movement skill proficiency among female primary school children. FSEM Thirteenth Annual Scientific Conference 2016. Royal College of Surgeons in Ireland. Dublin. September 17th

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2019). The effectiveness of an 8-week fundamental movement skills (FMS) intervention programme on FMS proficiency levels. All Ireland Postgraduate Conference in Sports Sciences, Physical Activity and Physical Education 2019. Athlone Institute of Technology. May 10th, 2019.

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2019). Immediate and long-term effects of a fundamental movement skills intervention: A cluster crossover study with 13-month follow-up. Healthy and active children: Lifespan motor development science and applications Congress. 2019. Verona, September 11th-14th.

Posters

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2016). An investigation into fundamental movement skill proficiency among Irish primary school children. All Ireland Postgraduate Conference in Sports Sciences, Physical Activity and Physical Education 2016. Waterford Institute of Technology.

Kelly, L., O'Connor, S., Harrison, A. and Ní Chéilleachair, N. (2018). Do Irish primary school children acquire a proficient level of FMS throughout the primary school years? Movement and Skill Acquisition Ireland Conference 2018. Cork Institute of Technology. (Award: best poster presentation)

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Chapter 1: Introduction

1.1 Background

Evidence from the national longitudinal Growing Up in Ireland study suggests an increasing trend in the prevalence of overweight and obesity over time. At age five, 20% of children were classified as overweight or obese which increased to 22% at age 9 (Growing Up in Ireland Study Team, 2018). In a separate Cohort, levels of overweight and obesity remained stable between the ages of 9- and 17/18-years-old (27%), however, increased to 36% between the age of 17/18 and 20-years-old (Growing Up in Ireland Study Team, 2019). Childhood overweight and obesity results in an estimated lifetime cost of €4.6 billion (Perry et al., 2017) in Ireland which could be reduced by €270 million if BMI was reduced by 1 percent (Jennings et al., 2018). Preventative measures to reduce the risk of becoming overweight or obese should be prioritised as prevention is more cost-effective than treating the issue (Jennings et al., 2018; Gill, 1997). One of many important modifiable factors is physical activity levels.

The most recent Children's Sports Participation and Physical Activity (CSPPA) Study (Woods et al., 2018) found that only 17% and 10% of Irish primary and post-primary pupils are meeting the recommended daily physical activity (PA) guidelines of 60-minutes moderate to vigorous PA per day respectively, a decline of 2% for both groups compared to 2010 (Woods et al., 2010). High levels of physical inactivity place children at increased risk of developing preventable obesity-related diseases as they get older. In Ireland, physical inactivity is accountable for 9% of the burden of coronary heart disease, 11% of type 2 diabetes, 15% of breast cancer and 16% of colon cancer (Lee et al., 2012), whilst engaging in regular PA and limiting screen-based behaviours is associated with fewer health complaints among school-aged children (Keane et al., 2017). Evidence suggests that health-related behaviours learned in childhood transfer to adulthood (Rudolf, 2009; Kelder et al., 1994), thus promoting healthy habits during the early years should be prioritised.

Biological (e.g. age, sex), demographic (e.g. socio-economic status, ethnicity) and socio-cultural (e.g. parental attitudes/behaviours, rules) factors contribute to the rising rates of sedentary behaviour and physical inactivity among children (British Heart Foundation, 2017; British Heart Foundation National Centre, 2012). Individuals who fail to meet the recommended daily physical activity guidelines are classed as physically inactive (Tremblay et al., 2017), whilst sedentary behaviour is defined as activities performed during waking hours that expend up to 1.5 metabolic equivalent units of energy.

Examples of sedentary behaviour include sitting, lying down and screen-based entertainment (Tremblay et al., 2017). The combination of physical inactivity and sedentary behaviours limit children's opportunities to develop the basic skills needed for participation in PA, known as fundamental movement skills (FMS). The role of FMS as a potential precursor to lifelong health and wellbeing, has gained considerable attention in recent years (Stodden et al., 2008; Robinson et al., 2015).

1.2 Significance of FMS

FMS are described as the basic observable patterns of movement that create a foundation for the development of more advanced movement skills required for daily living, PA, recreational and competitive sport (Gallahue et al., 2012). FMS can be divided into three categories, including locomotor, object-control and stability skills. Locomotor skills are those that allow movement from one location to another (Ulrich, 2000), including running, jumping and skipping. Object-control skills require the use of a body part or implement to send or receive objects (Ulrich, 2000) and include skills like catching, throwing, striking and dribbling. Stability skills include bending, twisting, rolling and single leg stance, whereby postural control is needed to maintain both static and dynamic balance (Gallahue et al., 2012; Department of Education Victoria, 1996).

Evidence suggests that proficiency in FMS can contribute to many physical, social and psychological health benefits (Tsangaridou 2012; Gallahue et al., 2012; Catuzzo et al. 2016; Lubans et al. 2010), including higher PA levels (Holfelder and Schott 2014; Barnett et al., 2008; Mazzardo et al., 2008; Laukkanen et al., 2014), improved cardiorespiratory fitness (Hardy et al., 2012; Catuzzo et al., 2016), better cognitive function (Draper et al. 2012; van der Fels, et al. 2015), increased physical self-perceptions (Babic et al., 2014) and a greater likelihood of maintaining a healthy weight status (Slotte et al., 2017; Bryant et al., 2014; Southall et al., 2004; O'Brien et al., 2016a; Okely et al., 2004; Catuzzo et al. 2016). Children have the potential to master most FMS by the age of 6 (Gallahue et al., 2012), however, regular practice opportunities, combined with quality instruction and feedback, are essential to acquiring proficiency. Failure to utilise the sensitive learning period between the ages of 3- and 8-years-old can make it more difficult to achieve FMS mastery later in life (Gallahue et al., 2012; Clark, 2005). For that reason, the early primary school years are an optimal time to facilitate FMS development.

Process-oriented assessments are useful tools to monitor children's FMS proficiency and development (Hulteen et al. In press; Logan et al. 2018). Skill performances are observed and scored based on the presence or absence of pre-determined criteria to assess movement quality (i.e. the throwing technique) rather than movement outcome (i.e. how far one can throw) (Ulrich 2000; Bardid et al. 2019). In addition to raw scores, categorical variables can be created to classify skill performances by mastery level (i.e. mastery/near mastery or poor mastery) (Hands 2002). To remain consistent with national literature, the definition of mastery used by O'Brien et al. (2016b) is used for the purpose of this thesis. Mastery is achieved when all skill criteria are correctly performed over two trials, near mastery is achieved when all but one skill criteria are correctly performed over two trials and anything else is classified as poor mastery. Children who achieved either mastery or near mastery are classified as having advanced skill proficiency indicating they had difficulty with only one skill criteria at most.

O'Brien et al. (2016b) was the first to highlight issues with FMS development within an Irish context. Only 11% of 12- to 14-year-old Irish adolescents achieved advanced skill proficiency in a battery test of nine basic FMS, which was supported more recently by Lester et al. (2017). Within the Irish primary school setting, the proportion of 6- and 10-year-old children from the Southwest of Ireland achieving mastery across 12 skills, ranged from 12.3 to 79.4% (Bolger et al. 2018), while Behan et al. (2019) reported mastery/near mastery levels ranging from 16% to 75.3% among a sample of 2098 5- to 12-year-old primary school children. These figures indicate that many Irish school children are performing well below their developmental potential and are transitioning to adolescence without prior acquisition of basic movement skill proficiency. Considering children with higher perceived and actual skill competence are less likely to drop out of sport and PA compared to those who are less skilful (Garn and Cothran 2006), methods to improve FMS proficiency levels are of utmost importance. Children from lower socioeconomic backgrounds often display significantly lower FMS competence than children from higher socioeconomic backgrounds (Hardy et al., 2015; Hardy et al., 2012; Morley et al., 2015) and are less likely to engage in non-school-based sport and PA (Woods et al., 2018; 2010). For some children, school PE may be their only opportunity to partake in PA. Therefore, PE lesson quality should be maximised to ensure all children are afforded an opportunity to develop their FMS.

1.3 Potential to improve FMS development through primary school PE lessons

To date only one study has looked at the effectiveness of a school-based intervention programme to improve FMS proficiency levels in an Irish primary school context. Bolger et al., (2019) implemented a multi-component intervention over a full academic year, where the intervention group significantly improved their locomotor, object-control and overall FMS scores at post-test. However, this type of intervention requires co-operation between schools, teachers, parents, children and researchers and may be overwhelming for some schools to implement. Many multi-component interventions have been effective (Bolger et al., 2019; Cohen et al., 2015; Tompsett et al., 2017; Lai et al., 2014), however, it is difficult to decipher the most important elements of the programmes (Lai et al., 2014). There is evidence to suggest that quality FMS instruction and feedback (Wick et al., 2017) and emphasising self-improvement rather than competition and winning can also provide significant improvements in FMS proficiency (Wick et al., 2017; Robinson and Goodway 2009; Valentini and Rudishill, 2004). However, in Ireland, over 40% of PE curriculum time is spent on the games strand, which can often overemphasise competitiveness and neglect basic skill development (Woods et al. 2018; 2010). This favours only a small minority of children who have already mastered the basic FMS required for the games. In such circumstances, less skilled children may disengage from PE lessons and miss out on valuable opportunities to develop a broad range of FMS.

One in ten Irish children stop playing regular sports such as GAA, basketball and soccer as they transition from primary to second level education (Lunn et al. 2013) which is often attributed to poor skill competence (Woods et al., 2010). PE teachers must be mindful of interindividual differences, but this can be difficult due to large curriculum demands and limited specialist knowledge for teaching PE and more specifically FMS (Petrie, 2010; Fletcher and Mandigo, 2012). Teachers act as role models in PE and their attitudes and perceptions can influence children's motivation to take part in PE and PA (Bryan and Solmon, 2012; Xiang et al., 2003). However, having positive attitudes towards PE is only beneficial where the teachers have the subsequent confidence to use various teaching strategies and pedagogical practices to deliver all aspects of the PE curriculum in a way that is developmentally appropriate and suited to the individual needs of each child in a class (Morgan and Hansen, 2007; Elliot et al., 2013). Whilst PE specialists may have a greater depth of content and pedagogical knowledge for teaching PE (Davis et al., 2005; Gordon and Inder, 2000), generalist teachers will have a better understanding of the specific needs of individual children in their class and an ability to integrate cross curricular learning into PE lessons (Coulter et al., 2009; Fletcher and Mandigo, 2012). Thus, ongoing debate exists with regard to how specialist PE teaching could be integrated into the Irish primary school system.

The Youth Sport Trust in the UK is a charity that assists schools in making sustainable improvements to their provision of PE and school sport, and to wisely spend their share of the 320 million pounds in funding provided through the UK governments PE and Sport premium. Upskilling teachers and enhancing their confidence and competence to teach high quality PE is a key focus. One example is the provision of the TOP Start professional development programme, formally called Start to Move (Morely et al., 2016), that educates teachers in how to adopt a movement-based approach when teaching PE. Since the implementation of Top Start in 2011, teacher confidence to teach PE increased by 30%, whilst 4- to 7-year-old children demonstrated a 10% average increase in movement competence with the lowest skilled children improving by up to 22%. In addition, an 11% increase in moderate to vigorous PA and a 9% decrease in sedentary behaviours were observed (Morley et al., 2016). However, caution is warranted when interpreting these results as improvements in FMS proficiency and PA levels were not compared to a control group. Nonetheless, after two years of PE lessons from a trained teacher, 60% of the children associated enjoyment of PE with FMS, whereas two years previous children regarded the opportunity to spent time with friends as the main source of enjoyment in PE. This suggests that FMS-based PE lessons may enhance children's feelings of positivity and enjoyment in PE but also that these improvements were likely influenced by the teachers improved confidence to teach PE. Therefore, creating these early positive experiences around PE may have important implications for children's long-term motivation to take part in PA and sport.

Efforts are being made to upskill Irish primary school teachers on ways to incorporate FMS into their PE curriculum through the Move Well Move Often teacher seminars (PDST, 2017). The initiative introduced in 2017, involves three seminars focused on locomotor skills, stability skills and manipulative skills (Intouch 2017). Teachers learn how to identify children's skill level and how to differentiate lessons, so they are developmentally appropriate for individual children within their class. The resources are designed to complement rather than replace the current primary PE curriculum. However, there is currently no information to determine if upskilling Irish primary school teachers in the area of FMS has any impact on their confidence or attitudes towards teaching PE.

Overall, there is a distinct paucity of research looking at effective methods to facilitate FMS development within the Irish primary school setting. This research will address this gap in the literature by firstly, identifying current levels of FMS proficiency among Irish primary school children and secondly, using this information to develop, implement and evaluate an FMS intervention programme that focuses on specialist FMS instruction. The final study will concentrate on Irish primary school teachers' perceptions, attitudes and perceived confidence to teach PE, with the aim of identifying potential factors that could be targeted to enhance the quality of PE lessons.

1.4 Aims and objectives of the research

The primary aim of this research is to determine how FMS proficiency levels of Irish primary school children could be improved whilst attending primary school.

1.4.1 Study 1 aim, objectives and hypothesis

Aim

To establish if Irish school children, from senior infants (Year 2) to 5th class (Year 7) are proficient in 15 different FMS.

Objectives

To examine differences in FMS proficiency levels by sex and weight status.

To identify if older children have better FMS proficiency levels than younger children.

Hypothesis

Irish school children will demonstrate poor proficiency across 15 FMS and significant differences will be observed between males and females and between overweight and non-overweight children.

1.4.2 Study 2 aim, objectives and hypothesis

Aim

To design, implement and evaluate the effectiveness of an 8-week FMS intervention programme that focuses on specialist FMS instruction.

Objectives

To investigate if a specialist-led intervention, delivered using a mastery-motivational climate, can improve children's FMS proficiency levels regardless of sex or weight-status.

To identify if any improvements observed following the 8-week intervention can be maintained 13 months post-intervention.

Hypothesis

An 8-week intervention delivered by an individual with specialist FMS knowledge and an understanding of mastery-motivational theory will lead to significant improvements in school children's FMS proficiency levels regardless of sex or weight-status.

1.4.3 Study 3 aim, objectives and hypothesis

Aim

To examine Irish primary school teachers' perceptions, attitudes and perceived confidence to teach PE.

Objectives

To identify if teacher gender influences perceptions, attitudes and perceived confidence to teach PE.

To ascertain the strand areas that teachers feel most and least confident to teach.

To examine if teachers who completed FMS based in-service training feel more confident to teach PE compared to teachers who completed non-FMS based in-service training.

To determine what the main barriers to the delivery of PE in Irish primary schools are.

Hypothesis

Irish primary school teachers will report mostly positive perceptions and attitudes towards teaching PE but may not feel confident to teach all strand areas of the PE curriculum equally.

1.5 Structure of the thesis

The thesis is organised into six chapters. Following this introduction (**Chapter one**) which provides the rationale for the research and outlines the main aims, objectives and hypothesis of the three main studies, **Chapter two** critically appraises the relevant literature pertaining to FMS and associated topics. These topics include motor development, motor learning theories, practice conditions, benefits associated with FMS proficiency, previous school-based intervention programmes, PE provision at primary school level and the teacher-related factors that may influence the quality of PE lessons.

Chapter three, which has been published in the peer reviewed Journal of Sports Sciences, presents the findings from the first study looking at FMS proficiency levels of Irish school children. The main finding highlighted that Irish school children displayed poor proficiency across a range of 15 FMS, and that females and overweight children were lagging behind their male and non-overweight counterparts, respectively. The findings necessitated the development of a suitable intervention programme that would support FMS development among children with varying characteristics, interests and abilities.

Chapter four has been accepted to the Physical Education and Sport Pedagogy journal. This chapter describes the outcomes from an 8-week school-based, specialist-led intervention programme that aimed to support children's FMS development. The delivery of the intervention was guided by the TARGET principles to create a mastery-motivational climate so as to ensure that children were placed at the centre of the learning experience. The findings suggest that specialist FMS knowledge and an ability to adjust PE teaching pedagogy that facilitates a mastery-motivational climate could support children's FMS development within the primary school setting.

Chapter five is based on the third and final study where a comprehensive teacher questionnaire was developed and validated using a modified Delphi technique. The results provide valuable insights into generalist teachers' perceptions, attitudes and perceived confidence to teach PE in primary schools in Ireland.

Chapter six summarises the main findings from each of the three studies. In addition, the potential translation of the research findings, limitations of the research and recommendations for future work are outlined.

Chapter 2: Literature Review

2.1 Introduction

Chapter 2 provides an overview of literature relevant to FMS and this body of research. The initial focus is on childhood motor development and the role of FMS. Theories of motor learning and skill acquisition are then discussed, followed by a review of papers highlighting the benefits associated with FMS proficiency and the efficacy of FMS based intervention programmes. The final section provides an overview of the Irish primary school PE curriculum and the potential for significant improvements to be made through the incorporation of FMS-based PE lessons.

2.2 Motor development and FMS

2.2.1 Phases of motor development

Motor development is defined as the change in motor behaviour over time and the underlying processes that contribute to these changes (Clark and Whitall, 1989). Humans undergo a specific pattern of motor development, as illustrated by the hourglass model (Gallahue et al., 2012) (Figure 2.1). This model shows the sequential four stages of motor development beginning from birth with the reflexive movement phase, followed by the rudimentary movement phase, the fundamental movement phase and finally the specialised movement phase. Each phase is subdivided into a number of stages that individuals progress through at different rates depending on physical, social, psychological and environmental factors (Clarke, 2007). The metaphorical mountain of motor development (Clarke and Metcalfe, 2002) proposes a similar pattern of development throughout life, whereby the fundamental motor skills period is deemed to be the most critical to skill attainment (Clarke, 2007).

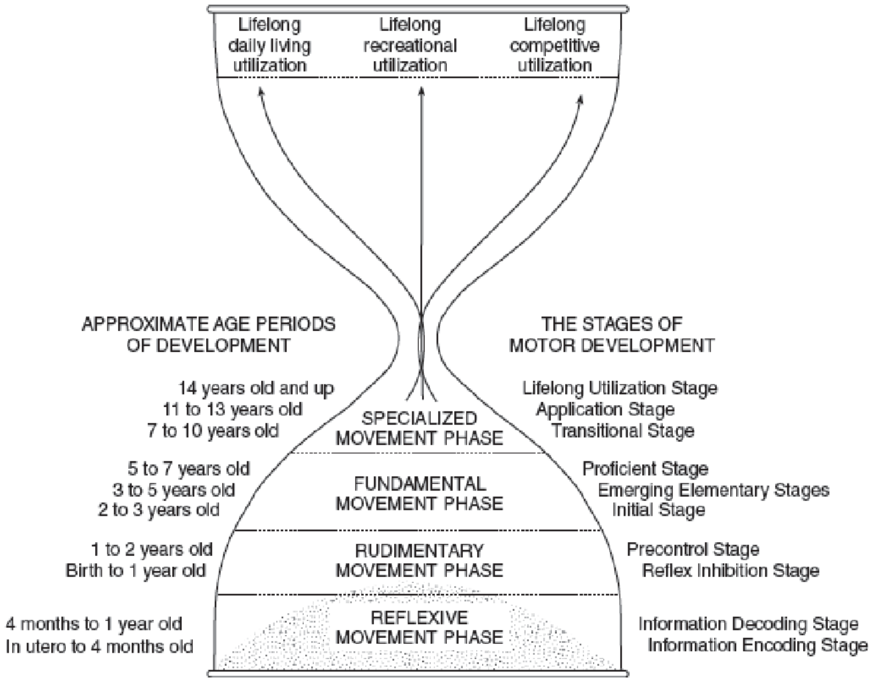

Figure 2.1 The phases and stages of motor development (Gallahue et al., 2012)

Each phase is critically important, as it is a cumulative process with one phase influencing the development of the next (Clarke and Metcalfe, 2002). The reflexive movement phase begins when the child is in the womb until approximately one year of age. The movement patterns displayed during this period are influenced by the child's interaction with the environment and are pre-programmed involuntary actions, an example of this being, the grasp reflex that occurs when the palm of a baby's hand is touched. The rudimentary movement phase involves a shift towards more spontaneous, better-controlled goal-oriented actions, whereby the child acquires the main skills needed for survival. Such skills include crawling and walking in the locomotor domain, reaching and grasping in the object-control skills domain and control of the head, neck and trunk in the stability domain. It is these three skill domains upon which the FMS phase of motor development is based. The FMS phase is broken down into three stages: initial, emerging elementary and proficient (Figure 2.1). Children without specific learning difficulties or physical disabilities tend to naturally reach the elementary stage (Payne and Isaacs, 2011) but more complex stimuli are required to reach the proficient stage. Contrary to widespread belief that children naturally acquire proficient levels of FMS over time, the child needs to be supported and facilitated in learning and developing these skills (Clark, 2007). Similar to how reaching the summit is the most demanding part of climbing a mountain, achieving context specific skilled movement is the most difficult period of motor development

(Clarke, 2007). Many individuals fail to reach the peak of the mountain due to inadequate exposure to FMS during childhood. This can have detrimental consequences for engagement in PA and may lead to higher levels of inactivity and consequential health problems in later life (Seefeldt, 1979; Stodden et al., 2008; Robinson et al., 2015). To further explain this, FMS need to be defined and critically analysed to understand their contribution to the holistic development of the child.

2.2.2 What are FMS?

FMS are basic observable patterns of movement that provide a foundation for more complex movement skills (Gallahue et al. 2012). They are vital during childhood (Gallahue et al., 2012), as proficiency in FMS is suggested to promote future involvement in PA (Stodden et al., 2008). FMS are divided into three categories, namely locomotor, object-control and stability skills (Barnett et al., 2016). Locomotor skills are those that allow an individual to move from one place to another, for example, running, jumping or skipping. Object-control skills require the use of a body part or implement to send or receive objects and include throwing, catching, kicking and striking. Stability skills include skills that do not fit into the other two categories. They typically require postural control for the maintenance of static or dynamic balance. Rolling, twisting, single leg stance and bending are examples. FMS are deemed to be 'fundamental' as learning these skills requires high levels of functional coordination and control and contribute to the acquisition of neuromotor and biomechanical developments (Barnett et al. 2016). Consequently, FMS not only create a foundation for specific skill transfer, but also generate transferable skills required for other forms of movement. The skill of kicking for example requires dynamic balance, contralateral co-ordination of extremities and timing. These components of learning a skill are applicable to everyday situations such as avoiding potentially hazardous obstacles, in addition to further enhancing other sports related skills that require similar components (Barnett et al., 2016).

FMS are proposed to be one of the four building blocks of physical literacy which is defined as "the motivation, confidence, physical competence, knowledge and understanding to remain physically active throughout the lifecourse" (Whitehead, 2010, p. 11-12). While variations exist across countries, the components 'ability', 'confidence' and 'desire' are consistently reported as essential prerequisites to maintaining a physically active lifestyle (The Aspen Institute: Project Play). These three components can be developed through the achievement of proficient levels of FMS. Children have the developmental capability to achieve proficiency in FMS by the age of six (Gallahue et al., 2012), but national (Bolger et al., 2018; Farmer et al., 2017) and international (Okely and Booth, 2004; van Beurden et al., 2002; Bardid et al., 2016) research shows that children are not mastering FMS, and are progressing to adolescence without the prerequisite skills for engaging in PA (Lester et al., 2017; O'Brien et al., 2016b; Barnett et al., 2008). To assess and track FMS in children, several FMS assessment tools have been developed.

2.2.3 FMS assessment tools

Assessing children's FMS proficiency is essential to ensure they are developing at an acceptable rate and to a suitable level. Information gathered from FMS assessments can be used to inform the development of targeted intervention programmes, help to identify children at risk of development delay or be used as a form of feedback when learning a skill (Hands, 2002; Bardid et al., 2019). The choice of assessment tool should be guided most importantly by the purpose of the assessment, but also administrative factors (e.g. time and cost), the population involved and the reliability and validity of the assessment tool (Bardid et al., 2019) must also be considered. A wide range of assessment tools claim to measure motor competence in children. However, confusion can arise when there is a lack of clarity regarding the definition of 'motor competence', as it can encompass various characteristics including, FMS, motor coordination, gross motor skills, fine motor skills and motor performance. For the purpose of this review of literature, the main focus is identifying the most appropriate tool for assessing FMS where FMS are defined as 'building blocks' for more advanced movement skills and can be categorised into locomotor, object-control or stability skills (Logan et al., 2018).

Assessment tools for measuring children's FMS proficiency can be objective or subjective in nature (Bardid et al., 2019). Lab based methods that utilise technology like motion sensors (Clark, 2019), force plates (Getchell and Roberton, 1989) and/or high-speed cameras (Whitall and Getchell, 1995) can provide accurate objective information of an individual's movement mechanics but are not suitable for large scale projects that aim to test large samples in a short period of time (Bardid et al., 2019). Instead, large scale projects tend to use assessment tools that utilise field-based observational methods (Bardid et al., 2019; Logan et al., 2017). These observational methods can be either product-oriented or process-oriented assessments (Logan et al., 2017).

Product-oriented assessments provide information about the outcome of a performance such as speed, accuracy or distance. The advantages of such assessments are the high degree of reliability and ease of administration. As scoring is objective in nature, i.e. a unit of measurement, the assessor does not require an in-depth knowledge of movement mechanics making it an attractive form of assessing children's FMS competency among physical education (PE) practitioners and coaches. Examples of product-oriented assessments include the Motoriktest für Vier- bis Sechjärige Kinder (MOT 4-6) (Zimmer and Volkamer, 1987), Movement Assessment Battery for Children (Movement-ABC) (Smits-Engelsman, 1998), Peabody Development Scales (PDMS) (Folio and Fewell, 1983; 2000), the Körperkoordinationtest für Kinder (KTK) (Kiphard and Shilling, 1974) and Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-BOT-2) (Bruininks, 1978; Bruininks and Bruininks, 2005). The MOT 4-6 is designed to assess both fine and gross motor skills among pre-schoolers and is therefore not suitable for use in a primary school setting. The Movement-ABC, PDMS and BOTMP-BOT-2 are more suited to identifying motor impairment or physical disability in children. The KTK focuses primarily on dynamic balance and fails to encompass locomotor or object-control skill proficiency. Furthermore, results from product-oriented assessments can be affected by physiological factors such as strength and size and are a more accurate assessment of motor performance than movement quality (Stodden et al., 2009). For example, a taller and more developed child with poor throwing mechanics is likely to throw a ball further than a smaller less developed child with a better throwing technique. Additionally, as a child gets older, they might improve their throwing distance, without improving their throwing technique. Changes in movement quality cannot be detected from product-based assessments and are thus less informative for the creation of targeted intervention programmes that aim to improve FMS proficiency levels.

In contrast, process-oriented assessments are used to assess movement quality. They are often scored based on the presence or absence of pre-determined skill criteria and are less influenced by physiological factors (Haywood and Getchell, 2009). Information gathered from process-oriented assessments can guide the development of targeted intervention programmes (Knudson and Morrison, 1997) and can be used to assess the effectiveness of such interventions (Sheur et al., 2019). The component stage theory suggests that FMS proficiency should be assessed by body part (e.g. legs or arms) or by the phase of a skill (e.g. backswing, follow-through) (Haywood and Getchell, 2009). As a skill is performed, the observer answers a series of 'yes' or 'no' questions and follows the flowchart to determine the developmental level of each body part. The run for example, has three steps for leg action and four steps for arm action. Advanced running is achieved by reaching step three and step four for arm and leg action, respectively. An advantage of this component stage approach to FMS assessment, is the acknowledgement that different body parts can develop at different rates. However, it may entice coaches/practitioners to teach skill components in isolation, which is not recommended by motor skill acquisition theorists, due to the potential loss of information-movement couplings which will be explained later (Renshaw et al., 2010). Therefore, assessing skills using the whole-body approach (Gallahue and Ozmun, 2006) may be more appropriate for informing coaching and PE praxis.

The fundamental movement pattern assessment instrument (McClenaghan and Gallahue, 1978) was the first FMS assessment tool to categorise skill performance as initial, elementary or mature based on the presence or absence of pre-determined skill criteria for each skill. This was a whole-body approach to movement skill assessment and the number of skills included in the instrument has increased from five to twenty-three (Gallahue and Cleland-Donnelly, 2003). The tool was unsuitable for research purposes (Gallahue et al., 2012), due to an overlap between each of the stages and poor specificity for categorising a performance as initial, elementary or mature. However, it contributed to the creation of commonly used valid and reliable FMS assessment tools including the Test of Gross Motor Development (TGMD), TGMD-2, TGMD-3 (Ulrich 1985; Ulrich 2000; Ulrich 2019), the Process Orient Assessment (van Beurden et al., 2003), the Victorian Fundamental Movement Skills manual (Department of Education Victoria 1996) and Get Skilled; Get Active protocol (New South Wales Department of Education and Training, 2000).

The design of the TGMD (Ulrich 1985; Ulrich 2000; Ulrich 2019), Process Orient Checklist (New South Wales Department of Health, 2003), Victorian Fundamental Movement skills manual (Department of Education Victoria 1996) and Get Skilled; Get Active (New South Wales Department of Education and Training, 2000) assessment tools are similar in how scores are assigned based on the presence or absence of pre-determined criteria for each skill. However, no specific assessment procedure or scoring protocols are outlined for the Victorian Fundamental Movement Skills Manual or the Get Skilled; Get Active tools and are therefore less reliable for research purposes. The eight skills included in the Process Orient Checklist (static balance, sprint run, side gallop, hop, vertical jump, kick, catch and overarm throw) were taken from the Get Skilled: Get Active protocol (New South Wales Department of Education and Training, 2000) and the

Victorian Fundamental Motor Skills Manual (Department of Education Victoria 1996), and have a specific administration and scoring procedure. Participants are required to complete five trials of each skill. If a behavioural component is correctly performed in at least four of the five trials, it is marked as being present. The performer is said to achieve mastery of a skill, when all skill criteria are marked as present, near mastery, if all but one criterion are present and poor mastery if more than one criterion is absent (van Beurden et al., 2002). Scores for the TGMD can also be assigned using the mastery/proficiency model, however, scoring differs slightly as only two test trials are counted rather than five. Therefore, mastery is assigned when all skill criteria are correctly performed over two trials, near mastery if all but one criterion are correctly performed over two trials and anything else as poor mastery (O'Brien et al., 2016b). Comparing mastery of FMS between studies is limited by the use of different assessment tools and must be considered when interpreting results.

An added advantage of the TGMD scoring procedure, is the inclusion of mean scores. A score of one is given when a performance criterion is correctly performed, with a score of zero assigned for an incorrect or absent performance criteria. Scores are summed for the two trials of each skill to give an overall skill score. Scores for each locomotor skill and object-control skill are summed to give overall locomotor and object-control subtest scores, respectively. Finally, the two subtest scores are summed to give the total FMS score. The maximum score possible for each skill is dependent on the number of performance criteria, which ranges from three to five, allowing for maximum scores of between six and ten per skill. This scoring procedure was used to develop age and gender specific norms among American school children aged 3- to-10 years (Ulrich, 2000; 2019). These values allow researchers to determine if children are reaching their developmental potential for FMS proficiency, however, the tool is developed based on sports and activities that are popular in America. Despite this potential cultural bias, the TGMD assessments are the most popular tool for assessing FMS in studies worldwide. According to a recent review, 64% of FMS based research studies used the TGMD protocols for assessing childhood FMS proficiency levels (Logan et al., 2017).

Skills included in the Process Orient Checklist have a larger number of behavioural components (i.e. five to seven) compared to the TGMD (i.e. three to five). This increases the risk of assessment/measurement error making the Process Orient Checklist a less reliable assessment tool than the TGMD (Hands, 2002). Interpreting whether or not a criterion was performed correctly can be subjective, thus, inter and intra-rater reliability should be established prior to testing (Goodway et al., 2014). There are a lack of studies establishing the reliability and validity of the Get Skilled; Get Active, while one study reported ICC values above 0.7 for all skills in the Victorian Fundamental Motor Skill manual (Department of Education Victoria, 1998). Kappa coefficients of k = 0.7 (Barnett et al., 2009) and k = 0.6 (van Beurden et al., 2003) were reported for the interrater reliability of the Process Orient Checklist. These may have been higher, had the performances been recorded and scored retrospectively, as is common practice in many research studies examining FMS proficiency.

In contrast, reliability and validity of the TGMD assessment tools have been researched extensively (Ulrich, 2000; Ulrich 2019; Barentt et al., 2014; Maeng et al., 2016; Rintala et al., 2017; Webster and Ulrich, 2017; Temple and Foley, 2017). ICC values for the inter-rater reliability of the TGMD-2 are consistently moderate to excellent ranging from 0.71 to 0.98 for object-control subtest, locomotor subtest and total FMS scores (Ulrich, 2000; Barnett et al., 2014). The newest edition, TGMD-3, includes updated administration guidelines and video displays of potential performance errors that may occur and the score that should be assigned in such situations (TGMD-3, 2017). Having the video resources is likely to reduce confusion between raters, as oftentimes it can be difficult to distinguish whether or not a performance criterion should be marked as present or absent. These resources may have contributed to the excellent ICC values for both intra and inter-rater reliability scores among five well trained raters (Maeng et al., 2016). ICC values ranged from 0.87 (kick) to 0.97 (gallop) for intra-rater reliability and from 0.82 (slide) to 0.98 (skip) for inter-rater reliability (Maeng et al., 2016). Lower intra-rater ICC values were reported by Rintala et al., (2017), however, they were also acceptable ranging from moderate to excellent for the total FMS score (ICC = 0.73-0.75) and for both the locomotor and ball skills subtest scores (ICC = 0.69-0.77) (Rintala et al. 2017). The raters in the study by Maeng et al., (2016) only had two weeks between initial and second scoring, compared to two months for those in the study by Rintala et al., (2017), which might explain the variation in intra-rater ICC values between the two studies.

Despite large similarities between the already validated TGMD-2 (Ulrich, 2000) and the more recent TGMD-3, new studies were conducted to establish the validity of the TGMD-3 for assessing children's FMS proficiency (Webster and Ulrich, 2017; Temple and Foley, 2017). Webster and Ulrich (2017) reported above acceptable item difficulty and item discrimination values for the TGMD-3. Developmental validity was established for the TGMD-3 where age related changes and sex differences were distinguishable over time (Temple and Foley, 2017) providing evidence for the tests construct-identification validity, which is the extent to which the test may be said to measure a theoretical construct or trait (Anastasi and Urbina, 1997). Construct-identification validity of the TGMD-2 was established based on five underlying constructs (Ulrich, 2000). These included age differentiation (FMS scores and chronological age should be strongly correlated), group differentiation (different ability levels should be distinguishable, which may be related to underlying factors such as socio-economic status or learning disabilities), item validity (e.g. individual locomotor skill scores should correlate with the locomotor subtest score), subtest correlations (locomotor subtest scores should be moderately correlated with object-control subtest scores as both are measures of gross motor performance) and factor analysis (Ulrich, 2000). Additionally, content-description validity (e.g. three experts in the area of FMS judged that the skills to be tested represented those commonly practiced by and taught to 3- to 10-year-old children) and criterion-prediction validity (e.g. the TGMD-2 test scores were correlated with the results from the 'Comprehensive scales of student abilities' score in a sample of 41 students) have also been established for the TGMD-2 (Ulrich, 2000) and TGMD-3 (Ulrich, 2019). The larger number of studies examining the reliability and validity of the TGMD assessment tools (Ulrich, 2000; Webster and Ulrich, 2017; Temple and Foley, 2017; Rintala et al., 2017; Maeng et al., 2016) compared to other process-oriented assessments, make it a more attractive tool for assessing FMS proficiency of primary school children (Hulteen et al., 2020).

The TGMD-3 assesses 13 skills compared to 12 that were assessed in the TGMD-2. The TGMD-3 assesses the run, gallop, hop, skip, slide and horizontal jump in the locomotor subtest and the two-hand strike, forehand strike, overhand throw, underhand throw, kick, catch and dribble in the ball skills subtest. The ball skills subtest was formerly called the object-control subtest in the TGMD-2, thus the terms are used interchangeably throughout this document. The forehand strike and skip were added to the TGMD-3 and the leap, which was previously assessed in the TGMD-2, was excluded. The developers excluded specific assessment of balance skills, however, justify this by the fact that balance is a pre-requisite skill needed for the performance of locomotor skills (Logan et al., 2018).

The TGMD is an attractive tool for assessing FMS in a primary school setting due to the ease of administration, simple equipment and time required for implementation. The TGMD-3 can be used for a number of purposes including identification of FMS proficiency levels and developmental delay in gross motor development and to design intervention programmes to improve FMS proficiency (Ulrich, 2000). As scores are assigned based on the presence or absence of predefined performance criteria, a ceiling effect is possible from using the TGMD assessment. However, considering the low levels of FMS proficiency being reported in recent times (Bolger et al., 2018; Behan et al., 2019; van Beurden et al., 2003; O'Brien et al., 2016b), the TGMD-3 is a suitable tool to measure FMS proficiency of Irish primary school children. The following section outlines the levels of FMS proficiency from various countries with greater emphasis on studies that have used process-oriented assessments.

2.2.4 FMS proficiency levels

Investigating FMS proficiency levels is gaining popularity within an Irish context. Evidence suggests that both primary (Bolger et al., 2018; Behan et al. 2019) and secondary (O'Brien et al., 2016b) school students are not reaching their developmental potential across a broad range of FMS. However, it is unclear if FMS proficiency levels improve across the primary school years. Current research suggests that proficiency levels of Irish school children are similar to that of our international counterparts (Bolger et al., 2018). Australia are leading the way with regard to monitoring and tackling low levels of FMS proficiency among primary school aged children and provide evidence that ongoing surveillance can help to improve FMS proficiency levels over time (Hardy et al., 2015).

O'Brien et al. (2016b) was the first to publish on FMS proficiency levels within an Irish context, where only 11% of adolescents aged 12- to 14-years achieved mastery/near mastery for all nine FMS examined. Since then, the number of publications investigating FMS within the Irish context has increased significantly. Lester et al., (2017) found that a range of between 14.8% and 86.6% of 12- to 16-year-old Irish adolescents achieved complete mastery across ten FMS with a progressive decline for the object-control subtest score observed from younger to older year groups ($p=0.002$). This is despite the fact that children have the potential to master these skills by age six (Gallahue et al., 2012). More recently, Farmer et al., (2017) and Bolger et al., (2018) investigated FMS proficiency among Irish primary school children from the Southwest region of Ireland, where mastery levels ranged from 36.9 to 68.4% and from 12.3 to 79.4% across seven and twelve FMS, respectively. Furthermore, Behan et al. (2019) reported mastery/near mastery levels ranging from 16% to 75.3% across 15 skills among 2098 Irish primary school children aged 5- to 12-years. The ideal window of opportunity for developing FMS is proposed to be between the ages of 3- and 8-years old (Gallahue et al., 2012; Clark 2005), however, the current evidence within the Irish context suggests that greater efforts are needed to facilitate FMS development during these years. To-date, only Behan et al. (2019) included children across the full primary school age range and reported a plateau in skill performances by age 10. This was older than the plateau that occurred among Belgian primary school children (Bardid et al. 2016) which was approximately 8 years old. The difference is likely due to variations in socio-cultural factors that can influence FMS development (e.g. variations in sporting culture, PE curriculum, family influences, access to amenities etc.). Thus, further research is required within the Irish primary school context to try and understand what can be done to maximise improvements in school children's FMS proficiency levels throughout the full duration of their primary education.

The New South Wales (NSW) Government in Australia monitor state-wide health and fitness measures of their child and adolescent population, which includes the assessment of FMS using the Process Orient Checklist (Department of Education Victoria, 1996). The 1997 Schools Fitness and Physical Activity Survey revealed that less than 40% of NSW children and adolescents achieved mastery in five of six FMS (Booth et al., 1999). Since then, the NSW Schools Physical Activity and Nutrition Survey, has been conducted in 2004 (Booth et al., 2006), 2010 (Hardy et al., 2010) and 2015 (Hardy et al., 2015). The proportion of children who achieved advanced skill proficiency increased between 2004 and 2015 (Hardy et al., 2015). However, FMS proficiency is still relatively low among Australian primary school children (aged 5-to 11-years) with between 16.3% (kick) and 80.4% (side gallop) of girls demonstrating advanced skill proficiency and between 24% (leap) and 75% (side gallop) of boys demonstrating advanced skill proficiency across seven skills in 2015.

Among English primary school children aged 6- to 11-years, mastery levels ranged between 3.3% (run) and 37.8% (catch) (Bryant et al., 2015) which was similar to the results of Booth et al., (1999) but lower than the findings of Bolger et al., (2018), who reported mastery levels of between 12.3% and 79.4% among 6- and 10-year-old Irish primary school children. However, Bryant et al., (2015) and Booth et al., (1999) both used the

Process Orient Checklist, whilst Bolger et al., (2018) used the TGMD-2 making it difficult to directly compare results. The TGMD-2 was also used to assess FMS proficiency among Singaporean children aged 6-to 9-years (Mukherjee et al., 2017), Belgian children aged 3- to 8-years (Bardid et al., 2016) and Brazilian children aged 3- to 10-years (Spessato et al., 2013). Each study revealed a skewed distribution with a larger proportion displaying below average proficiency for both locomotor and object-control subtest scores and very few displaying above average proficiency. In contrast, 6- to 9-year-old children from Hong Kong displayed higher than average FMS proficiency (Pang and Fong, 2009), which may be somewhat attributed to a newly reformed PE curriculum that was implemented in 2002 which prioritised FMS development and the cultivation of positive attitudes towards PA and PE (Curriculum Development Council, 2002).

The aim of achieving advanced skill proficiency is to exceed the 'proficiency barrier' outlined by Seefeldt (1979) as the level whereby skills can be applied to more complex situations known as the specialised movement phase of motor development (Gallahue et al., 2012). A study by O'Keefe et al. (2007) found that Irish students coached to achieve advanced overarm throwing proficiency were better able to perform the badminton overhand clear and javelin throw than those who were coached in the badminton overhead clear only. Additionally, Kokstejn and Musalek, (2019) found that children with better FMS proficiency were more likely to demonstrate more advanced sports-specific skills in soccer. As such, improving children's FMS competency is likely to transfer to more advanced skills and thus encourage lifelong engagement in PA behaviours (Barnett et al., 2016; Hulteen et al., 2018). However, various studies have highlighted significant heterogeneity regarding FMS proficiency levels according to sex. Consequently, the influence of sex on FMS development will be discussed in the next section.

2.2.5 Sex differences in FMS proficiency

Researchers have found notable differences in FMS development between males and females, especially with regard to object-control skills (Bolger et al., 2018; O'Brien et al., 2016b; Goodway, et al., 2010; Foulkes and Knowles, 2015; Bryant et al., 2014; Hardy et al., 2010). Sex differences are reported among pre-school, primary and post-primary school children and adolescents. Using the TGMD-2 to assess FMS, Hardy et al. (2010) found Australian pre-school males (n=171) performed significantly better than their female counterparts (n=159) in the object-control skills of striking (p=0.001), kicking (p=0.002) and overhand throwing (p=0.01), with no significant difference for the catch (p=0.6). However, females performed significantly better than males in the locomotor subtest score (p=0.005), despite being significantly better in the skill of hopping only (p=0.01). Similar findings were reported among a sample of English pre-school children aged 3- to 5-years (Foulkes et al., 2015). Males significantly outperformed females in the object-control skills of kicking (p<0.001) and overhand throwing (p=0.05) with females significantly better at the locomotor skills, hopping (p=0.01) and galloping (p=0.003).

A quasi-experimental evaluation of 1,045 Australian primary school pupils aged 7- to 10-years, whose FMS were assessed using the Get Skilled; Get Active tool, also showed similar results (Van Beurden et al., 2003). At baseline, males were significantly better in the performance of kicking (p<0.001) and overhand throwing (p<0.001) with females significantly better at the side gallop (p<0.001). Likewise, Bryant et al. (2014) reported English males to be significantly better than females in the performance of kicking (p=0.0001) and throwing (p=0.0001) with females better at static balance (p=0.0001) only. Furthermore, Bolger et al., (2018) in their study of Irish 6- and 10-year-old children revealed significantly higher object-control subtest scores among males compared to their female counterparts (p<0.001) with these findings more recently supported in a study that included over 2000 Irish school children aged between 6- and 12-years-old (Behan et al., 2019). At secondary school level, O'Brien et al. (2016b) states that first year Irish male students, were significantly better than their female counterparts in the overhand throw (p<0.001), run (p=0.007) and horizontal jump (p<0.001) with females performing significantly better at skipping (p<0.001) only. Despite the overhand throw being the only individual object-control skill to be significantly different when comparing males to females, the object-control subtest score was also significantly in favour of males (p=0.001) with no significant difference between males and females for the locomotor subtest score (p>0.05).

Evidence suggests that males are outperforming females in many object-control skills, which seems to be independent of, age, country of residence or the assessment tool being used (Bolger et al., 2018; Behan et al., 2019; Barnett et al., 2009; van Beurden et al., 2003). Sex differences for locomotor and stability skills are less consistent but are occasionally in favour of females. For example Irish females aged 6- and 10-years-old (Bolger et al., 2018) and Australian females aged 8- to 10-years-old (Barnett et al., 2009) and 4- to-5-years-old (Hardy et al., 2010) displayed higher locomotor subtest scores than their male counterparts. However, among 3- to 8-year-old Belgian children (Bardid et al., 2018) and

American preschool children (Goodway et al., 2010), locomotor subtest scores were similar for males and females.

Van Beurden et al., (2002) reported no significant difference between primary aged Australian males and females in their performance of the static balance. In contrast, Danish females aged 4- to 5-years significantly outperformed males in the balance subtest ($p<0.001$) which was assessed using alternative product-oriented assessments. There is a lack of process-oriented skill assessments to determine if a sex difference exists within the balance domain of FMS. Reasons for the sex disparity in the object-control skills domain have not yet been extensively investigated. However, a meta-analysis by Thomas and French (1985), suggests that environmental influences are the main reasons for the differences in skill performance between males and females. Socio-cultural norms and biological factors can also affect FMS development but to what extent remains unclear (Nobre et al., 2020; Greendorfer, 1983; Thomas and French, 1985).

2.2.5.1 Factors influencing sex differences in FMS proficiency levels

As mentioned above, FMS proficiency levels can vary by sex, particularly where males outperform females in object-control skills (Lubans et al., 2010; Barnett et al., 2016) The reasons for male superiority in object-control skills are not clear, but biological, sociological, and environmental factors are likely contributing factors. These factors are less likely to influence locomotor and balance skill competence, as many activities of daily living require competence in these domains (Ulrich, 2000). Males are biologically bigger and stronger than females following puberty and thus possess a greater advantage for the performance of skills requiring strength, such as throwing a ball for distance or running as fast as possible (Thomas and French, 1985; McKenzie et al. 2002). However, due to biological similarities prior to puberty, and the fact that FMS are assessed qualitatively, biology does not explain why males often display higher object-control skill competence than females. Therefore, socio-cultural influences may be the primary reason for any observed sex differences in FMS performances (Thomas and French, 1985; Garcia, 1994; Lever 1978).

Significant others (coaches, parents, peers and teachers), the social environment and personal attributes affect an individual's exposure to motor experiences (Haywood and Getchell, 2009). Parent's interactions with their kids, their attitudes to PA, the toys and soft furnishings provided to their children and activities pursued as a family, hugely influence their motor experiences (Thomas and French, 1984). Gender identity can form by the age 3-years-old (Perry et al., 2019; Stoller et al., 1964) and it is likely influenced by the perceptions instilled in the child within the home environment. Parents, who are more physically active, act as positive role models for children (Xu et al., 2020; Crawford et al., 2010) and can instil positive PA behaviours, which would facilitate FMS practice opportunities. However, some parents encourage children to participate in particular activities according to gender (Sääkslahti et al., 1999). For example, fathers may be more likely to engage in rough and tumble type playtime activities with their male children but treat their female children more delicately (Johnson et al., 2005). This often-subconscious behaviour can greatly limit motor skill practice opportunities for young girls. Consequently, if females are receiving less practice opportunities compared to males, females may be more likely to experience disappointment in PA and sport, and consequently lose interest for future participation (Witt and Dangi, 2018; Greendorfer, 1983). Males are habitually more competitive than females and tend to gain satisfaction from winning, whereas females often prefer to engage in co-operative, non-competitive pastimes (Coulter et al., 2020; Garcia, 1994; Hardy et al., 2010). However, competitive sport activities tend to dominate Irish primary school PE lessons (Coulter et al., 2020; Woods et al., 2018) and therefore, may also be negatively affecting female's intrinsic motivation to participate in PA and sport outside of the school environment.

Due to the link between PA and FMS proficiency (Stodden et al., 2008), both the type and quantity of PA participation may be a significant contributing factor to the differences in FMS competency between males and females. As outlined in the 'Children's Sports Participation and Physical Activity Study' (CSPPA) (Woods et al., 2010; 2018), males are more active than females, receive more PE time and are more likely to reach the recommended levels of 60 minutes of moderate to vigorous PA per day. Only 13% and 23% of primary school females and males are meeting the recommended PA guidelines, respectively, whilst only 7% and 14% of secondary school females and males are meeting the guidelines (Woods et al. 2018). This gender gap in PA participation rates has been consistently reported in an Irish context (Woods et al., 2018; Fahey et al., 2014) with poor quality planning and delivery of PE in schools a potential contributing factor.

According to Woods et al. (2018), basketball, Gaelic football and soccer were the top three activities covered in PE for both males and females, whilst the fourth and fifth most popular activities were athletics and dance for females and swimming and rounders for males. Worryingly, the top three activities are all from the games strand of the curriculum, which may over-emphasise competition and winning. As mentioned previously, these activities tend to be more enjoyable for boys and for those with advanced skills but can lead to feelings of incompetence, anxiety and boredom among females and less skilled individuals (Garcia, 1994), increasing their risk of dropping out of sport and PA when the option arises. Almost all primary school children receive exposure to the games strand as part of their PE curriculum (98%), however, 44%, 57%, 59%, 75% and 80% are getting no exposure to athletics, aquatics, dance, gymnastics and outdoor and adventure strands, respectively (Woods et al., 2018). Despite this lack of variety and overemphasis on games being highlighted as a concern in the 2010 CSPPA report (Woods et al., 2010), these figures from the 2018 CSPPA report (Woods et al., 2010) demonstrate that very little has changed over an eight-year period. Consequently, reformation of the current delivery of primary PE lessons should be considered as a potential avenue to foster FMS development and PA engagement among Irish primary school children.

As primary school PE classes may be the only exposure to PA for some children, classes must be meaningful and engaging. Motivation to participate in PA for life is likely influenced by perceived competence in ones' skill level (Scarpa and Nart, 2012). As such, encouragement and opportunities to experience success during PE must be prioritised. Primary school boys reported the three main reasons for not participating in PA after school were that they already do enough activity, they felt incompetent or had no form of transport to attend training (Woods et al., 2010). Similarly, females also stated transport difficulties and poor competence to be barriers to PA participation but additionally 'no suitable activities' were a top reason. Although these barriers relate to PA opportunities outside of school, teachers are ideally situated to address issues around skill competence and the variety of activities offered during PE. Particular attention must be given to helping females improve their proficiency levels in object-control skills, so that they can keep up with their male counterparts (Okely and Booth, 2004). Teachers may need to consider not only the variety of activities offered during PE lessons, but also the pedagogical approach adopted, to ensure children of all abilities feel confident and motivated to fully participate in lessons (Hastie et al., 2012; Ames, 1992). An understanding of different motor learning theories may influence how teachers structure practice sessions to support skill acquisition and retention (Rudd et al., 2020). Motor learning theories from both cognitive and behavioural perspectives will be outlined in the following paragraphs.

2.3 Motor skill acquisition and retention

2.3.1 Motor learning theories

Motor skill acquisition can be described as a relatively permanent change in movement performance, which occurs gradually as a result of many practice opportunities over time (Schmidt and Wrisberg, 2004). Motor control theories attempt to explain how the nervous system produces coordinated movements in a variety of environments to achieve a specific task goal. Coordination and the degrees of freedom problem are central to motor learning theories. Coordination is defined as the process whereby the multiple degrees of freedom are converted to a controllable system (Bernstein, 1967) while the degrees of freedom problem refers to how the nervous system controls the many muscles, limbs and joints of the body to enable a person to perform an action as intended. As the human body is made up of hundreds of muscles and joints, countless numbers of degrees of freedom are present. Understanding motor skill acquisition theories is essential for practitioners, as it provides a base of support from which to develop effective skill instruction and practice environments (Magill, 2007). Understanding how the body coordinates its multiple degrees of freedom, to produce the desired movement response, is described differently by theorists from cognitivist or behavioural backgrounds.

Traditional motor learning theories are viewed from a cognitivist perspective and include Adams (1971) loop theory and Schmidt's (1975) schema theory. These representational/ information-processing accounts of skill acquisition, view the human brain as being similar in design to a computer software programme, proposing that skill acquisition and performance is brought about primarily by the central nervous system. Such theories ignore the qualitative aspects of human movement and how external and internal constraints influence learning. In contrast, behaviourists endorse non-representational accounts of motor learning, commonly referred to as dynamic pattern theory or ecological psychology theories, which describe the non-linear, self-organisation of movement patterns that emerge because of the complex interaction of individual, task and environmental constraints (Newell 1986). The differences between these theoretical perspectives and how they influence skill acquisition, retention and practice environments will be discussed in the following paragraphs.

2.3.1.1 Cognitive accounts of skill acquisition

As mentioned above, representational or cognitive accounts of motor learning include Adams loop theory (Adams, 1971) and Schmidt's schema theory (Schmidt, 1975). These theories are based on the premise that skills are stored as motor programmes in the brain, which are refined and become more efficient through practice. The central nervous system, comprised of the brain and spinal cord, acts as the control system which gathers and processes information, formulates a response and sends instructions to the effectors, i.e. muscles and joints, to produce a movement response (Magill, 2007).

The open loop control system, as illustrated in Figure 2.2, is responsible for producing fast ballistic movements whereby feedback cannot be used to adjust the movement once it has started. The movement is pre-planned and initiated by the memory trace (also known as the motor program) and feedback about how the movement was performed and the correctness of the movement can only be utilised once the movement has been completed. This information is processed and stored in the memory trace and used to inform future attempts of the movement task. Throwing a dart or putting a golf ball are examples of the open loop control system in operation. In both tasks, the performer examines the situation, information is relayed to the central nervous system, a response is selected, and information is sent back to the effectors in order to perform the throw or putt. Once the movement is initiated, it cannot be altered. However, the result of the throw or putt i.e. the output, is a form of feedback that can be utilised to alter the technique for subsequent attempts.

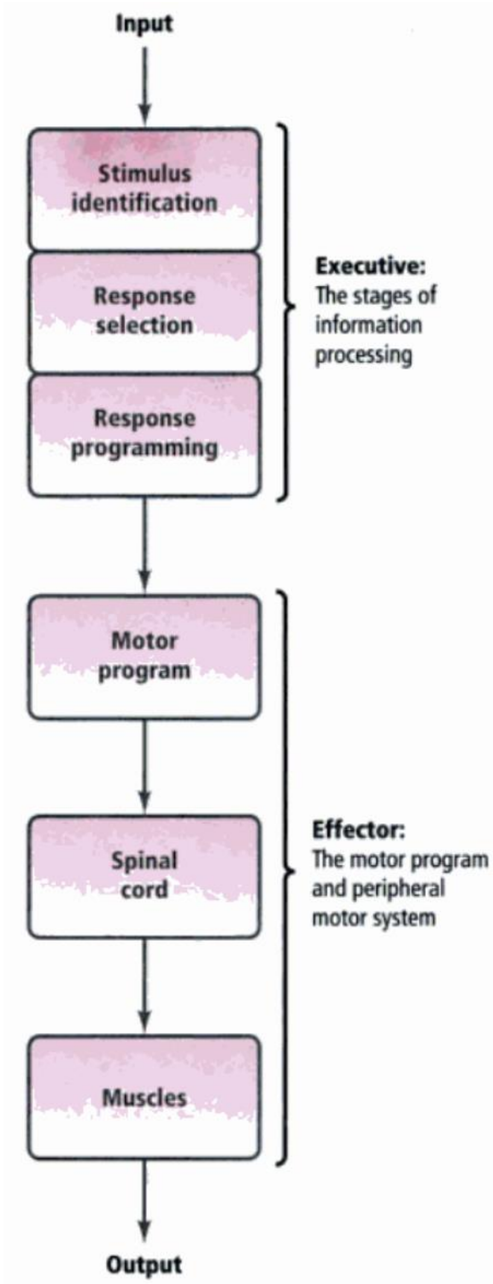

Figure 2.2 Open loop control according to Adams (1971) (Schmidt and Wrisberg, 2008)

In contrast, longer duration tasks, such as maintaining balance when skiing, utilise the closed loop control system. Feedback can be used to adjust the movement performance as it is being carried out. The perceptual trace is an image of the correctness of the desired movement and is formed based on prior experiences of the action. It acts as a reference point for which the current action being produced can be compared to. Should the action match up with the reference, the movement can be completed without the need for modification, however, should a mismatch between the movement and the memory trace be incurred, adjustments can be made accordingly. The regaining of balance before falling over during skiing exemplifies the workings of the closed loop control system. Kinaesthetic feedback informs the control centre that the skier is losing balance and information is sent back to the muscles and joints so that the positioning can be altered, and balance regained. Learning is the process of eliminating mismatches and errors (Adams, 1971) and so repeated practice of the same movement is necessary to enhance learning (Zwicker and Harris, 2009).

Problems associated with memory representations of motor learning theories include the storage problem and the novelty problem (Newell, 1991). The storage problem refers to the fact that the brain would need to have a limitless capacity to store motor programs for the endless possibilities of skill production. Also, despite the fact that repeated performances of a skill may look the same, the processes involved, and the precise movements are never the exact same. As such, every performance of a skill is in some way novel. These storage and novelty problems are not accounted for by motor program theories. Schmidt's schema theory (1975) addressed these issues suggesting that rather than storing every motor skill as an individual motor program in the brain, generalised motor programs (GMP) are created. A GMP is an abstract representation of a movement plan consisting of both fixed and flexible elements. The fixed components of the GMP, known as invariant features, do not change between performances (Schmidt, 2003) and include elements such as ordering, phasing and relative forces of the action (Schmidt 1985). Parameters are the features of a movement that can vary between trials (e.g. speed and force production) depending on the demands of a situation and are influenced by two types of 'Schema' otherwise known as memory representations of movement (Magill, 2007).

Recall schema is the memory structure used for movement production and control, while recognition schema evaluates the movement performance (Schmidt, 2003). As such, the recall schema is responsible for movement production and is influenced by the initial conditions present before the action such as body position and equipment and the parameters required to execute a specific task. The recognition schema evaluates the movement performance with information provided from the outcome of the movement performance and the sensory consequence of the movement (i.e. how it felt). As such, the performer needs to acquire two things from practice, the first being the generalised motor program or overall form of the movement and the second being the schemata which allows the action to be scaled to the environment (Schmidt 2003). Difficulty arises when deciding how to structure practice conditions, as the development of Schemata requires variable practice conditions, whereas refinement of the GMP requires repetition.

Information-processing accounts of skill acquisition do not account for the ability of individuals to instantaneously adapt to changing environments. The human brain would need to process incredibly vast amounts of information in a minimal amount of time. The forehand strike in tennis is categorised as a FMS in the TGMD protocols. In order to perform this skill, co-ordination of over 800 independent muscles and 100 joints is required (Wells, 1976). The coordination of the endless number of system degrees of freedom to complete a task goal, cannot be fully explained from an information-processing standpoint (Kugler and Turvey, 1987). Much of the research conducted from an information-processing perspective has largely focused on single degree of freedom tasks and so may have limited applicability to complex, multiple degree of freedom tasks, which includes learning FMS. The underlying concepts largely contrast with the non-representational accounts of motor skill acquisition favoured by ecological psychologists/behaviourists.

2.3.1.2 Behaviourists accounts of skill acquisition

Influenced by the work of Bernstein (1967), Gibson (1979) and Newell (1982), the ecological dynamics theory combines the concepts of ecological psychology and dynamical systems theories to explain skill acquisition (Seifert and Davids, 2015). The framework addresses shortcomings of traditional approaches by focusing on skill acquisition at the performer-environment interface. Key factors addressed in this theory include direct perception (e.g. an awareness of the environment), attunement to affordances (e.g. the ability to react to environmental cues for movement, which can be influenced by the perceiver's past experiences), rate limiters (i.e. factors that influence how an individual learns), self-organisation (i.e. the ability of the body to adjust movement patterns to make them more efficient) and constraints (e.g. factors within the individual, environment or task that can be altered to enhance learning). Gibson's (1979) theory of ecological psychology is primarily concerned with the interactions between neurobiological systems and the environment (Warren, 2006). Information from the environment is provided to the learner and is directly perceived without reference to past experiences. The environmental information provides opportunities for action otherwise known as affordances (Fajan et al., 2009). In contrast to information-processing theories, whereby perception and action are viewed as separate entities, and perception precedes action (Schmidt, 1975), perception and action are coupled and function as a synergistic unit to influence movement (Gibson, 1979). That is, an action must take place in order to perceive (e.g. scan the environment for affordances), but also perception must take place in order to act (Gibson, 1979). Improvement in skill performance takes place as one becomes more attuned to the affordances in the environment (Shaw and Turvey, 1999; Gibson, 1979).

This ecological perspective is combined with the beliefs of dynamical systems theorists, who focus on the non-linear, self-organising capabilities of individuals influenced by the principles of nonlinear thermodynamics (Kelso, 1995). According to dynamical systems theory, the multiple systems within an individual (musculoskeletal, nervous system etc.) constantly strive to self-organise into a coordinative structure so as to maintain a state of equilibrium known as an attractor state (Kelso, 1995). This attractor state is characterised by stability within the overall system. For any task, two parameters are present, the order parameter which is the outcome of the movement and the control parameters which are the variables that can be manipulated and act as a catalyst for the reorganisation of behaviour. Control parameters include subsystems of task, environmental and individual constraints (Newell, 1986). For example, task constraints such as the rules of a game or use of different equipment can be altered to change the movement response. Changes in constraints alter the attractor state so that it becomes unstable. As the system tries to regain stability and self-organises, a new pattern of movement is created. This occurs in phase shifts that initially, may be expressed as a combination of the old and new technique but with practice, can self-organise into a new stable attractor state. Phase shifts, and thus learning, occur as an individual adapts to the interacting constraints during the performance of a given task. Coaches who adopt a constraints led approach to practice are utilising the principles of ecological dynamics to facilitate learning.

In terms of how skills are acquired, cognitivists rely on the development of memory representations known as motor programs, which are developed in a linear fashion whilst the ecologists support the view that the learner becomes attuned to affordances in the environment (Warren, 2006). That is, getting better at recognising opportunities for action depending on the acting constraints in a given situation. Ecological psychologists encourage the learner to actively engage in the learning process by altering constraints and allowing the learner to problem-solve and come up with their own movement solutions (Renshaw et al., 2010), whereas the information processing theorist would simply tell the learner how exactly to perform a specific movement. Pedagogical practices are influenced by the practitioner's understanding of, or preference for certain motor learning theories (Handford et al., 1997). Therefore, information-processing theorists will adopt a linear, stage-like approach to teaching skills, whereas ecological psychologists will adopt a non-linear, constraints-led approach to teaching (Rudd et al., 2020).

While both approaches have strengths and weaknesses, Renshaw et al. (2009) suggests that movement practitioners should adopt the ecological approach to facilitate the learning of gross motor skills. Information processing theories may better explain decision making and reaction, but physical movement may be better explained from an ecologist's perspective (McMorris, 2004). The processes underlying linear and non-linear learning are different and thus have diverse influences on how practice is structured.

2.3.2 Information processing: linear learning

Traditional loop control theories of motor learning suggest that skill instruction should be repetitive in nature and focus on the reduction of errors and provision of prescriptive feedback to improve performance (Adams, 1971). Learning is believed to occur in a linear fashion whereby the nature of information processing changes as the learner moves through three distinct stages (Fitts and Posner, 1967; Anderson, 1982; VanLehn, 1996).

The first stage is the cognitive stage (Fitts and Posner, 1967) where the aim is to develop an understanding of the specific goal of the skill. Performances are characterised by highly variable and inconsistent movements with large errors. Skill demonstrations and verbal instructions are central to the learning process, as the performer does not have the knowledge to self-correct the errors at this stage. Anderson's (1982) model refers to the first stage as the declarative stage with VanLehn (1996) naming it the early stage of learning. Both declarative knowledge, which includes verbal descriptions and mental imagery of the skill, and procedural knowledge, which is a kinaesthetic awareness of how the correct movement pattern should feel, are acquired at this initial stage (Kim et al., 2013).

After developing an understanding of what to do, the learner enters the second stage, known as the 'Associative Stage' (Fitts and Posner, 1967), 'Transitional Stage' (Anderson, 1982) or 'Intermediate Stage' (VanLehn, 1996). At this stage, the focus is on how to perform the skill. Performances become more consistent with fewer errors and less variability. The performer starts self-detecting and correcting performance errors through kinaesthetic feedback with less reliance on verbal cues and direction. The knowledge acquired from stage one is consolidated through practice, leading to a deeper understanding and better performances over time (Kim et al., 2013).

The third stage, referred to as the 'Autonomous Stage' (Fitts and Posner, 1967), the 'Procedural Stage' (Anderson, 1982) or the 'Late Stage' (VanLehn, 1996), is not always achieved. This stage is highly dependent on the time spent practising the skills, in addition to the quality of instruction and practice. At this stage, the skill can be performed with very little thought and with very few errors. Automaticity of a motor skill requires less brain activation and so fewer attentional demands are required (Poldrack et al., 2005). The skill is engraved in the subconscious of the performer, making it a habitual action, which allows the performer to focus on secondary tasks like game strategies or movement form. Fine-tuning the knowledge from the previous stages, leads to increased automaticity of skill performance (Kim et al., 2013). Once a skill becomes an automatic process, it is difficult to modify (Schneider and Griffin, 1977) and thus highlights the necessity for quality instruction and feedback during learning. Even though a skill may be in the autonomous stage, it may not be correct. In such situations, the learner may need to revisit the cognitive and associative stages in order to correct the movement and further improve their performance, a process referred to as relearning. A major criticism of this stage approach to learning is the failure to recognise the impact of past experiences and individual perceptions on skill acquisition (Light, 2008). Those from an ecological background, whereby learning is said to be a non-linear process, address this shortfall.

2.3.3 Ecological dynamics: non-linear learning

Instead of focusing on skill acquisition in three specific stages, ecologists support the view that skill acquisition occurs at three primary levels, intrinsic, individual and interactive (Smith, 2016). These areas of skill acquisition do not develop in a linear fashion but are improved under different practice conditions through the alteration of individual, environmental and task constraints (Newell, 1982). At the intrinsic level, the development of co-ordinated patterns and technique are the key focus. The development of skill at this level requires task specific behaviours and feedback regarding technical aspects of a skill. Although not generally favoured by dynamical systems theorists, this form of practice may be essential to correct technique and should be incorporated into overall pedagogical practices when necessary (Smith, 2016). The individual level of analysis occurs at the individual/environmental interface, typically seen as performing discrete tasks in a closed environment e.g. kicking a ball at a target. The overall aim of this type of practice, is to develop co-ordinated movements between an individual and an external object, and enhance the synergy between the performer, the object and the task goal. While this level of skill can be developed through isolated skill practises, it is essential that constraints are modified to replicate potential game situations. At the interactive level, the physical and social interactions of all individuals, the environment and the task constraints are considered and are best developed within the situated learning environment of games. For this to be effective, the coach/teacher requires both knowledge of the game and an understanding of relational dynamics (Smith, 2016).

As mentioned previously, many primary school teachers overemphasise competitive games in PE (Youth Sport Trust, 2015; Woods et al., 2018 Hardman, 2008) and often neglect the development of FMS. Others are likely to neglect games in the early years and utilise repetitive drill-based activities to teach individual skills before moving on to games (Smith, 2016). Smith (2016) suggests that neither FMS nor fundamental games skills should be taught in isolation, but that they should be given equal attention across all stages of development and taught in a complementary manner. This may facilitate skill development at the intrinsic, individual and interactive level. Practitioners who wish to facilitate FMS development among children, can manipulate a range of factors so that the quality of the learning experience for each individual is maximised.

2.3.4 Practice

Practice is an integral part of skill acquisition, however, the amount of practice time needed to become proficient in a skill is not well understood (Davids, 2008). Simon and Chase (1973) suggest 10,000 hours of practice are required to become skilled to an elite level. From an information-processing perspective, practice leads to a linear improvement in performance and is explained by the Power Law (Newell and Rosenbloom, 1981). However, this theory is limited to tasks whereby performance improvements are time dependent. For example, the more time spent practicing typing, the greater the performance improvement is likely to be, which would be indicated by a linear improvement in typing speed and accuracy.

In contrast, the acquisition of FMS is more likely to be a non-linear process due to the role of perception and its effect on task performance (Shaw and Alley, 1985; Chow, 2013). The premise behind learning FMS is to ensure children have the basic skills to engage in different forms of PA and sport. Unlike typing for example, which is typically performed in a constant environment with limited external distractions, learning to kick a ball can be performed in a variety of different contexts (i.e. indoors or outdoors, alone or surrounded by other people etc.) which means the various external distractions will affect the learners ability to kick the ball in a given situation. Therefore, the time required to become proficient in FMS will vary from person to person and may be sporadic in nature. Regardless of whether improvements are linear or non-linear, researchers agree that the more time spent in deliberate practice, the greater the skill improvements (Ericsson et al., 1993). In reality, some children may have limited opportunities to engage in organised practice to learn FMS and for many, primary PE lessons may be their only opportunity. It is therefore essential that the quality of such practice opportunities is optimised. The person facilitating the practice must therefore consider a wide range of factors including, ways of teaching skills (i.e. task simplification or part-task decomposition), the variability and distribution of practice, the different types of instruction and feedback and the motivational climate (Chow et al. 2011).

2.3.4.1 Task simplification or part-task decomposition

Skills can be taught by simplifying the task in the early stages and gradually increasing the difficulty or by breaking each component of the movement into individual parts (part-task decomposition). If a complex coordination pattern, such as a volleyball serve which requires a toss followed by a hitting action is separated and taught as individual components (part-task decomposition), the information-movement coupling is lost. This could limit a learner's ability to perform the task as whole (Handford, 2006). Instead, simplifying a task is encouraged to maintain the information-movement coupling (Davids et al., 2008) and aid in learning and long-term retention of skills. For the volleyball serve, this could be facilitated by practicing the movement with a balloon during the initial stages of learning, followed by a blow-up beach ball and finally a volleyball as skill levels improve.

Coordinating the large numbers of degrees of freedom to accomplish the task goal is the primary focus within motor skill acquisition and varies between novice and expert performers. The number of degrees of freedom utilised for a task performance increases with practice with Bernstein (1967) suggesting a transition through three distinct stages. The first stage involves reducing the degrees of freedom, which can be done by simplifying the task. Once the learner can perform the simplified version of the task, additional degrees of freedom can be introduced signifying a move to the second stage of learning known as exploration of the degrees of freedom. The final stage involves capitalisation of degrees of freedom, where degrees of freedom are optimised to produce more economical and efficient movement patterns. This was demonstrated in a study by Vereijken et al. (1992) whereby participants learning to perform on a ski-apparatus demonstrated movements that were highly coupled in the initial stages of learning. This coupling was decreased with practice, indicating a release of the number of degrees of freedom. This study suggests that experts have the ability to coordinate a larger number of degrees of freedom to achieve a task goal. Consequently, having a novice observe only an expert performer and attempt to replicate the performance may be detrimental to learning as the novice is unlikely to have the ability to co-ordinate the same number of degrees of freedom as the expert (Bernstein, 1967). Discovery learning where the learner is encouraged to experiment with different movement solutions and gradually release the degrees of freedom, may provide greater opportunities for learning motor skills (McMorris, 2004; Sigmundsson et al., 2017). Discovery learning can be facilitated through variable practice conditions.

2.3.4.2 Variability and distribution of practice

Variable practice, where learners are encouraged to explore a range of movement patterns, may be more advantageous in the early stages of learning than constant practice where repetition could limit opportunities to experience failure. Variability in practice should encourage learners to adopt their own movement solutions as opposed to following a modelled template (Hodges and Franks, 2002). Experiencing failure during variable practice allows the learner to detect and correct errors and consequently enhance their ability to understand how the correct movement pattern should feel. Although constant repetitive practice may provide a greater opportunity to experience success (Croker, 2017), which may be motivating for the learner, it may limit their ability for skill transfer like adapting the skill to game situations. Bernstein (1996) emphasised the importance of repetition without repetition, which refers to repeating the problem-solving process of a task goal as opposed to constantly repeating the exact same movement pattern without altering any conditions. For example, rather than repeatedly practicing a free kick from the same spot, practice taking a free kick from various distances and angles. The desired outcome for each condition is the same (i.e. to score a goal), however, variability facilitates the exploration of multiple movement patterns in a bid to enable individuals to discover the most efficient methods of achieving a task goal (Kelso and Ding, 1993).

In addition to the recommendation for variable practice conditions, the distribution of practice should also be carefully considered. Practice can be massed, meaning the overall time period for practice is condensed, but each individual practice session is long with limited opportunity for rest and recovery (Donovan and Radosevich, 1999). In contrast, distributed practice is where practice conditions are spread out over an extended period of time, but individual practice sessions are shorter and rest intervals are relatively long (Magill, 2007). Although the overall time engaged in practice can be identical for either form, more frequent, short-duration sessions are potentially better for learning than fewer, longer-duration sessions (Magill, 2007; Baddeley and Longman, 1978). Compared to massed practice, distributed practice allows for greater rest and recovery which subsequently, minimises fatigue, enhances cognitive effort and improves the memory consolidation process to assist the learning process (Magill, 2007; Shadmehr and Brashers-Krug, 1997).

2.3.4.3 Instruction and feedback

Information is essential to learning, however too much or too little can impede progress. The optimal amount of information required to facilitate learning is dependent on the skill level of the learner, the difficulty of the task and the environmental conditions (Guadagnoli and Lee, 2004). Pre-practice information can be given in the form of verbal description or demonstration of the task goal. Either form is only useful if it provides information not previously known to the learner.

When giving instructions, the coach/practitioner can direct a learner's attention internally or externally depending on the types of cues provided to the learner (Wulf et al., 2000). Effect relevant cues are used to facilitate an external focus of attention, whereas an internal focus of attention is promoted by directing attention towards the precise positioning of limbs throughout the different phases of a skill performance. Using the basketball free throw as an example, telling the player to focus on hitting the square on the backboard directs attention externally, whereas telling the player to flex the wrist during the follow through directs attention internally. A 15-year review found that skill learning, retention and transfer were better facilitated by using an external focus of attention compared to an internal focus of attention (Wulf, 2013). This held true across a range of ages and abilities and for various performance measures including accuracy tasks, balance, consistency and movement efficiency (Wulf, 2013). The language used by the instructor can have significant implications on the learning process, not only when giving instructions but also when providing feedback.

Feedback, which can be intrinsic or extrinsic in nature, is essential to efficient learning (Winstein, 1991) and to the learner's motivation to practice (Williams and Hodges, 2005). Intrinsic feedback includes sensory perceptual information, which is a natural part of performing a skill, and is constructed by the learner. Extrinsic or augmented feedback enhances intrinsic feedback and comes from an external source such as a coach. It can be given as knowledge of results (e.g. distance, time) or knowledge of performance (specific movement characteristics) to provide information that may not have been picked up from the sensory systems (van Dijk et al., 2005). For example, when performing a long jump, the coach may measure the distance and give feedback to the athlete about the exact distance jumped (knowledge of results) or provide feedback about the position of specific limbs at take-off or during flight of the jump (knowledge of performance). Video-replays are a useful tool for providing knowledge of performance as the performer can see exactly what they did to bring about the performance outcome (Magill, 2007). Coaches must understand the difference between knowledge of results and knowledge of performance and how each type of feedback influences learning. Sharma et al. (2016) found that providing knowledge of performance led to significantly better performance in the overhand throw compared to a group who received knowledge of results only ($p < 0.05$). This study was conducted in adults aged 18 to 30, thus the results cannot be generalised to children. Despite that, knowledge of results are an important reference point from which improvements in performance outcomes can be tracked over time, however, only providing knowledge of results without knowledge of performance may not assist the learning process (Salmoni, Schmidt and Walter, 1984).

The optimal frequency, timing and type of feedback provided by coaches can positively or negatively influence a learner's self-confidence (Smith et al., 1995) and must be adapted according to the learner's ability, the type of task and stage of learning. Providing immediate feedback may interfere with mental processes and the ability to self-detect and correct errors of a performance. As such, it is recommended that the learner is given at least a few seconds to process their performance before augmented feedback is given (Swinnen et al., 1990). Doing so may enhance skill learning and the learner's self-confidence (Williams and Hodges, 2005; Wulf and Shea, 2004). Furthermore, Tzetzis et al., (2008) looked at how different forms of feedback affected learning and self-confidence of 10- to 14-year-old males performing two types of badminton skills, and suggested that the type of feedback may need to be altered depending on the learners ability and the difficulty level of the task. Badminton skills of low difficulty (forehand clear) and high difficulty (backhand clear) were performed by four groups receiving different combinations of either positive feedback, correction cues, error cues or no feedback. For the easy task, receiving either correction cues or error cues were enough to facilitate learning, however, for the difficult task, the combination of both corrective and error cues in addition to positive feedback were most beneficial to learning the task and to perceived confidence.

In the study by Tzetzis et al., (2008), defining the skills as easy or difficult was relatively simple in the context of badminton, however, classifying the difficulty level of FMS is less straight forward. When using the definition given by Wulf and Shea (2002), all FMS may be regarded as difficult skills as they typically take longer than one session to master, they require the co-ordination of multiple joints and muscles to be executed, and are ecologically valid, meaning they are transferable across different environmental contexts (Wulf and Shea 2002). However, when learning FMS, the difficulty level of a skill will be perceived differently by each individual. For example, a child who plays soccer may find the skill of kicking a ball as relatively simple compared to a child who has never played soccer. Despite the skill requirement being the same, the perceived difficulty of the skill is highly variable. Therefore, when teaching FMS, the coach should alter the type of instruction and feedback they provide to each learner, based on the learner's individual needs rather than their own perception of how difficult they think a specific skill is.

2.3.4.4 Types of practice

Evidence suggests that both physical and observational practice can lead to learning, however, combining the two may be more beneficial than either form in isolation (Shea et al., 2000). Observational learning can engage one in similar cognitive processes that occur during physical practice (Blandin et al., 1999) and allows the learner to process relevant information, such as coordination patterns and timing, prior to attempting the skill. The effects of observational practice vary between adults and children and is likely due to children being in the early stages of learning in comparison to adults who would already have some prior experience of performing the skill or a similar skill (Newell, 1985). As such, observational learning can enhance a child's ability to achieve a movement outcome, whereas adults often utilise observational learning to refine the movement quality of their performance. Practicing in pairs, or dyadic practice, is another strategy that can enhance the learning process (Shea et al., 1999). Dyadic practice requires partners to alternate between observing and physically practicing a skill. Although the learner may only physically practice the skill for half the time as a group who practice individually, they often perform as well or even better on retention tests and transfer tests (Wulf et al., 2010). This type of practice may be particularly useful where time and space is limited, such as in primary PE lessons.

The coach/practitioner can vary the practice conditions and types of instruction and feedback they use to promote either implicit or explicit learning strategies (Wulf, 2013). Implicit learning is described as a passive process whereby knowledge which is acquired through experience relies less on working memory processes than explicit learning. Explicit learning is an active process whereby the learner makes and tests hypotheses in a search for structure (Maxwell et al., 2003). According to Masters (1992), the key difference between implicit and explicit learning is the amount of declarative knowledge accumulated by the learner. Explicit motor learning is demonstrated by an understanding of the rules required for effective movement responses and is signified by the learner's ability to verbally communicate details of the movement dynamics. In contrast, a learner may not be able to verbally communicate the precise movements of a skilled performance that is implicitly learnt but rather has a kinaesthetic awareness of how the correct movement should feel.

Implicit learning can be facilitated using a strategy known as errorless performance, i.e. modifying constraints to minimise errors in performance (Maxwell et al., 2001; Masters et al., 2008). When this errorless strategy (implicit learning) is implemented in the early stages of learning it can significantly improve skill retention compared to those who experience errorful learning (explicit) during initial practice (Capio et al. 2013). In addition, implicit learning strategies seem to be less affected by a secondary cognitive task during transfer tests and hence indicate a reduced reliance on working memory processes for performance. The initial skill level of the learner must also be considered when deciding on implicit or explicit learning strategies. Implicit motor learning strategies may benefit children with low motor ability to a greater extent than those with higher motor ability (Maxwell et al. 2017). The reasons for this are not yet clear but may be as a result of less pressure on working memory processes, in addition to higher levels of motivation as a result of experiencing more success and fewer errors with such approaches. The number of children in a practice session or a PE lesson that experience a sense of success can vary according to the type of motivational climate created by the coach or teacher.

2.3.4.5 Motivational climate

According to the achievement goal theory (Nicholls, 1989; Roberts, 2012), individuals are motivated by either task/mastery goals, where enjoyment comes from recognising improvements in personal performance over time, or performance/ego goals, where satisfaction is gained from winning and being the best with as little effort as possible (Roberts, 2012; Nicholls, 1989). Evidence suggests that mastery-motivational climates are a more inclusive pedagogical practice than performance-oriented climates (Wilhelmsen et al., 2019), which is particularly important in primary PE lessons where the abilities and interests of individuals within any one class are largely heterogeneous. Teachers/coaches who promote competition, reward the best performances, limit student autonomy and deliver lessons using direct instruction are fostering a performance-oriented motivational climate (Roberts, 2012). Perceived performance climates in PE are associated with negative emotional experiences, disengagement, anxiety and boredom (Braithwaite et al., 2011). Even highly skilled children may be at risk of becoming demotivated if they feel the chances of winning are low (Nicholls, 1989).

In contrast, teachers/coaches who promote self-improvement, avoid social comparison, reward hard work and effort, encourage student autonomy and avoid direct teaching strategies are fostering a mastery-motivational climate. Evidence suggests that mastery-oriented climates in PE are associated with enjoyment, high levels of effort, persistence to master tasks, skill development, confidence and high intrinsic motivation to learn (Ntoumanis and Biddle, 1999; Braithwaite et al. 2011).

Tenets of achievement goal theory are often combined with self-determination theory to further understand the role of motivation in achievement settings such as sport and PE. Self-determination theory postulates that individuals are more self-determined and intrinsically motivated when their three basic psychological needs of competence, autonomy and relatedness are met (Deci and Ryan, 2000). Autonomy relates to perceptions of control and choice over one's own behaviour, competence refers to an individual's perceived ability to experience success in a given situation and relatedness refers to a sense of social acceptance and belonging (Deci and Ryan, 2000). These needs are more likely to be met where lessons are high on mastery- rather than performanceorientation (Parish and Treasure, 2003) and have been shown to enhance enjoyment of PE (Ommundsen and Kvalø, 2007).

The TARGET acronym stands for task, authority, recognition, grouping, evaluation and time (Ames, 1992; Epstein, 1988), and is recognised as a pedagogical framework that can be used to create a mastery-motivational climate. A teacher who wants to facilitate FMS development should offer a range of tasks in the one lesson. The learner can self-select the task to suit their own perceived level of ability. Authority is a collaborative process between the learner and teacher to allow the learner to feel in control of his/her learning experience. Individuals should be recognised and rewarded for hard work and effort. Evaluation should be done in private with a focus on self-referenced progress. Grouping would be flexible where learners can choose who to work with and the teacher supports collaboration and peer support rather than competition and peer comparison.

This section of the literature review highlighted a range of variables that can be manipulated in order to maximise the quality of practice opportunities that support FMS learning. Children who are exposed to good quality FMS practice conditions may also experience multiple health-related benefits associated with having proficient levels of FMS.

2.4 Benefits associated with FMS competence

Many studies have reported significant positive relationships between FMS competence and PA levels, cardiovascular fitness (CVF), cognitive function and academic performance (Lubans et al., 2010; Logan et al., 2015; Barnett et al., 2016; Catuzzo et al., 2016). In addition, children with higher levels of FMS competence are more likely to be within a healthy weight range for their age (Okely et al., 2004; Lubans et al., 2010). The health-related benefits associated with proficiency in FMS have been investigated in several studies, with PA levels and weight status the most widely investigated areas (Holfelder and Schott, 2014; Logan et al., 2014; Barnett et al., 2016). Figure 2.3 illustrates the developmental model by Stodden et al. (2008) which highlights the inter-relationship between actual FMS competence, perceived FMS competence, PA levels, health-related fitness and weight status. Evidence for the reciprocal nature of these variables and their associated health-related consequences, will be discussed in the following paragraphs.

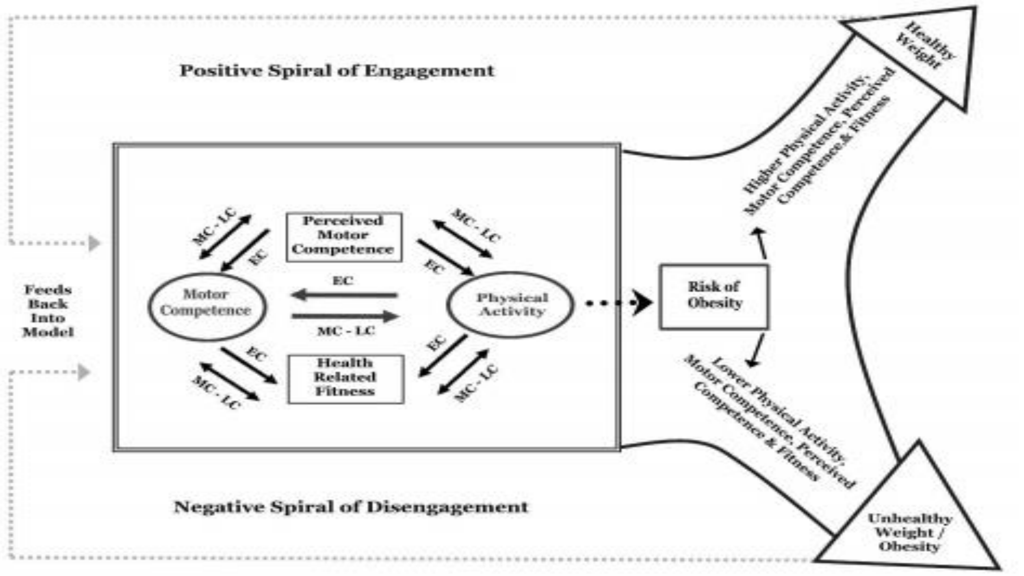

Figure 2.3 Developmental model showing the relationship between motor competence, perceived motor competence, health related fitness, physical activity and weight status (Stodden et al., 2008)

2.4.1 FMS and PA

Stodden et al., (2008) define motor competence as the ability to proficiently perform locomotor and object-control skills. Achieving competency in FMS has gained recognition as an important pre-requisite to maintaining a physically active lifestyle (Seefeldt, 1980; Stodden et al., 2008; Robinson et al., 2015). The relationship between PA and FMS is reciprocal in nature as children must be physically active in order to develop FMS, but also more skilled children display greater confidence and motivation to remain physically active (Stodden at al., 2008; Robinson et al., 2015). This relationship is anticipated to strengthen with age and is likely mediated by changes in cognitive awareness (Stodden et al., 2008).

A review paper that included only process-oriented measures of FMS, reported poor to moderate correlations between FMS competence and PA levels among 3- to 5-year-old children (r=0.16 – 0.48, R^2=3-23%; 4 studies) and 13- to 18-year-old adolescents (r=0.14-0.35; R^2=2-12.3%; 2 studies), whilst poor to strong correlations were found among 6- to 12-year-old children (r=0.24-0.55; R^2=6-30%; 7 studies) (Logan et al., 2015). Although, the model by Stodden et al. (2008) would expect the association between PA levels and FMS proficiency to be stronger among older children compared to younger children, only two studies included older adolescents (Barnett et al., 2011; Okeley et al., 2001) and both used only self-report measures of PA levels which limits the accuracy and generalisability of the results.

Review papers have mainly supported the presence of a positive relationship between FMS competence and PA levels, however, the number of studies supporting this within each review paper varied from 52% (Holfelder and Schott, 2014) to 75% (Barnett et al., 2016) to 92% (Lubans et al., 2010). Furthermore, the strength of the relationship between FMS competence and PA levels ranged from very poor ($r=0.10$) to very strong ($r=0.92$) (Holfelder and Schott, 2014). Lubans et al. (2010), only included studies where FMS composite score was reported. In contrast, Holfelder and Schott (2014) and Barnett et al., (2016) looked at how the relationship varied according to different subsets of FMS. The relationship between object-control skill competence and PA levels was supported in only 45% (Barnett et al., 2016) and 26% (Holfelder and Schott, 2014) of the studies, where effect sizes ranged from weak to moderate ($r=0.19$-0.35, $r^2=0.18$) (Holfelder and Schott, 2014). Similarly, the relationship between PA levels and locomotor skill competence is ambiguous, supported in only 45% of studies (Barnett et al., 2016). Inconsistencies around the definition of FMS, the types of assessment tools used to assess FMS and the inclusion/exclusion criteria make it difficult to compare results from different studies.

Among a sample of 361 6- to 11-year-old US children, those with high motor competence were 2.5 times more likely to reach the recommended levels of 60-minutes moderate to vigorous PA per day, compared to children with low motor competence ($p=0.003$) (De Meester et al., 2018). However, this was a cross-sectional study and doesn't determine if having high FMS competence during childhood can lead to higher engagement in regular PA as children ger older. Longitudinal studies provide some support for the developmental trajectory hypothesis of PA and FMS competence (Barnett et al., 2009; Lopes et al., 2012; Jaakkola et al., 2016). One was a 6-year follow-up study whereby childhood object-control skill competence accounted for only 3.6% of the variation of time spent in adolescent moderate to vigorous PA ($r^2=0.036$, $p=0.001$) and 18.2% of adolescent participation in organised PA ($r^2=0.182$, $p=0.003$) (Barnett et al., 2009). Children with higher levels of object-control skill proficiency, had at least 20% greater chance of participating in some vigorous PA as adolescents. Lopes et al. (2011) further supported these findings, reporting that 6-year-old children with high motor competence engaged in more PA after 3 years, compared to children with low and moderate levels of motor competence. In contrast, McKenzie et al. (2002) found FMS competence at age 4- to 6-years, was not associated with PA levels, measured using a seven-day recall questionnaire 6 years later (p 0.05), however, only three skills were assessed at baseline.

Furthermore, PA was assessed subjectively using questionnaires in all three studies, increasing the risk of bias. Bürgi et al. (2011), looked at the relationship between FMS and objectively measured PA using accelerometers among 4- to 6-year-old Swiss children. Although baseline motor skills did not predict changes in PA levels nine-months later, baseline PA levels were predictive of follow-up motor competence. This supports Stodden's suggestion that younger children who engage in regular PA are more likely to develop better motor skills, and perhaps a longer follow-up would be required to determine the effect on PA levels in later years.

Inconsistencies in findings regarding the link between FMS and PA engagement may stem from differences between males and females and as mentioned in previous sections, the typical activities they pursue. Logan et al. (2015) concluded that object-control skills are more highly correlated with male PA levels, whereas locomotor skills tend to be more highly correlated with females PA levels. This trend seems evident from pre-school age where Cliff et al. (2009) reported a moderate to strong significant positive correlation between pre-school boys object-control skills and both moderate PA ($r=0.52$, $p=0.008$), and moderate to vigorous PA levels ($r=0.48$, $p=0.015$). Object-control skill proficiency explained 16.9% of the variance in moderate to vigorous PA and 13.7% of the variance in time spent in total PA. However, for pre-school girls, object-control scores were not related to PA outcomes ($p>0.05$) but locomotor scores were inversely associated with percentage of time spent in moderate PA ($r=-0.52$, $p=0.015$) and moderate to vigorous PA ($r=-0.50$, $p=0.022$), explaining 19.2% of the variance in moderate to vigorous PA. Additionally, Finnish female's leaping skills in primary school were significantly associated with moderate to vigorous PA levels in secondary school, however, no associations between FMS and PA were found among males (Jaakkola et al., 2019). Similarly, among Irish adolescents, the relationship between male FMS proficiency and PA was not significant, whilst female locomotor skill proficiency ($r=0.37$, $p<0.05$) and total FMS scores ($r=0.36$, $p<0.05$) were significantly positively related to vigorous PA only (O'Brien et al., 2016a).

Evidence suggests that from a young age, males are more likely to engage in team games and competitive type activities that facilitate object-control skill development, whereas females are more likely to engage in more individual sports with limited opportunities to practice object-control skills (Garcia, 1994; Hardy et al., 2010). Consequently, female PA levels are more commonly correlated with locomotor skill proficiency, whilst male PA levels are more often associated with object-control skill proficiency (Barnett et al., 2016). Limiting the range of activities that children of either sex engage with during their early years, may limit the types of PA that they will feel confident to pursue in later years. According to Stodden et al. (2008), this important mediating factor is known as the individuals perceived motor competence.

2.4.2 FMS and perceived motor competence

Physical self-concept or perceived competence relates to the individual's perceptions and confidence in their own ability to complete specific tasks and skills and can influence their motivation and desire to partake in or avoid certain activities (Bandura, 1997). Having confidence in one's personal ability to complete sports and exercise related activities may generalise to a broader perceived physical competence and can facilitate happiness, motivation and resilience (Sonstroem et al., 1994; Craven et al., 2008). Lower perceptions can contribute to dropout from sport and avoidance of PE (Crane et al., 2015; Gibbons, 2008). In the model by Stodden et al. (2008) (Figure 2.3), perceived motor competence is described as a mediating variable, as it provides a potential explanation for the relationship or connection between motor competence and PA participation, particularly as children get older and their cognitive awareness improves (Robinson et al., 2015). For example, in early childhood, children are typically motivated to engage in PA despite having poor proficiency in FMS, but through regular engagement in PA their FMS improve. However, during middle and late childhood cognitive awareness improves, and children who have not mastered many FMS may become increasingly aware of their lack of motor competence and consequently avoid PA and sport due to feeling incompetent and embarrassed.

A review by Babic et al. (2014) found that perceived competence was most strongly correlated with PA levels ($r=0.30$, $p<0.001$) compared to other forms of physical self-concept. This included perceived fitness ($r=0.26$, $p<0.001$), general physical self-concept ($r=0.25$, $p<0.001$) and perceived physical appearance ($r=0.12$, $p<0.001$). Perceived FMS competence has also been linked to actual FMS competence, but it is difficult to determine whether perceptions influence actual competence or vice versa (Robinson et al., 2015; Barnett et al., 2011). Perceived competence may have a greater influence on one's motivation to participate in PA even more than actual competence (Harter, 1978; Weiss and Amorose, 2005). Therefore, understanding the relationship between actual and perceived FMS competence and PA participation will have implications for how interventions to improve FMS and PA levels should be implemented. Consideration must therefore be given to the instructional strategy adopted when implementing intervention programmes due to the potential impact it can have on motivation and perceived self-competence of the children engaging in the programme. This may be particularly true for children who are overweight or obese. According to Stodden et al., (2008) overweight and obese children are more likely to have low levels of perceived motor competence and are consequently at risk of disengaging from PA. The relationship between weight status, perceived and actual FMS competence and PA participation has received some attention in the literature.

2.4.3 FMS and weight status

As outlined in the developmental model by Stodden et al. (2008) (Figure 2.3), weight status may be influenced by motor competence, but also motor competence may be influenced by weight status. As a mediating variable, the belief is that children who have low levels of motor competence are less likely to partake in PA due to embarrassment and lack of confidence in their ability. Moreover, avoiding PA leads to lower levels of actual motor competence and subsequently increases the chances of gaining weight (Slotte et al., 2017). With increases in weight, self-confidence declines further, thus contributing to avoidance of PA. As PA engagement is required for the acquisition of FMS competence, being overweight can contribute to low levels of motor competence.

A significant inverse association between FMS competence and weight status was confirmed in 82% (Catuzzo et al., 2016) and 58% (Slotte et al., 2017) of studies included in two separate review studies. As the association is proposed to strengthen with age (Stodden et al., 2008; Robinson et al., 2015), the different proportions confirming a relationship, might be explained by the fact that Catuzzo et al., (2016) included studies with participants aged 3- to 18-years, whilst only children aged 3- to 12-years were included in the review by Slotte et al. (2016). Similar to reports looking at the relationship between FMS competence and PA levels, the strength of the relationship between FMS competence and weight status are also inconsistent with correlation coefficients ranging from weak to large ($r = -0.20$ to $r = -0.62$) (Robinson et al., 2015), but may be influenced by the subdomain of FMS.

Weight status is more often correlated with locomotor skills than object-control skills (Slotte et al., 2017; Bryant et al., 2014; Southall et al., 2004; O'Brien et al., 2016a; Okely et al., 2004). Among a sample of 4363, 9- to 15-year-old Australian children and adolescents, BMI and waist circumference were inversely associated with both overall FMS and locomotor subtest scores, but not object-control subtest scores (Okely et al., 2004). Similar results were also reported among 10-year-old Australian children (Southall et al., 2004) and Irish adolescents (O'Brien et al., 2016a). Additionally, O'Brien et al. (2016a) found that overall FMS proficiency could explain 14.6% of the variance in the prediction of BMI. Sex differences were also identified, whereby male BMI was negatively correlated with locomotor subtest ($r=-0.37$, $p<0.01$), stability ($r=-0.49$, $p<0.01$) and overall FMS scores ($r=-0.45$, $p<0.01$) while BMI for females was negatively correlated with locomotor subtest scores only ($r=-0.34$, $p<0.05$).

At the individual skill level, overweight children and adolescents are more likely to struggle with the skill of running compared to their non-overweight peers (Hume et al., 2008; Bryant et al., 2014). However, O'Brien et al., (2016a) only found significant differences for the jump ($p=0.008$), balance ($p=0.03$) and underhand roll ($p=0.04$). Although less consistent, there is some evidence that non-overweight children also have better object-control scores, than overweight children (Morano et al., 2011; Slotte et al., 2015). Using BMI as the only measure of weight status is problematic due to its inability to distinguish between fat mass and fat-free mass. Interestingly, the study by Slotte et al., (2015) used dual x-ray absorptiometry (DXA) to categorise weight status of 8-year-old Finnish school children, which might explain why object-control scores also varied by weight status. In this study, body fat percentage was more strongly correlated with total ($r=-0.41$, $p<0.001$), locomotor ($r=-0.38$, $p<0.001$) and object-control ($r=-0.30$, $p<0.001$) skill proficiency for males, whereas for females, abdominal fat percentage was the strongest predictor of object-control skill proficiency ($r=-0.18$, $p<0.001$) and waist circumference the strongest predictor of locomotor skill proficiency ($r=-0.33$, $p<0.001$).

Despite some inconsistencies, there are strong indications that overweight children are likely to display lower FMS proficiency levels than their healthy weight peers (Morano et al., 2011; Slotte et al., 2015; Catuzzo et al., 2016). This may be related to biomechanical issues resulting from high body mass (Riddiford-Harland et al., 2006). i.e. those with higher body mass tend to have increased adipose tissue around joints which may limit their range of motion, and thus their ability to achieve mastery in many locomotor skills. This negative association between FMS proficiency and weight status may affect an overweight child's motivation to participate in regular PA (Stodden et al., 2008; Robinson et al., 2015). An overweight child is more likely to engage in sedentary behaviours, due to feelings of incompetence and embarrassment around PA (Trost et al., 2001), and therefore miss out on opportunities to improve their health-related physical fitness (Stodden et al., 2008).

2.4.4 FMS and physical fitness

Investigations into the relationship between FMS competence and physical fitness largely focus on cardiorespiratory fitness (CRF), however muscular endurance, flexibility, speed and agility are also important constructs of physical fitness (Ortega et al. 2008). Although it is difficult to determine the exact influence of FMS competence on CRF, some associations have been highlighted where males and females with lower FMS competence can be three- to seven- and two- to six-times more likely to be unfit than those with higher FMS competence, respectively (Hardy et al., 2012). This may have profound health related consequences, as children get older.

Strong evidence exists for a relationship between FMS competence and health-related physical fitness (Cattuzzo et al., 2016). Barnett et al. (2008), as part of the longitudinal children's Physical Activity and Skills study (PASS), found that childhood object-control skill proficiency could predict 26% of the variance in adolescent CRF ($p=0.01$) seven years later. Higher skilled children achieved approximately six more laps on the progressive aerobic cardiovascular endurance run (PACER) test compared to lower skilled children. Similarly, a cross-sectional investigation revealed significant associations between CRF and both locomotor skills (sprint run, vertical jump) and object-control skills (overarm throw, catch, forehand strike and kick) among a sample of 2,026 Australian adolescents at grade 8 (13-years) and grade 10 (15-years) (Okely et al., 2001). Total FMS score explained 20% and 26% of the variance in the number of laps completed in the PACER test for grade 8 and 10 participants, respectively.

Musculoskeletal fitness, including measures of abdominal endurance, upper body strength, tennis ball throw and medicine ball toss, have been shown to be positively correlated with FMS competence in 64% of studies included in a review paper by Catuzzo et al. (2016). Having a high level of physical fitness was strongly correlated with motor competence ($r=-0.6$, $p<0.01$) among 9- and 10-year-old Norwegian school children (Haga, 2008). The association between physical fitness and balance skills was stronger for girls ($r=-0.8$, $p<0.01$) compared to boys ($r=-0.3$, $p<0.05$). Furthermore, ball skill competence was only significantly correlated with physical fitness for girls ($r=-0.6$, $p<0.01$) and not boys ($p>0.05$). These findings suggest that children with higher FMS competence are more likely to be fit compared to children with lower FMS competence. This was further supported by Haga (2009) whereby children with low motor competence (n=8, mean age 9.5±0.3 years) were found to have significantly lower physical fitness than children with high motor competence (n=10, mean age 9.9±0.1) ($p<0.05$, $\eta_p^2=0.9$). The relative difference between the groups remained constant from baseline to 32 months, which meant the low motor competence group, were unable to catch up with their peers who had high motor competence. After 32 months, the high competence group improved their motor competence by 43% more than the low competence group. Similarly, a group of 5- and 6-year-old children with low motor competence performed significantly worse in the broad jump ($p\leq0.005$, $\eta_p^2=0.56$), 50m run test ($p\leq0.005$, $\eta_p^2=0.60$), balance ($p\leq0.005$, $\eta_p^2=0.66$), overhand throw ($p\leq0.005$, $\eta_p^2=0.28$) and cardiorespiratory endurance ($p\leq0.005$, $\eta_p^2=0.38$) compared to a group of age and gender matched highly competent peers (Hands, 2008). The difference between both groups was maintained each year, for a period of five years.

Despite the limitations of small sample sizes and product-oriented assessment of motor competence, these studies investigating the relationship between FMS competence and physical fitness suggest that poor motor competence can impede one's ability to engage in PA, subsequently limiting opportunities to improve physical fitness (Haga, 2008; Haga, 2009; Hands, 2008). They also suggest that children with low motor competence are unlikely to catch up with their higher skilled peers over time (Hands, 2008). Thus, interventions must be implemented to assist less competent children as early as possible. Furthermore, increasing motor competence and physical fitness is likely to have cognitive benefits, which has the potential to lead to improvements in academic performance (Macdonald et al., 2018).

2.4.5 FMS, cognitive function and academic achievement

It has been proposed that CRF and motor competence may be beneficial for cognitive development and academic performance but that the association of either CRF or motor competency individually with cognition and academic performance remains inconclusive (Haapala 2013). van der Fels, et al. (2015) concluded that insufficient evidence exists for or against a relationship between motor skill competence and cognitive abilities in children aged 4- to 16-years. However, there are indications that complex motor skills are related to higher order cognitive skills, which tends to be stronger among prepubescent children under 13 years (van der Fels et al., 2015). The link between motor development and cognitive functioning is said to arise as a result of similar parts of the brain being utilised for the performance of these tasks (Diamond, 2000), in addition to both functions having common underlying processes. For example, acquisition of locomotor skills and reading ability rely on the process of automaticity (where skills become so fluent, they no longer need conscious control) (Nicolson et al., 2001). In contrast, mathematical ability requires a higher level of cognitive function such as problem solving, working memory and procedural processes similar to that of object-control skills, which are more complex, compared to locomotor skills (Latash and Turvey, 1996). Strong evidence to support the relationship between FMS competence, cognitive function and academic achievement among typically developing children is limited but may be more pertinent for children with learning disabilities and for those from disadvantaged backgrounds.

In two separate studies, Draper et al. (2012) found that an 8-month 'Little Champs' community-based motor development programme positively impacted on cognitive function and gross motor skill proficiency in preschool children from disadvantaged communities in South Africa. The programme included supervised free-play and low intensity structured activities delivered by community-based coaches once per week for 45 to 60 minutes. Numeracy and literacy tasks were also incorporated to stimulate cognitive development. Study one was a quasi-experimental design where FMS was measured using the TGMD-2 in a sample of 60 intervention participants and 58 control participants. The lack of pre-test scores for FMS competence is a major limitation to this study, however at post-intervention, the intervention group were significantly superior in both locomotor ($p<0.005$) and object-control skills ($p<0.01$) compared to the control group. In study two, the intervention ($n=43$) and control ($n=40$) groups were assessed for cognitive function using the Herbst test (Herbst and Huysamen, 2000) at pre- and post-intervention. Three early childhood centres were part of the intervention, however, only one group ($n=22$) adhered to the Little Champs programme regularly with two groups ceasing attendance after a two-month period with the group that continued, being referred to as the active intervention group. As expected, cognitive function improved over time for both groups, but the active intervention group was the only group to achieve a significant improvement ($p=0.001$). As this group had higher cognitive scores to begin with, it is difficult to attribute the improvements solely to the intervention. Differences in the level of effort and motivation from the leaders and coaches may have also influenced the improvements more than the intervention itself. Due to poor implementation and tracking of the programme, the results must be considered with caution.

Children between 6- and 8-years-old (Woodard and Surburg, 2001) and 7- and 12-years-old (Westendorp et al., 2011) with learning difficulties have demonstrated lower locomotor and object-control skill scores compared to children without learning difficulties. Westendorp et al. (2011) reported a stronger effect size for object-control skills (p 0.001, $d=0.61$) compared to locomotor skills ($p<0.001$, $d=0.47$). The differences may be explained by the greater reliance on executive functioning, required for execution of object-control skills. Among those with a learning disability, poorer locomotor skill scores were weakly, but significantly associated with both reading ($r=-0.24$, $p<0.05$) and spelling ability ($r=-0.22$, $p<0.05$), whereas object-control skill competence was weakly, but significantly correlated with mathematical ability ($r=-0.29$, $p<0.01$). Regression analysis revealed reading ability could predict 4.8% of the variance in locomotor skill competence ($p=0.04$), but mathematical ability was not a significant predictor of object-control skill competence ($p=0.05$). This study highlights that children with combined learning disabilities and poor FMS, have poor academic ability, but results cannot be generalised to typically developing children. Despite that, the findings suggest that motor skill development and academic ability may be related.

Typically developing Portuguese children with insufficient motor coordination, demonstrated lower levels of academic ability compared to their peers with normal or good coordination (Lopes et al., 2013). Similarly, Ericsson (2008) found that Swedish children who undertook an extended school-based PA and extra motor training intervention, scored higher in Swedish language and mathematics tests than children who continued with their usual two PE classes per week. No specific statistics were reported but Cramer’s index values reported differences between the control and intervention groups to be moderate, ranging from 0.21 to 0.29. In addition, Frick and Möhring (2016) identified a moderate but significant relationship between balance skills and spatial scaling ($r=0.30$, $p<0.01$) and a weak but significant relationship between balance and proportional reasoning skills ($r=-0.26$, $p<0.01$) among Swiss kindergarten children. Spatial scaling and proportional reasoning skills are essential for understanding many mathematical concepts including fractions (Möhring et al., 2015) and therefore children who demonstrate higher balance proficiency, could have enhanced mathematical ability. The reason provided for this association is that balance is a pre-requisite for locomotion, which facilitates active exploration of the spatial environment. By actively exploring the environment, children can explore the spatial relations between objects and agents and thus improve their spatial cognitive skills. Alternatively, advanced balance skills suggest that an individual can effectively process visual, proprioceptive and vestibular information simultaneously, and this ability for sensory integration may contribute to superior mathematical understanding.

Significant, but weak relationships were observed between academic performance (combined Finnish language, mathematic and history scores) and FMS scores among grade seven (mean age: 13.08±0.25years) Finnish junior high school males ($r=0.16$, $p<0.05$) and females ($r=0.19$, $p<0.05$). A longitudinal design was adopted with FMS measured in grades seven and eight and academic performance at grades seven, eight and nine. Interestingly, the strongest relationship was found between leaping in grade eight and mathematics in grade nine which was significantly, moderately correlated for both males ($r=0.30$, $p<0.001$) and females ($r=0.41$, $p<0.001$). It may be speculated that leaping required higher levels of static and dynamic balance in comparison to the dribble and shuttle run and therefore could provide further support for the potential relationship between balance skills and mathematical ability (Frick and Möhring, 2016).

As learning complex motor skills potentially relies on similar executive functions and processing, to that of cognitive abilities, FMS based interventions may have the potential to improve both motor competence and academic performance simultaneously. This could have significant implications for school-based PE lessons. Teachers often fear that increasing PE time will negatively affect progress in what are deemed to be more academic subjects like mathematics and languages (Harris, Cale and Musson, 2012; MacPhail and Halbert, 2005). However, as higher levels of motor competence may enhance academic performance, increasing time spent in quality FMS based PE lessons may lead to benefits both inside and outside the classroom (Macdonald et al., 2018).

2.4.6 Summary of health-related benefits associated with higher motor competence

Evidence suggests that improving FMS competence can provide both physical and cognitive benefits (Lubans et al., 2010; Logan et al., 2015; Barnett et al., 2016; Catuzzo et al., 2016). Higher levels of FMS proficiency may improve perceived competence providing a greater sense of confidence to engage in regular PA and sports (Stodden et al., 2008; Robinson et al., 2015). Consequently, children are more likely to maintain a healthy weight status, increase health-related physical fitness and perform better academically. Due to the range of positive health consequences that may occur, it is important to identify the types of intervention programmes that may support children's FMS development.

2.5 Intervention programmes to improve FMS competence among primary school children

Intervention programmes have been successful at improving both FMS competence and PA engagement in both children and adolescents (Lai et al., 2014). Schools are a popular setting for implementing intervention programmes as they are accessible to children from multiple backgrounds; however, some evidence also exists for successful home and community-based interventions (Bardid et al., 2017; Draper et al., 2012). Interventions that adopt a multi-component approach tend to be more effective, whereby co-operation between school staff, parents and the community is required (Tompsett et al., 2017). Such interventions require large amounts of planning and co-operation and are not always feasible due to time restrictions and funding difficulties in schools. Following the poor PA participation rates from the first Children's Sports Participation and Physical Activity (CSPPA) study, Woods et al. (2010) recommended the implementation of a robust surveillance system to monitor PA and health behaviours of children and adolescents. This has not yet been introduced and the second CSPPA study reported a 2% drop in the proportion of primary and secondary school students meeting the recommended daily PA guidelines to 17% and 10%, respectively (Woods et al., 2018).

An example of one such surveillance system is the Australian Schools Physical Activity and Nutrition Survey (SPANs) which gathers information on school children's PA levels, weight status, dietary habits, FMS competence, sedentary behaviours, school environment and school travel. Monitoring these factors has facilitated the development of targeted interventions and consequently contributed to significant improvements in FMS competence and stabilisation of weight status among Australian primary school children between 2010 and 2015 (Hardy et al., 2016). The significance of these findings are highlighted when compared to a previous report (Booth et al., 1997) which found a decrease of between 40 and 50% in vertical jump competency, and increasing male superiority in skills such as kicking and overarm throwing between 1997 and 2010 (Hardy et al., 2013). Furthermore, the SPANs programme highlights the potential positive implications associated with adopting a large scale, school-based surveillance system. In addition to identifying the specific behaviours in need of attention, the SPAN's programme also recognized that children from lower socioeconomic backgrounds and Middle Eastern cultural background were more likely to be overweight/obese than Australian born children from higher socioeconomic backgrounds. The identification of these trends is essential to ensure the cost-effectiveness and efficacy of intervention programmes are maximised. However, the success of intervention programmes will depend on a number of factors such as who implements the programme, the duration and frequency of individual sessions, the duration of the overall intervention and the ability to differentiate content to facilitate individual needs and capabilities. As such, it is important to analyse previous programmes and identify key characteristics associated with successful outcomes.

Systematic reviews and meta-analysis have reported mainly positive intervention effects for at least one FMS across all age groups, including 3 to 6-year old pre-school and kindergarten children (Wick et al., 2017; Veldman et al., 2016; Riethmuller et al., 2009) and 5- to 18-year-old, primary and secondary school children and adolescents (Morgan et al., 2013). Additionally, Lai et al. (2013) and Tompsett et al. (2017) suggest that multi-component interventions delivered over one academic year, and which are underpinned by pedagogical practices informed by a motor learning theory, are most effective. However, Morgan et al., (2013) and Wick et al. (2017) speculate that short-duration interventions, delivered over 12 weeks or less, may provide similar improvements in FMS proficiency. Due to large heterogeneity across studies, the intervention components that are most effective for FMS development are unclear. The following paragraphs aim to identify the factors that may be most influential.

2.5.1 Short-duration intervention programmes (≤ 12 weeks)

Improvements in FMS proficiency have been observed following intervention programmes as short as 6 (Bryant et al., 2016; Mitchell et al., 2013) and 7 weeks (Miller et al., 2016). However, interventions that have focused on pedagogical practices may be more effective. Bryant et al. (2016) failed to specify if the intervention group, who received one 60-minute FMS session in place of one of their two PE lessons per week over 6 weeks, improved to a significantly greater extent than the control group. Both groups improved from pre to post intervention but there was a high risk of cross-contamination due to both intervention and control participants being in the same school. It was also not specified if the instructional strategy was based upon any learning theories.

Similarly, the instructional strategy was not prioritised in the 6-week active video game intervention by Johnson et al. (2016), where no significant improvements in object-control skills or perceived motor competence were observed from pre to post intervention.

In contrast, a 6-week intervention that focused on training teachers to implement the FMS component of the large-scale multi-component Project Energise intervention in New Zealand, reported significant improvements from pre to post intervention for all 12 FMS that were assessed (Mitchell et al., 2013). Teachers were encouraged to provide student-centred PE lessons that focused on improving FMS. Although no control group was included in this study, it is likely that the teacher's ability to assess FMS and subsequently tailor the PE lessons to the needs of each child contributed to the observed improvements. PE lessons are often teacher-led to the extent that student autonomy is neglected. This may have negative implications for enjoyment of PE and motivation to engage in PE activities (Standage et al., 2005; Perlman and Webster, 2013). Consequently, the effectiveness of an intervention programme can be significantly influenced by the type of motivational climate that is created during the lessons.

Short-duration interventions delivered through a mastery-motivational climate (Miller et al., 2016; Lander et al., 2017) have provided significant improvements in FMS proficiency, when compared to a control group. As discussed in section 2.3.4.5, mastery-motivational climate encourages children to focus on self-improvement and to avoid peer comparison and competition with others (Ames, 1992). The role of the teacher is to limit the provision of direct instructions, but to rather act as a facilitator and alter environmental cues that will facilitate skill development. Children are more likely to feel intrinsically motivated if they experience success, therefore all children should experience success in each lesson. Success is only experienced by more highly skills individuals in ego-centric, competitive environments. It is therefore unsurprising that mastery-motivational climates are being introduced to enhance the efficacy of FMS based intervention programmes. However, short-duration intervention studies that incorporate a mastery-motivational climate as a strategy to improve FMS proficiency levels in a primary school setting are lacking, with only one reported to date (Miller et al., 2016). In the study by Miller et al. (2016), teachers received 6 hours of training and in-class support for 5 of 7 lessons. Although object-control scores significantly improved at post-intervention compared to the control group who continued with their usual PE routine ($p<0.001$, $d=1.0$), only three skills were assessed in the study.

However, significant improvements were reported for preschool children (Martin et al., 2009; Robinson and Goodway, 2009; Valentini and Rudisill, 2004; Robinson et al., 2012) and adolescents (Lander et al., 2017) who underwent intervention programmes of 12 weeks or less and were underpinned by mastery-motivational theory. Furthermore, preschool children were more likely to retain their post-intervention skill improvements at a 9-week (Robinson and Goodway, 2009) and 6 month (Valentini and Rudisill, 2004) follow-up. Further investigations are required to determine if similar results are possible among a primary school population, however there is evidence to suggest that mastery-motivational climates adopted for longer-duration interventions can provide significant improvements in FMS competence (Lai et al., 2014).

An additional concern among many movement practitioners is that too much focus on skill development may lead to a reduction in PA participation and intensity and negatively impact CRF. However, the Professional Learning for Understanding Games Education (PLUNGE) programme (Miller et al., 2017) proves that it is possible to both increase in-class step count and improve FMS competence using a game-centred approach with gradually increasing difficulty. This approach to teaching FMS contrasts with the advice provided by Woods et al. (2010), whereby it was recommended that teachers put less emphasis on game-centred activities in a bid to improve FMS competence. Similarly, Karabournitios et al. (2002) found that games-centred PE lessons did not lead to improvements in FMS competence in comparison to a skill-based programme that incorporated self-testing activities. The conflicting findings from game-centred activities may be due to how they are implemented. Traditionally, games can be highly competitive and only suited to those with higher skill levels. However, non-competitive, developmentally appropriate, small-sided games may be more effective at improving FMS competence and increasing enjoyment of PA engagement (Smith, 2016). For this to be successful, movement practitioners, require specialist knowledge to identify movement capabilities of the children they are teaching and must understand how to provide developmentally appropriate and inclusive pedagogical practices.

Oftentimes, principals and teachers can be hesitant to participate in intervention programmes and ignore advice to increase time or frequency of PE lessons due to the already overcrowded curriculum. The Great Leaders Active Students (GLASS) program is an alternative approach whereby older school children received FMS and leadership skills training and were assigned to teach FMS lessons to groups of younger children in their school (Nathan et al. 2017). Oftentimes, children can learn and retain information better by teaching others and so encouraging children to teach each other may be more attractive within a school environment. The peer leaders successfully conducted the FMS lessons and the younger children significantly improved their object-control skill competence from pre to post-test in comparison to a control group. While the peer leaders did not report a significant improvement in self-reported leadership skills, the teacher's perceptions of the peer leaders' leadership skills significantly improved following the intervention ($p<0.001$). It is therefore reasonable to suggest that short-duration FMS based intervention programmes can provide multiple learning opportunities in a way that is both cost-effective and time efficient.

2.5.2 Longer-duration intervention programmes (> 12 weeks)

Many longer-duration interventions, that aim to improve FMS proficiency or PA levels of primary school children, tend to be delivered over a full academic year (van Beurden et al., 2003; Cohen et al., 2015; Bolger et al., 2019). These longer-duration interventions tend to be multi-component, requiring co-operation between the school, teachers, researchers, children and parents. Significant improvements in FMS proficiency levels are often reported at post-intervention, however it can be difficult to determine what components of the intervention were most influential. It is also difficult to track adherence to each element of the programme. Follow-up studies are also lacking, which limits the interpretability of the long-term effectiveness of the programmes. PE in Irish primary schools is typically taught by a non-specialist, generalist teacher (Fletcher and Mandigo, 2012). Large curriculum demands are inevitable and oftentimes PE lessons are seen to be of less importance than other subjects like math and languages (Hardman, 2008). Although the multi-component interventions provide a holistic approach to improve FMS and other health related outcomes, they may be too overwhelming for some schools to engage with. However, investigating the components and impact of the longer-duration interventions, may signify the most influential elements that contribute to successful outcomes.

Similar to Ireland, the generalist teacher is responsible for teaching PE in Australian primary schools. However, large efforts have been made to upskill their teachers on how to implement FMS based PE lessons. The Move it Groove it (MIGI) collaborative health promotion intervention, aimed to improve FMS and PA behaviours among 1045, 7 to 10-year-old primary school pupils (van Beurden et al., 2003). Intervention components included, whole-school policy adaptations, buddy systems, teacher professional development and website resources. FMS competence improved by 16.8% from pre- to post-intervention. Relative to the control group, the intervention group improved significantly more in seven out of eight FMS. The largest differences were observed in boys sprint run performance and girls side gallop for which intervention participants achieved a 26% ($p<0.001$) and 22% ($p<0.001$) greater improvement than their control group, respectively. However, the intervention had little effect on children's PA levels, which significantly increased by only 3.3%, or 58 seconds per 21-minute class, for intervention participants compared to controls. Furthermore, 276 participants were reassessed six years later (Barnett et al., 2009), where they were five times more proficient at catching, but had not improved in any other skill, and were no more active than those from the control condition. This suggests the intervention had limited long-term effects. The multi-component nature of the programme may have been too complex for schools to fully engage with at one time. Additionally, self-report measures of PA were used which can often be inaccurate if children are unable to accurately recall their PA engagement. Some of these issues were addressed in a cluster randomised controlled trial by Cohen et al. (2015).

To reduce the burden on teachers and schools, Cohen et al., (2015) introduced the components of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention in a staged manner. The socio-ecological model provided a framework for the intervention, which supports the idea that the environment and social context is essential to learning (McLeroy et al., 1988). Teacher professional development, school policies, provision of equipment, parent involvement and community links, were all targeted to facilitate opportunities for PA engagement and skill development. Although the improvement in overall FMS was small at post-intervention, compared to the control group, children in the intervention group were engaging in 13 minutes more moderate to vigorous PA per day ($p<0.003$), measured using accelerometers, and were running five extra laps in the 20m multi-stage fitness test ($p=0.003$). A follow-up study revealed that 23% of the improvements in PA levels and CRF were mediated by overall FMS scores, suggesting that targeting FMS within interventions may be essential to their success. Improving actual FMS competence could contribute to behaviour modification, as having the skills to engage in different sports and PA will make it easier for children to be more physically active (Stodden et al., 2008).

The inclusion of FMS based lessons within multi-component school-based interventions was also a significant factor influencing the successful outcomes in studies by Bolger et al. (2019) and Salmon et al., (2008). Bolger et al. (2019) investigated the impact of a one-year PA intervention with no FMS focus, followed by a one-year multi-component FMS-based intervention on 6- to 11-year-old Irish primary school children's FMS proficiency levels. Both interventions were delivered by a qualified specialist with a strong FMS background, whilst the control conditions consisted of normal PE, delivered by the class teacher. The PA intervention provided limited improvements in FMS proficiency levels. The intervention group significantly improved their locomotor subtest scores compared to baseline ($p=0.04$), but locomotor, object-control and total FMS scores were similar to the control group at post-intervention ($p>0.05$). In contrast, the targeted FMS intervention led to significant improvements in locomotor, object-control and total FMS scores from pre to post FMS intervention (all $p<0.001$), whilst the control group (i.e. those engaging in their usual PE lessons) had significantly lower FMS scores at post-test. The findings of this study suggest that rather than general PA instruction, specific FMS instruction by qualified professionals with a significant understanding of FMS, is required to facilitate FMS development

Many primary school teachers in Ireland have limited specialist knowledge for teaching PE (Fletcher and Mandigo, 2012; Kinchin et al., 2012). It is therefore unsurprising that Irish adolescents enter second level education with inadequate FMS proficiency (O'Brien et al., 2016a; Lester et al., 2017), and that many female adolescents are dropping out of sport after leaving primary school (Woods et al., 2018; Lunn et al., 2013). For example, the proportion of girls in secondary school who do not participate in any community sport is 45% compared to only 8% at primary level (Woods et al., 2018). Furthermore, Salmon et al., (2008) identified that, compared to a control group, a combined FMS and behaviour modification group were 60% less likely to be overweight or obese following the Switch-play intervention (1 academic year) which was also maintained at 6- and 12-month follow-up. Australian school children (aged 10-to 11-years) from low-income backgrounds were assigned to either a control, FMS only, behaviour modification only or combined group at baseline. The FMS only group, engaged in an average of 13% more moderate to vigorous PA, and reported greater enjoyment of PA, at post-intervention, which were also maintained at 6- and 12-month follow-up. Interestingly, only girls in the FMS group and the behaviour modification group, significantly improved their FMS scores following the intervention and maintained them at 12-month follow-up. However, there was no significant improvements in FMS proficiency levels among girls in the combined group or among males in any of the three intervention groups. Despite some disparities, the results provide further evidence of the potential impact of FMS based intervention programmes. The FMS sessions were delivered by a specialist FMS instructor who emphasised fun and maximum engagement. This ability to provide an inclusive environment may have contributed to the increased engagement and enjoyment among the FMS group following the intervention period.

2.5.3 Summary of intervention programmes

This section has highlighted the potential benefits associated with implementing school-based FMS intervention programmes. Long-duration programmes have resulted in improved weight status (Salmon et al., 2008), FMS competence (van Beurden et al., 2003; Bolger et al., 2019; Cohen et al., 2015), PA levels (Salmon et al., 2008; Cohen et al., 2015) and enjoyment of PA (Salmon et al., 2008). Improvements in primary school children's FMS proficiency were also observed following short-duration interventions (Miller et al., 2016; Mitchell et al., 2013; Nathan et al., 2017). Follow-up analysis of both short and long-duration primary school-based intervention programmes are lacking and require further investigation. Although effective, the multi-component nature of many interventions, makes it difficult to decipher the most important elements that should be included. The combined evidence from both long and short-duration studies, suggest that the teaching of FMS may be a significant contributing factor to the success of these programmes, especially when an underlying theory such as mastery-motivation is used to guide the lessons. Perhaps, teachers need specific training on how to effectively teach FMS in PE lessons (Lander et al., 2015; Ross et al., 2014). Due to large curriculum demands in Irish primary schools, shorter duration interventions may be more feasible for schools to implement than those that require adherence over a full academic year. The feasibility of implementing programmes is hugely influenced by teachers' willingness to engage with the process. Generalist teachers are responsible for the delivery of PE in Irish primary schools; however, many have received as little as 12 hours of PE specific training during their pre-service teacher education (Fletcher and Mandigo, 2012). Thus, further PE teacher education opportunities should be provided for both pre-service and in-service teachers. Training related to how FMS can be incorporated into the overall PE curriculum may also enhance the quality of the teaching and learning experience.

2.6 PE in Irish primary schools: currently and moving forward

Primary education in Ireland is an eight-year cycle, catering for children between approximately 5- and 12-years-old. Each primary school teacher is responsible for the delivery of all areas of the curriculum, which includes languages (English and Irish), mathematics, social, environment and scientific education, arts education, PE and social personal and health education. As such, teacher training at primary level is not specialised for the delivery of any one specific subject area, but rather focuses on how to implement the various components of the overall curriculum. The revised curriculum launched in 1999 by the National Council for Curriculum and Assessment (NCCA), aims to provide a well-rounded, holistic education for the child in the modern world. Unfortunately, failure to provide adequate upskilling and specialist training for teachers makes it difficult for all desired curriculum changes to be implemented (Walsh, 2016). This is especially true for PE lessons which are often perceived to be 'of less importance' than other subjects like English and maths (Hardman, 2008). However, if the curriculum was designed to keep up with modern societal change in a bid to facilitate the holistic development of the child, implementation of high-quality PE lessons would be of utmost importance.

While the current PE curriculum mentions little in terms of the importance of FMS, it does mention that FMS should be embedded throughout the PE curriculum and taught through the six strand areas of games, athletics, gymnastics, dance, outdoor and adventure and aquatics (NCCA, 1999). However, the level of PE specific training that pre-service teachers receive, varies depending on what teacher training college they attend (Crawford et al., 2016) and whether they choose PE as a subject specialism. Using one teacher training college as an example, all trainee teachers must complete two core PE modules, one in first year and one in second year, amounting to 48 hours of PE related contact time (Marron et al., 2018). First year students are introduced to PE pedagogy and practice through the exploration of the games, athletics and dance strands and are also introduced to FMS, teaching methodologies and how to prepare for teaching PE on placement. Year 2 offers further study related to athletics, games and dance for senior classes and introduces aquatics, gymnastics, and outdoor and adventure activities. Greater emphasis is put on differentiation, inclusion, and the promotion of PA (Marron et al., 2018). Due to the vast array of content to be covered in relation to teaching PE, 48 hours of PE specific teacher education provides only a brief insight into the different areas.

PE has only been offered as a subject specialism since 2013 (Teaching Council, 2013) and is limited to approximately 25 trainee teachers in each college that offers the PE specialism. Teachers gain PE specialism status by completing an additional 120 hours of PE related study in second, third and fourth year on top of the two core modules that are compulsory for all trainee teachers. Teachers accepted to the PE specialism gain further insight into theory, practice and FMS development in second year. Third year focuses on inclusive practice, teaching games for understanding and personal and social development through PE. Leadership skills are taught in fourth year to encourage PE specialists to support fellow teachers and to take the lead in encouraging a whole school approach to delivering quality PE programmes in their schools (Marron et al., 2018). Although positive steps are being taken in recent years to increase the quality of PE lessons in Irish primary schools, capacity issues limit the numbers that can choose PE as their subject specialism during pre-service training (Marron et al., 2018). Consequently, teacher confidence to teach PE is typically low following pre-service teacher education (Fletcher and Mandigo, 2012). With new curriculum reforms in the primary education system due to be implemented soon, PE is likely to be of particular interest to stakeholders. Areas of interest include time allocation for PE and also the quality of PE lessons which should adequately support children to develop proficiency in a broad range of FMS. As such, the 2015 All Island All Ireland position Statement on FMS in Initial Teacher Education suggests that "FMS teaching and learning should be mandatory for all pre-service primary and physical education teachers." (Crawford et al., 2016, pg. 74) and recommend that "appropriate time is allocated to FMS in undergraduate degree programmes" (Crawford et al., 2016, pg. 74).

However, updating PE policy in written format is the least complex step, and a roadmap for practically implementing the policy aspirations is a consistent oversight from policy makers (Walsh, 2016). The United Nations Educational, Scientific and Cultural Organisation (UNESCO) (2014) have provided a policy to practice infrastructure model (Figure 2.4) which highlights the complexity and broad number of factors that need to be addressed to ensure successful implementation of policy change. Significant shortfalls preventing successful implementation within an Irish context include issues around PE time and curriculum content in addition to both teacher and institutional related factors.

Figure 2.4 School Physical Education Basic Needs Model: Policy to Practice Infrastructure Template (UNESCO, 2014)

2.6.1 Time allocation and content

Currently, Irish primary teachers are advised to teach a minimum of 60 minutes of PE per week. However, weekly averages can range from 10 to 140 minutes (Department of Education and Skills 2016) and more recent evidence highlights that 18% of Irish school children receive less than 30 minutes of PE lesson time per week (Woods et al. 2018). This is in comparison to global and European weekly averages of 103 and 112 minutes respectively (UNESCO 2014; European Commission 2013). Males and females received equal PE time in Irish primary schools and the minutes spent in PE per week is not influenced by socioeconomic status, designated disadvantaged status or location (rural or urban) (Woods et al., 2018). New curriculum proposals have called for a minimum of 150 minutes of PE to be implemented to all primary school children each week (IPPEA, 2017) which may be possible through a weekly provision of 2 hours extra 'flexible time' to be used at each teacher's discretion. However, there is a risk that teachers will be likely to choose other subjects which they perceive to be more important or more enjoyable for them to teach, and therefore providing the two extra hours 'flexible time' does not guarantee a greater commitment to teaching PE. Furthermore, the European Commission Expert Group on health-enhancing PA recommends that pupils engage in one hour of PE daily (European Commission for Sport 2015). This may be overly ambitious considering schools are already struggling with the current minimum requirement of one hour per week. Further to the allocation of extra time to teach PE, the content covered in PE lessons should also be improved. Although guidelines are provided for teachers, the current PE curriculum is extremely broad and the implementation is highly variable among different teachers and schools (Woods et al., 2018).

As mentioned earlier, six strands are included in the teacher guidelines for teaching PE, however, not all are given equal attention. The three most popular activities covered in primary PE lessons were basketball, soccer and Gaelic football (Woods et al., 2018). Furthermore, when asked about the content covered in PE over the previous year, 98% of the reported content represented activities from the games strand, whilst athletics (56%), aquatics (43%), dance (41%), gymnastics (25%) and outdoor and adventure (20%) strands were much more poorly represented (Woods et al., 2018). Whilst plans are ongoing for the implementation of a newly reformed primary PE curriculum (Woods et al, 2018), those responsible for creating and setting the guidelines must carefully consider how a more equal spread of activities from all six strands will be taught. Ensuring more equal coverage of all strand areas may help to combat the low levels of FMS proficiency among Irish school children (Bolger et al., 2018; Behan et al., 2019) and adolescents (O'Brien et al., 2016b; Lester et al., 2017). Both institutional and teacher-related factors need to be considered to support this change (UNESCO, 2014; Morgan and Hansen, 2008).

2.6.2 Teacher-related factors

According to Bandura (1977; 1986), teachers can positively or negatively influence a child's perception of PE and PA behaviours. This is based upon the social cognitive theory (Bandura 1986) whereby children learn through their observation of others. Teachers who act as positive role models with high motivation and self-efficacy for PA may have a positive influence on their student's attitudes and engagement for PE (Trudeau and Shephard, 2005). However, generalist teachers consistently report a lack of confidence and competence in teaching PE (Fletcher and Mandigo, 2012; Morgan and Bourke, 2008) which in turn can negatively affect their students' experiences of PE and PA (Broderick and Shiel 2000; Deenihan 2005). In contrast, specialist PE teachers may be better role models as they are typically more motivated and have higher levels of self-efficacy to teach PE compared to generalist teachers (Truelove et al., 2019; Breslin et al., 2012). However, consideration is needed with regard to what constitutes being a specialist in the context of teaching PE to primary school children so as not to confuse specialist PE teachers, who possess a primary teaching qualification with additional PE specific training, with external providers.

In some instances, external providers who are typically local sports coaches with no formal teaching qualification, and often only present in the school for a few weeks each year (Ní Chróinín and O'Brien 2019; Woods et al., 2010; 2018), assist the generalist teacher in teaching PE (Bowles and O'Sullivan, 2020; Ní Chróinín, 2017). However, rather than working collaboratively with external providers to try and enhance their own content and pedagogical knowledge, the classroom teachers tend to take a backseat and allow the external provider to have full control of the lessons they are teaching (Ní Chróinín and O'Brien 2019). Due to having limited interaction with children, external providers are not in the same position as the classroom teacher to monitor the progress of individual children over time and may find it difficult to differentiate tasks and activities based on ability (Griggs, 2007). This may have negative implications for less skilled children who already struggle with perceived competence and confidence to take part in PE and PA. Furthermore, external providers typically teach some aspect of the games strand (Woods et al., 2018), particularly GAA in the Irish context (Bowles and O'Sullivan 2020). However, games is also the strand area that non-specialist teachers feel most confident to teach (Morgan and Bourke, 2008). Although there are benefits to including external providers in teaching PE, the main responsibility should remain with the classroom teacher (NCAA, 1999). Thus, greater care needs to be given to the type of external providers that are employed in addition to the working relationship between the external provider and classroom teacher to further enhance the learning experience for all involved (Ní Chróinín and O'Brien 2019; Blair and Capel, 2011).

When PE is taught by the non-specialist mainstream teacher, classes may be poorly planned and consist of mainly free-play activities or competitive style games, with little opportunity for quality instruction and feedback to improve FMS (Gordon and Inder 2000). Teacher's confidence to teach PE has a huge impact on how often they teach PE, and this is largely determined through their own personal attitudes and behaviours to PA and their teacher training experiences (Morgan and Hansen 2008). Although having a specialist teacher does not guarantee a quality programme, they are generally more effective through their use of varied and individualised instructional methods, provision of opportunities for skill development, use of quality assessment and feedback and commonly have a positive impact on the overall school environment (Davis et al., 2005).

Levels of self-efficacy vary between specialist and non-specialist teachers and can significantly influence the delivery of PE (Breslin et al., 2012). As part of a four-year course in Northern Ireland, 11 teachers underwent approximately 340 hours of PE focused training and were classified as specialists, with the remaining 11 (non-specialist group) having engaged in only 24 hours of specialist PE training (Breslin et al., 2012). Compared to non-specialist teachers, specialist teachers engaged in four times more vigorous PA (η_p^2=0.37; p=0.003) and had significantly higher levels of self-determination towards exercise (η_p^2=0.56, p=0.01) as measured using the International Physical Activity Questionnaire and Behavioural Regulation in Exercise Questionnaire-2. Furthermore, 72.7% of specialist teachers met the recommended levels of daily moderate to vigorous PA compared to only 36.4% of non-specialist teachers. In alignment with the social cognitive theory, these findings suggest that specialist teachers may act as better role models than non-specialist teachers and provide a more positive learning experience for their students during PE (Bandura 1986). Either specialist teachers should be employed within the Irish primary school system, or mainstream teachers should be provided with sufficient training and support to ensure they acquire the skills and confidence to deliver a high-quality PE curriculum.

The quality of the learning experience for students is largely determined by the quality of the teacher (Sandholtz 2002). Therefore, investments should be made to ensure adequate training is provided to teachers. Irish primary teachers are often upskilled through continuing professional development (CPD) programmes, which typically involve short courses or workshops where the teacher is introduced to new content knowledge. Such training courses may increase the teacher's confidence (Hart 2005) but are often deemed ineffective, as teachers are not taught how to practically implement what they learn (Humphries and Ashy, 2006) resulting in minimal impact on actual pedagogical practices. In recognition of this issue, the National In-service Physical Education Programme (NIPEP) was introduced to train teachers through more active engagement with lesson content and to learn through experience (Murphy and O'Leary, 2012). In addition, provisions of local support networks were deemed to be effective methods of instilling confidence in teachers to implement the curriculum to a higher standard (Murphy and

O'Leary, 2012). This was further supported by Coulter and Woods (2012) who examined how an on-site PE professional development programme (PE-PDP) can affect a teacher's experience of delivering PE. A PE expert facilitated the class teachers in the delivery of all PE classes over six weeks. Support was offered at varying levels depending on the needs of the individual teachers including support on how to effectively adapt the information provided in external resources and materials to suit the needs of their class. Focus groups were conducted at the end of the six-week period whereby modelling of the PE lessons by the PE expert was deemed to be highly effective in raising teachers' perceived confidence to teach the class themselves. Watching an expert deliver the lesson in a context specific to their individual situation was more beneficial than trying to visualise the delivery of a lesson from reading a lesson plan.

While Coulter and Woods (2012) focused on training teachers in a specific strand area of the curriculum, training teachers to incorporate FMS based lessons into their overall PE programmes may be more beneficial as it can significantly improve the overall instruction and assessment practices (Breslin et al., 2012; Lander et al., 2015). In addition, children who were taught by FMS trained teachers had significantly higher levels of self-perception, across all four domains of the Harter Self-Perception Profile for Children (Harter 1985) compared to those taught by non-FMS trained teachers. This included scholastic competence ($p<0.001$), social acceptance ($p=0.002$), athletic competence ($p=0.001$) and global self-worth ($p=0.006$) (Breslin et al., 2012). Children aged 7- and 8-years from ten schools in Northern Ireland were included in the study with 107 taught by FMS trained teachers and 70 by non-FMS trained teachers. The findings suggest that FMS trained teachers may have a greater influence on children's attitudes and perceptions of PA and PE which is likely to provide long-term health benefits (Breslin et al., 2012).

As part of Healthy Ireland's National Physical Activity Plan, launched in 2016, CPD opportunities and resources for teachers regarding the provision of PE have improved (Department of Health, 2018). At primary level, the Professional Development Services for Teachers (PDST) have delivered workshops, summer courses and national seminars on teaching PE through the lens of FMS through their Move Well Move Often initiative. Various resources for planning, teaching, and assessing FMS are now freely available for teachers to use through their online platform (Scoilnet, 2019). These positive initiatives demonstrate that national stakeholders in Ireland recognise the importance of quality PE and the need to support children's FMS development through PE lessons. However, there is currently no understanding of how effective these initiatives are or whether or not primary school teachers in Ireland feel confident to teach all aspects of the primary PE curriculum.

2.7 Summary

Children worldwide (van Beurden et al., 2002; Bardid et al., 2016; Spessato et al., 2013; Pang and Fong, 2009; Hardy et al., 2015) and in Ireland (Bolger et al., 2018; Behan et al., 2019), are not achieving adequate proficiency in FMS. This is a potential contributor to the high rates of physical inactivity, rising obesity levels and worsening health status of children. Limited FMS based research has been conducted in the Irish primary school setting. However, the current evidence reporting low levels of FMS proficiency among both primary school children (Bolger et al., 2018; Behan et al., 2019) and adolescents (O'Brien et al., 2016b), highlights the need for further research in this area. To achieve competency in FMS, children require quality instruction and practice opportunities (Gallahue et al., 2012), ideally during the primary school years. However, in order to be effective, the instructors require specialist FMS knowledge and perhaps an underlying understanding of motor learning theories to guide their teaching strategies. Intervention programmes that are guided by an underlying theory such as self-determination theory and achievement goal theory have significantly improved FMS proficiency levels in the school setting (Lai et al., 2014). However, many of the programmes are multi-component and of long duration which are not always appealing for schools trying to keep up with the current curriculum demands. Therefore, there is a need to determine if a short-duration, less complex intervention can improve FMS proficiency levels and to see if there are any lasting effects. The final section of this review looked at the current situation of PE in Irish primary schools. As PE in Irish primary schools is taught by non-specialist mainstream teachers, the quality of PE and commitment to teaching PE varies between schools and may be largely dependent upon the teacher's personal interest in the subject (Morgan and Bourke, 2008). There is a dearth of information to determine current perceptions, attitudes, and perceived confidence to teach PE among Irish primary educators. The teachers' attitude towards, and commitment to teaching PE may have a long-term influence on the child's FMS development and subsequent enjoyment of and motivation to engage in regular PA throughout life (Trudeau and Shephard, 2005; Standage et al., 2005; Cairney et al., 2012). It is therefore essential to understand these attributes within an Irish context to ensure adequate resources and support structures can be provided.

Chapter 3: Fundamental movement skill proficiency levels of Irish primary school children

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3.1 Abstract

Introduction: Fundamental movement skills (FMS) are basic observable patterns of movement that create a foundation for the development of more advanced skills needed for activities of daily living, physical activity, and/or competitive sport. The aim of this study is to investigate FMS proficiency among Irish primary school children and to identify any differences according to sex, class group and weight status.

Methods: A convenience sample of 414 school children (age range: 6-12 years) were recruited from three primary schools in the midlands of Ireland. All children were video recorded performing two trials of 15 FMS. These skills were later analysed using performance criteria outlined in the TGMD-3 (run, gallop, hop, skip, slide, horizontal jump, two-hand strike, forehand strike, kick, overhand throw, underhand throw, dribble, catch), the Victorian Fundamental Motor Skills Manual (vertical jump) and the Get Skilled: Get Active (static balance) protocols.

Results: Intra-rater reliability was established prior to scoring skill performances (ICC: 0.79 – 0.94). Percentage mastery ranged between 1.4% (gallop) and 35.7% (slide). A two-way ANOVA evaluated the effect of sex (male/female) and class group (Year 2/3/4/5/6/7) on individual skills, locomotor subtest, ball skills subtest and total TGMD-3 scores. No significant sex × class interaction effects were found. Large effect sizes were reported for male superiority in the ball skills subtest (η_p^2=0.26) and total TGMD-3 (η_p^2=0.16) scores (both $p<0.001$). Older classes had higher ball skills subtest scores than younger classes, but scores plateaued after Year 5. Furthermore, overweight participants had significantly lower locomotor subtest ($p<0.001$, d=0.7), ball skills subtest (p=0.03, d=0.3) and total TGMD-3 scores ($p<0.001$, d=0.5) than non-overweight participants.

Conclusion: Irish primary school pupils are not reaching their developmental potential for FMS mastery with females and overweight children performing significantly worse than males and non-overweight children, respectively. Poor FMS mastery may be a contributor to the development of overweight and obesity and may increase the likelihood of dropout from physical activity and sport. All children attending primary school should be facilitated to achieve adequate levels of mastery across a broad range of FMS.

3.2 Introduction

Fundamental movement skills (FMS), referred to as the ABC's of PA (Goodway et al., 2013), are proposed as an essential requirement for the maintenance of a healthy, active lifestyle (Haywood and Getchell 2009; Stodden et al., 2008). They include locomotor (i.e. run, skip), object-control (i.e. throw, kick) and stability (i.e. static and dynamic balance) skills, which need to be taught and practiced during childhood, ideally between the ages of 3- and 8-years old (Gallahue et al., 2012; Gallahue and Cleland-Donnelly, 2007). Modern life has contributed to increasing sedentary behaviours among children (Kohl et al., 2013). In the past, children were more likely to spend their free time engaging in outdoor activities that offered opportunities to practice FMS, including climbing trees, jumping over obstacles, and playing games like tag and football (Moss, 2012). Today, however, children spend more time watching TV, playing video-games and interacting with peers through social media (Kohl et al., 2013). Consequently, most children are not reaching the minimum daily recommendations of 60 minutes moderate to vigorous physical activity (MVPA) (Woods et al., 2018), which may be detrimental to their future health and wellbeing.

Obesity is a global epidemic and costs the Irish healthcare system up to €1.16 billion each year (Dee et al., 2015) but has the potential to be reduced through healthy lifestyle changes. The Children's Sports Participation and Physical Activity study (CSPPA) (Woods et al., 2018), found that only 17% and 10% of Irish primary and secondary school pupils are reaching the recommended levels of 60 minutes MVPA per day respectively, with 'lack of competence' highlighted as a top reason for avoiding physical activity (PA) and sport (Woods et al., 2010). Furthermore, children with high FMS competence are 2.4 times more likely to reach the recommended levels of daily MVPA (De Meester et al., 2018), have better cardiorespiratory fitness (CRF), higher levels of academic achievement and a greater chance of maintaining a healthy weight status compared to children with low motor competence (Lubans et al., 2010; Wrotniak et al., 2006; Catuzzo et al., 2016; Barnett et al., 2008). Motor competence is proposed to be reciprocally related to PA levels, CRF, weight status and perceived competence (Stodden et al., 2008), though, causal pathways have yet to be understood (Robinson et al., 2015; Stodden et al., 2008). However, overweight children are more likely to demonstrate poorer FMS competence than non-overweight children, especially within the locomotor skills category of FMS (Stodden et al., 2008; Okely et al., 2004; Logan et al., 2011). The differences for object-control skills are less consistent, however, O'Brien et al., (2016a) revealed that Irish second level pupils classified as overweight/obese were more likely to achieve advanced skill proficiency in the object-control skills category compared to their non-overweight peers. Further investigations are warranted to identify if the same is true among Irish primary school children.

Despite the purported health related benefits associated with higher FMS proficiency levels, FMS are not widely assessed or monitored among Irish school children. The limited research conducted to date reports that less than 50% of Irish Year 2 (6.0±0.4 years) and Year 6 (9.9±0.4 years) pupils achieved mastery in 8 of 12 FMS including the hop, slide, horizontal jump, two-hand strike, overhand throw, underhand roll, dribble and two-handed catch (Bolger et al., 2018). This is worrying considering children have the potential to master most FMS by the age of 6 (Gallahue et al., 2012). In addition, 98.1% of Irish 8- to 12-year-old females did not achieve the level of FMS proficiency expected for their age (Farmer et al., 2017), only 11% of Irish 12- to 14-year-old adolescents demonstrated advanced skill proficiency of nine basic FMS (O'Brien et al., 2016b) and the proportion of 12- to 16-year-old adolescents achieving complete mastery of ten FMS ranged from only 14.8% (horizontal jump) to 86.6% (catch) (Lester et al., 2017). These findings highlight the need for targeted intervention programmes to facilitate the development of FMS among Irish school children.

However, further complexity is added when dealing with school-going children as there is a wide range of ages, abilities, and interests to cater for. For example, sociocultural influences (Garcia, 1994; Thomas and French, 1985) have likely contributed to males often outperforming females in object-control skills (Bolger et al., 2017; Foulkes et al., 2015; Hardy, King, Farrell, Macniven and Howlett, 2010). Males tend to be more ego-centric and prefer competitive, rough and tumble type activities compared to females who are more likely to engage in non-competitive, goal-oriented activities (Spencer, Rehman and Kirk, 2015; Thomas and French, 1985; Garcia, 1994). Motor development occurs in specific stages; however, the rate of change is dependent upon the interactions between environmental factors (e.g. practice opportunities and instruction) and the individuals physical, psychological, and social status (Clarke and Metcalfe, 2002). Therefore, although children in one class may be a similar age, different social, environmental, and personal experiences will contribute to variations in their skill capabilities.

Understanding and highlighting these differences will better inform the development of future intervention programmes. Qualitative assessment tools that evaluate how a skill is performed as opposed to quantitative assessments that focus on the outcome of a performance (e.g. distance or speed) may better inform the creation of such intervention programmes (Cools et al., 2009). The Test of Gross Motor Development, currently in its third edition (TGMD-3), is a valid and reliable tool for assessing 13 FMS (6 locomotor and 7 ball/object-control skills) among children aged three to ten years-old (Ulrich, 2019; Valentini, Zanell and Webster 2016; Rintala, Sääkslahti and Iivonen, 2017; Temple and Foley, 2016). Scores are assigned based on the presence or absence of 3-5 performance criteria. Ideally, all children should be achieving maximum scores in each skill by the age of ten (Ulrich, 2000). This most recent edition has not yet been used to assess FMS proficiency levels of children attending Irish primary schools.

The aim of this study is to investigate FMS proficiency levels of Irish school children from Year 2 to Year 7. This study is one of the first to examine differences in FMS proficiency levels across six consecutive class groups in the Irish primary school setting. In addition, differences in FMS scores by sex and weight status will also be analysed.

3.3 Methods

3.3.1 Participants and recruitment

A convenience sample of 440 participants (232 males and 208 females) were recruited from three primary schools in the midlands region of Ireland. Sample size statistics were used to establish a suitable number of participants. Previous research by Wai-Yin Pang and Tik-Pui Fong (2009) which tested a comparable age group (6-9 years) and used similar testing methods (TGMD-2), was used to identify the standard deviation required for the sample size calculation. With $\alpha = 0.05$, power = 0.8, detectable difference = 1 and standard deviation = 4.4, the projected sample size required was 310. Allowing for a 20% dropout rate, a minimum of 372 participants had to be recruited. Once ethical approval was granted by the Institutes research ethics board, school principals and teachers were contacted either in person or through email (Appendix A). At initial contact, the study outline and its importance were briefly explained to the relevant teacher or principal. One week after, the principal investigator followed up with a phone call to identify interested schools.

School principals that expressed an interest in participating in the study were visited by the principal investigator. Details of the study procedure, risks and benefits were explained in detail. The parents of potential participants were given plain language statements and informed consent forms (Appendix B) to take home and were asked to return the consent form, signed by both the legal guardian and the participating child, to the relevant teacher. The consent forms were collected and screened by the principal investigator before testing commenced.

3.3.1.1 Inclusion/exclusion criteria

Children in Year 2 to Year 7 inclusive, and free from any injury or disability that limited their ability to participate in PA were eligible to take part in the study. Written parent/guardian consent and participant assent was a prerequisite for participation. Pupils in Year 1 and Year 8 were excluded along with those who had a musculoskeletal injury, disability or medical condition, that limited their ability to participate in PA. Participants who did not give written assent or whose legal guardians did not give informed consent were excluded.

The final sample included 414 participants (Mean age 9.0±1.7 years) and comprised of 61 Year 2 (6.5±0.4 years), 94 Year 3 (7.8±0.5 years), 55 Year 4 (8.6±0.5 years), 70 Year 5 (9.5±0.4 years), 66 Year 6 (10.5±0.4 years) and 68 Year 7 (11.5±0.4 years) pupils (Figure 3.1). The percentage of males and females in each class is outlined in Figure 3.1. Males made up 52.2% of the sample (mean age = 9.0±1.6 years; mean height = 135.9±11 cm; mean weight = 32.8±10.1 kg) and females the remaining 47.8% (mean age = 8.8±1.7 years; mean height = 133.7±12 cm; mean weight = 32.4±11.5 kg).

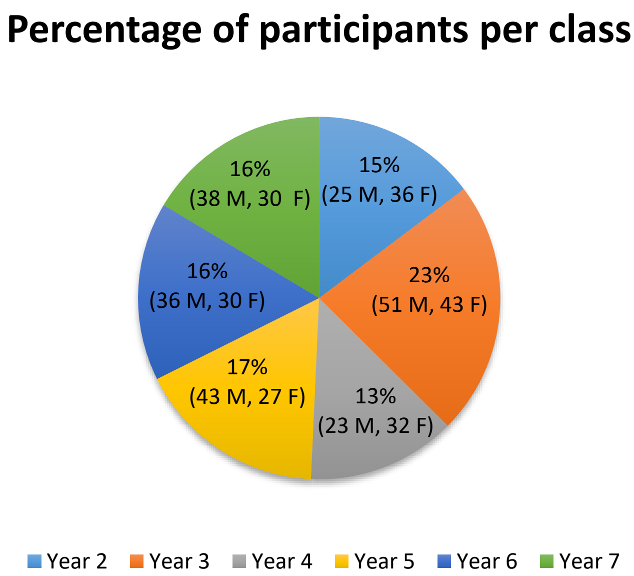

Figure 3.1 Percentage of participants per class including number of males and females
Note: **M**: male, **F**: female

3.3.2 Measures

3.3.2.1 Fundamental Movement Skills Assessment

FMS were assessed using a battery test of 15 FMS. The Test of Gross Motor Development – third edition (TGMD-3) (Ulrich 2019), was used to assess 13 skills, namely run, gallop, hop, skip, horizontal jump and slide in the locomotor category and two-hand strike of a stationary ball, one-hand forehand strike of self-bounced ball, one-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw and underhand throw in the ball skills category. The TGMD-3 is a reliable and valid tool for testing FMS in children aged 3 to 10 years (Valentini et al. 2016; Rintala et al. 2017; Temple and Foley, 2016).

Static balance was assessed using the single leg stance as outlined in the 'Get Skilled; Get Active' protocol (NSW Department of Education and Training, 2000). In addition, vertical jump was assessed using the performance criteria outlined in the 'Victorian Fundamental Motor Skills Manual' protocol (Department of Education Victoria, 1996). All participants were video-recorded performing two trials of each skill, which could be replayed later for scoring.

3.3.2.2 Study location and procedure

Testing was conducted in the PE hall of each school. The hall was divided into stations which required space for the pre-test procedure, warm-up/cool-down zone and testing stations 1, 2 and 3 (Figure 3.2). Procedures for each station are explained below.

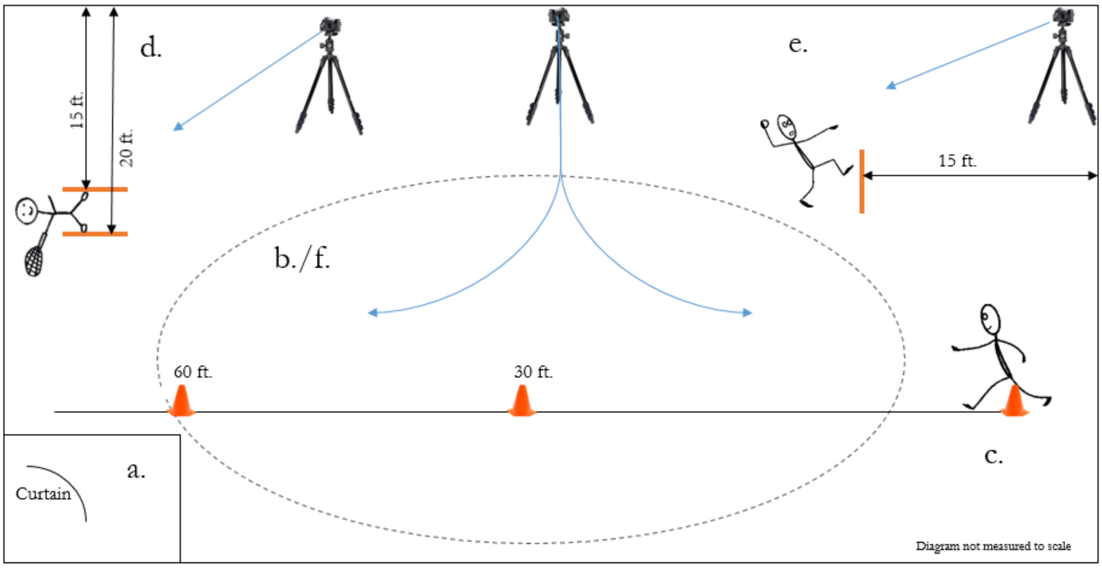

Figure 3.2 Sample school hall set-up for testing

a. Participant check-in:

During check-in, participant's sex, date of birth, class group and anthropometric data were recorded. To ensure anonymity, each participant was assigned a participant ID number under which relevant participant information was recorded. ID numbers were written on stickers which each participant themselves stuck on to their chest. Each participant's ID number was stated verbally to the video camera during his or her performance of each skill, so that the principal investigator could score each participant accordingly.

Anthropometry

Height was measured, to the nearest 0.1 cm, using a portable height stadiometer (SECA 217, SECA ltd., Leicester, UK). Participants removed their shoes and stood with feet together and heels against the base. The back was kept straight with head and shoulders touching the backboard and arms resting by their sides. Once the participant was comfortable, the headboard was moved down to touch the head and the measurement recorded.

A portable SECA heavy-duty scale (SECA colorata 760, SECA ltd., Leicester, UK) was used to measure body mass to the nearest 0.1 kg. Participants wore shorts or a tracksuit pants, a t-shirt, socks, and no shoes. BMI was derived using the equation: body mass (kg)/ height (m^2). Weight status was defined using the extended age- and gender-specific International Obesity Task Force cut-offs as grade 3 thinness, grade 2 thinness, grade 1 thinness, overweight, obese, and morbidly obese (Cole and Lobstein, 2012).

b. Warm up

Participants were guided by the principal investigator, through a 5-10 minute standardised dynamic warm up (Faigenbaum and McFarland, 2009). The warm up station was set up with cones to mark out a distance of 10-yards. Each exercise was demonstrated before instructing the participants to repeat each exercise afterwards. The exercises and reps are outlined in Table 3.1.

Table 3.1 Warm-up exercise protocol used prior to testing (Faigenbaum and McFarland, 2009)

Exercise	Time/reps
Jumping jacks	
High	20 seconds
Low	20 seconds
High knee march	
On the spot	20 seconds
Walking	10 yards (x2)
Standing flutter	20 seconds (x2)
Toe touches	
Standing	5 each leg
Walking	10 yards (x2)
Trunk turns	
Standing	5 each side
Stepping	10 yards (x2)
Crunches	20 seconds (x2)
Marching lateral shuffle	10 yards (x2)
High knee skips	10 yards (x2)
Partial push-ups	20 seconds (x2)
Run and go	Run slow to 5-yard mark and faster to 10-yard mark (x2)

Following the warm up, participants were divided into three groups. As there is no specified testing order required for implementing the TGMD-3 protocol, each group was randomly assigned to testing station 1, 2 or 3. Each group rotated in a clockwise direction until all groups completed each station. This set-up minimised the time required for overall testing which took on average 80 minutes per class of approximately 24 pupils.

c. Testing Station 1

Locomotor skills including the run, gallop, hop, skip and slide were assessed at station one. As illustrated in Figure 3.2, a maximum of 60 feet of space was required. Performance criteria, equipment and instructions are outlined in Appendix C. All participants were video recorded performing the skills from the side.

d. Testing Station 2

Ball handling skills were assessed at station two which included, two-hand strike of a stationary ball, one-hand forehand strike of a self-bounced ball, kick a stationary ball, overhand throw, and underhand throw. As shown in Figure 3.2, at least 20 feet from a wall was the ideal location for this station. All skills at station 2 were video recorded from the side for each participant.

e. Testing Station 3

Horizontal jump, vertical jump, static balance, one-hand stationary dribble and two-hand catch were assessed at station three. Fifteen feet of space was required for this station. All skills apart from static balance (video recorded from the front) were videoed from the side.

f. Cool down

To finish, participants were guided through a five-minute cool down, which included light jogging and static stretching of all major muscle groups. If at any stage, a participant experienced pain or any form of discomfort, they were given the option to withdraw from the study. Any participant who did so, joined in on activities directed by the class teacher.

3.3.3 Administration and scoring

A standardised protocol was adopted for the administration and scoring of all FMS for each participant in each school. Each skill was scored based on the presence or absence of a number of performance criteria. Table 3.2 outlines the performance criteria for the run and two-hand strike of a stationary ball. The assessment and scoring protocol for all 15 skills can be viewed in Appendix C. An accurate demonstration and verbal description of the skill was given to each participant before their performance. Each participant performed a practice trial followed by two test-trials for each skill. If after the initial practice trial, the participant was unsure of what was asked, a second demonstration and practice trial was provided prior to the test trials. No prompts were given as the participant was performing each skill (Ulrich 2000; 2019). The video camera was set up so that a full view of the skill performance was recorded for scoring at a later date.

Each skill was scored based on the presence or absence of the predefined performance criteria. A score of 1 was given for each performance criterion correctly performed and 0 for any absent or incorrectly performed criterion. No partial marks were given. Scores for two trials of each skill were summed to give individual skill scores. Due to not being part of the TGMD-3 assessment, the vertical jump and single leg stance were only assigned individual skill scores. The total FMS (max possible score = 100), locomotor subtest (max possible score = 46) and ball skills subtest scores (max possible score = 54) were summed for each participant as outlined in the TGMD-3 protocol. Similar to the definitions used by O'Brien et al. (2016b), 'mastery' was defined as correct performance of all performance criteria over two trials, 'near mastery' as correct performance of all but one performance criteria over two trials and 'poor mastery' was assigned when more than one performance criteria were incorrectly performed or absent over two trials.

Table 3.2 Performance criteria and instructions for assessing the run and two-hand strike as outlined in the TGMD-3 protocol (Ulrich 2019)

Skill	Instructions	Performance Criteria	Equipment
Run	*'Run fast from cone 1 to cone 2'* (50 feet apart) Video: Side view	(1) Arms move in opposition to legs with elbows bent (2) Brief period where both feet are off the surface (3) Narrow foot placement landing on heel or toe (not flat footed) (4) Non-support leg bent about 90 degrees, so foot is close to buttocks	Measuring tape 2 cones
Two-hand strike of a stationary ball	(place ball on batting tee at child's waist level) *'Hit the ball hard with this bat, straight ahead towards the wall'* Video: Side view	(1) Childs preferred hand grips bat above non-preferred hand (2) Child's non-preferred hip-shoulder faces straight ahead (3) Hip and shoulders rotate and derotate during swing (4) Steps with non-preferred foot (5) Hits ball, sending it straight ahead	Batting tee Plastic bat 4-inch plastic ball

3.3.3.1 Video recording

Participants were video recorded performing all 15 FMS using wireless camcorders (Panasonic V260 full HD camcorder, hc-v260eb-k, Panasonic, UK). Separate cameras were set-up in view of each testing station. A strict procedure was adhered to throughout testing to ensure all data collected remained anonymous and confidential. Only recordings of the single leg stance and the slide had the participant's faces in view. All other skills were viewed from the side. Each participant wore a sticker with an ID number on it for identification and coding purposes as no names were recorded in the study. The participant's face was pixelated immediately after testing, upon first viewing of the tape, to remove identification. This was done in private, by the principal investigator only. Once testing was finished in each school, the tapes were stored on an encrypted hard drive. The hard drive was transported to AIT and stored in a locked filing cabinet only accessible to the principal investigator.

3.3.4 Reliability

The principal investigator examined their reliability for scoring the skills included in the TGMD-3 protocol using an online reliability scoring system (Reliability Videos - TGMD-3, 2016). For this, the principal investigator observed and scored two trials for two children performing all TGMD-3 skills. The videos were available on the TGMD-3 website. The scores were submitted online to a TGMD expert for analysis. A reliability score of 99% was returned. Following this, intra-rater reliability analysis was conducted whereby the principal investigator scored a random sample of 32 participants performing the 15 skills on two occasions, two weeks apart. The number of participants was determined using a sample size calculation. Previous research by Cano-Cappellacci et al. (2015) was used to identify the standard deviation required for the sample size calculation. With $\alpha = 0.05$, power = 0.8, detectable difference = 1 and standard deviation = 1.4 the projected sample size required was 32 participants. A two-way mixed effects model was used to calculate ICC. Table 3.3 shows that all skills demonstrated good to excellent ICC values (Koo and Li, 2016) ranging from 0.79 for the run to 0.98 for the kick.

Table 3.3 Intraclass correlations (ICC) and 95% confidence intervals for intra-rater reliability of scoring each FMS

Skill	ICC	95% Confidence Interval
Run	0.79	0.62-0.89
Gallop	0.81	0.65-0.90
Hop	0.93	0.86-0.96
Skip	0.94	0.88-0.97
Slide	0.94	0.88-0.97
Horizontal jump	0.91	0.82-0.95
Two-hand strike	0.90	0.81-0.95
Forehand strike	0.93	0.87-0.97
Kick	0.98	0.96-0.99
Overhand throw	0.91	0.82-0.95
Underhand throw	0.90	0.81-0.95
Dribble	0.94	0.89-0.97
Catch	0.91	0.83-0.95
Vertical jump	0.91	0.83-0.95
Balance	0.94	0.88-0.96

3.3.5 Field staff training and familiarisation

The principal investigator was Garda vetted and had experience working with minors through coaching and as a trainee primary school teacher. Six trained field staff assisted the principal investigator during testing. The trained field staff were recruited from the Department of Sport and Health Sciences at Athlone Institute of Technology and included third- and fourth-year Garda vetted undergraduate students who had previous experience working with the public from previous placements. Prior to testing, training was provided over two days by the principal investigator.

During training, each individual received a copy of the TGMD-3 assessment sheet and a detailed explanation of the testing and scoring procedures. Following this, the trained field staff watched the videos on the TGMD-3 website which demonstrated the procedures to be followed when videoing each skill performance. Each of the trained field staff practiced setting up a hall for a testing session where they needed to establish a suitable location for video recording at each station to ensure the performance of each skill could be viewed in full. The trained field staff were assigned to one of three stations and practiced both the role of the instructor and the videographer. The principal investigator answered any questions that arose during the testing sessions.

3.3.6 Data analysis

FMS data were analysed using SPSS version 24 and statistical significance was set at $p<0.05$. Descriptive statistics and frequencies were used to present mean scores and percentage mastery for each skill. Percentage of maximum possible (POMP) scores were calculated using the equation ([(observed score − minimum score)/(maximum score − minimum score)] × 100) (Cohen, 1999) for the locomotor subtest and ball skills subtest for males and females. Differences in individual skill, locomotor subtest, ball skills subtest and total FMS scores with respect to sex (male/female) and class group (Year 2, 3, 4, 5, 6 and 7) were established using a two-way ANOVA with Tukeys post-hoc test used to identify the specific significant differences across class groups. Partial eta squared values (η_p^2) of 0.01, 0.06 or 0.14, represented small, medium and large effect sizes respectively (Cohen, 1988). A dichotomous variable for weight status was created where G3 thinness, G2 thinness and G1 thinness were classified as non-overweight and overweight, obese and morbidly obese were classified as overweight/obese. Differences in skill performance between overweight/obese and non-overweight participants were detected using independent samples t-tests. Effect sizes were calculated using Cohen's d where d=0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen, 1988).

3.4 Results

3.4.1 Participant information

Participant information and percentage of maximum possible (POMP) scores for the locomotor subtest and ball skills subtest by class group and sex are summarised in Table 3.4. The calculation for the POMP scores revealed that for the overall sample males and females scored on average 64% for the locomotor subtest, whereas for the ball skills subtest, males scored on average 72% whilst females scored an average of 58% (Table

3.4). Figure 3.3 illustrates the percentage of participants in each weight category defined using the extended International Obesity Task Force (IOTF) classification (Cole and Lobstein, 2012). The majority had a BMI within the normal range for their age and sex, however, 23% were classified as overweight or obese. A similar proportion of males and females were in each weight category (Figure 3.3).

Table 3.4 Participant information and percentage of maximum possible (POMP) scores for locomotor and ball skills subtests classified by class group and sex

Class	Sex	N	Age (yr.)±SD	Weight (kg)±SD	Height (cm)±SD	POMP LM	POMP BS
Y2	M	25	6.6±0.4	23.6±4.1	121.6±5.0	62.1	59.6
	F	36	6.4±0.4	22.2±3.4	118.9±4.5	61.6	41.8
Y3	M	51	7.8±0.4	26.7±5.1	128.0±5.4	63.2	69.1
	F	43	7.7±0.5	27.6±6.4	128.8±4.6	65.6	55.6
Y4	M	23	8.6±0.4	30.0±5.9	132.6±5.7	68.3	74.6
	F	32	8.5±0.5	31.2±12.1	131.7±8.1	64.1	58.7
Y5	M	43	9.5±0.4	32.9±5.4	137.1±4.9	61.2	76.9
	F	27	9.5±0.4	33.2±6.9	134.7±6.4	62.2	64.1
Y6	M	36	10.5±0.4	36.7±10.7	144.4±7.4	62.8	74.4
	F	30	10.5±0.5	39.4±12.6	144.1±8.2	64.7	63.8
Y7	M	38	11.6±0.4	42.2±11.9	148.9±8.9	67.7	76.2
	F	30	11.5±0.4	45.4±9.5	149.2±6.5	62.7	65.9
Total	M	216	9.2±1.7	32.8±10.2	136.0 ± 11.1	63.9	72.3
	F	198	8.9±1.8	32.4±11.6	133.7 ± 12.0	63.6	57.6

Note: **M:** Male, **F:** Female, **n:** Number of participants, **SD:** Standard deviation, **POMP:** Percentage of maximum possible scores, **LM:** Locomotor subtest, **BS:** Ball skills subtest

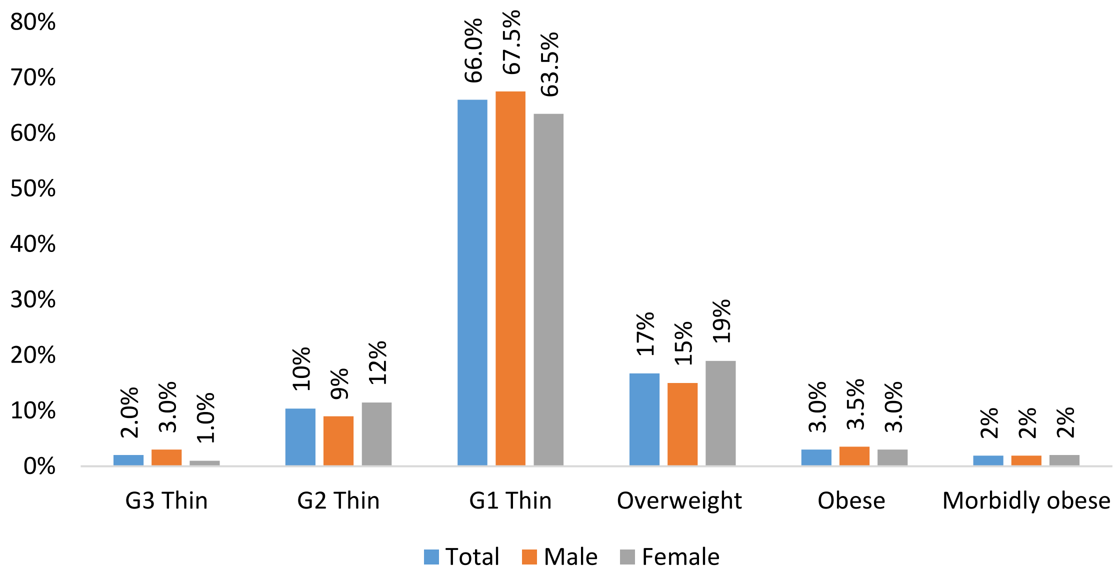

Figure 3.3 Percentage of participants in each weight category, classified according to the extended age- and gender-specific International Obesity Task Force cut-off points (Cole and Lobstein, 2012).
Note: **G3 Thin**: Grade 3 thinness, **G2 Thin**: Grade 2 Thinness, **G1 Thin**: Grade 1 Thinness

3.4.2 FMS mastery

Overall, participants demonstrated low levels of mastery across all fifteen skills ranging from 1.4% (gallop) to 35.7% (slide) (Figure 3.4). Over 50% of participants had poor mastery in nine of the fifteen skills including two hand strike (78%), vertical jump (77.8%), hop (72.5%), one-hand forehand strike (65.5%), gallop (62.8%), kick a stationary ball (62.1%), run (57.3%) and overhand throw (55.1%). The slide, two-hand catch and skip were the best performed with 80.9%, 75.6% and 73.2% classified as having mastery/near mastery respectively.

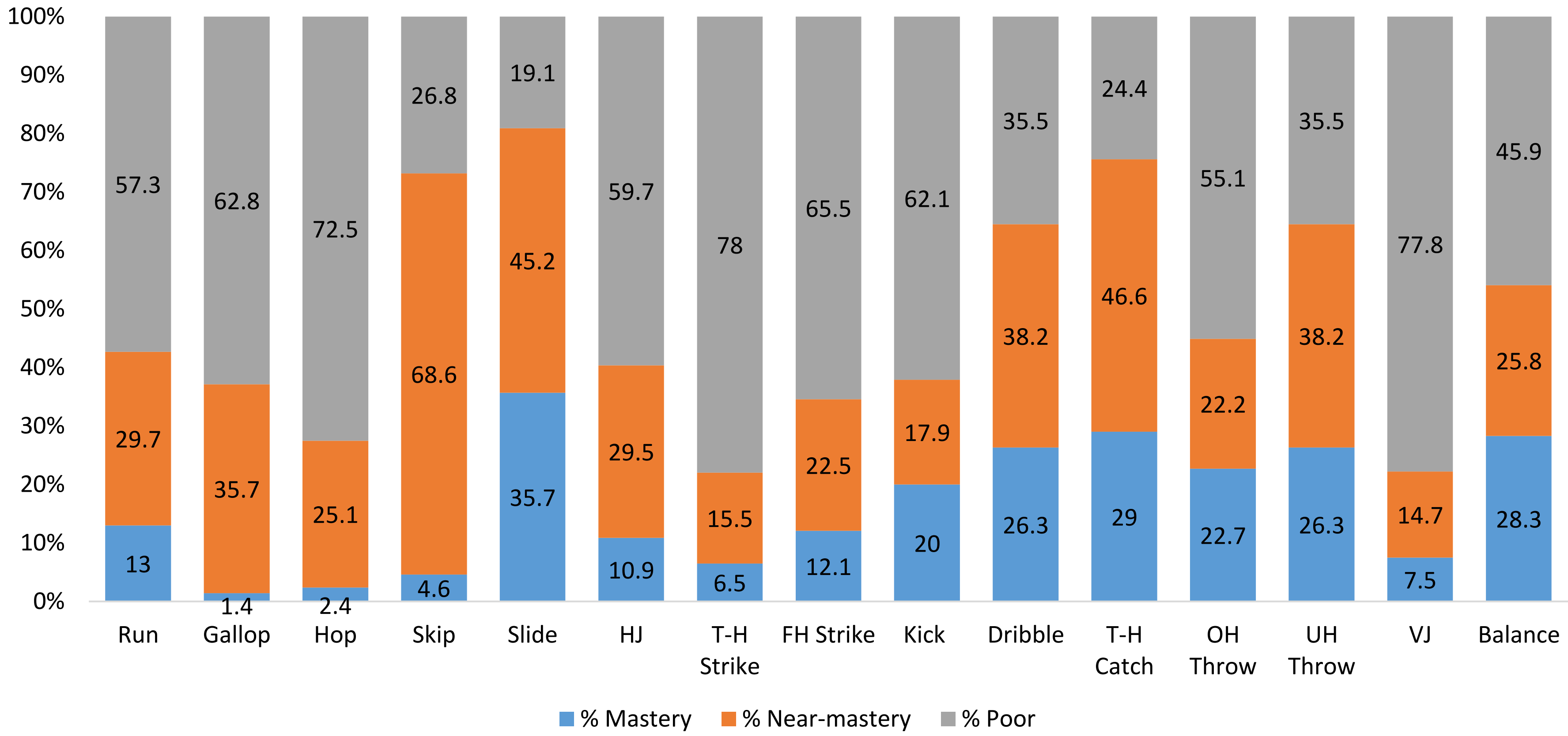

Figure 3.4 Percentage of participants (n=414) achieving mastery, near-mastery and poor in each skill
Note: **HJ:** Horizontal jump, **T-H Strike:** Two-hand strike, **FH Strike:** Forehand strike, **OH Throw:** Overhand throw, **UH throw:** Underhand throw, **T-H Catch:** Two-hand catch, **VJ:** Vertical jump

3.4.3 Sex and class group differences in FMS proficiency

Results of the two-way ANOVA investigating the impact of sex (male/female) and class group (Year 2/3/4/5/6/7) on individual skill, locomotor subtest, ball skills subtest and total FMS scores are summarised in Table 3.5. No interaction effects were present ($p>0.05$), suggesting that the effect of class group on FMS proficiency was similar for both males and females and the effect of sex on FMS proficiency was similar across class groups.

Although males were better than females in the slide and females were better than males in the skip (both $p<0.001$, $\eta_p^2=0.03$) (Figure 3.5), effect sizes were small and sex did not significantly affect overall locomotor subtest scores ($p>0.05$, $\eta_p^2=0.00$). Males were significantly better than females in the performance of six of seven ball skills (Figure 3.6). A significant, large effect size was reported for male superiority in the ball skills subtest ($p<0.001$, $\eta_p^2=0.26$) and total FMS scores ($p<0.001$, $\eta_p^2=0.14$) (Figure 3.7).

Significant differences were reported across class groups for 11 of the 15 skills and for the ball skills subtest ($p<0.001$, $\eta_p^2=0.27$) and total FMS ($p<0.001$, $\eta_p^2=0.16$) scores, but locomotor subtest scores were similar across all class groups ($p>0.05$; $\eta_p^2=0.02$). Participants in Year 2 had significantly lower scores than all other class groups for each ball skill and were significantly poorer than Year 7 pupils for only one locomotor skill (skip). Improvements in ball skills subtest scores peaked at Year 5 after which a plateau/slight decline was observed (Table 3.5).

Table 3.5 Two-way ANOVA for the effect of class group and sex on FMS proficiency levels

	Skill	S	Year 2 (6 yrs.)	Year 3 (7 yrs.)	Year 4 (8 yrs.)	Year 5 (9 yrs.)	Year 6 (10 yrs.)	Year 7 (11 yrs.)	Total	Sex P	Sex η_p^2	Class p	Class η_p^2	Post hoc
			Mean (raw score) ± SD											
TGMD-3	Run	M	5.6 ± 1.8	5.1 ± 1.7	5.4 ± 1.6	4.7 ± 1.7	5.0 ± 1.7	5.6 ± 1.9	5.2 ± 1.7	0.12	0.01	0.09	0.02	NA
LM	*MS = 8*	F	5.2 ± 1.6	5.3 ± 1.5	5.9 ± 1.6	4.5 ± 1.4	4.9 ± 1.8	5.1 ± 1.8	5.0 ± 1.6					
Skills		T	5.4 ± 1.7	5.2 ± 1.6	5.1 ± 1.6	4.7 ± 1.6	4.9 ± 1.7	5.4 ± 1.9	5.1 ± 1.7					
	Gallop	M	4.5 ± 1.8	4.8 ± 1.6	5.5 ± 1.3	4.2 ± 1.8	4.3 ± 1.9	4.7 ± 1.6	4.6 ± 1.7	0.53	0.00	**0.001**	0.05	Y4>Y5+Y7
	MS = 8	F	4.7 ± 1.4	5.1 ± 1.1	5.2 ± 1.1	4.2 ± 1.8	5.0 ± 0.8	4.4 ± 1.7	4.8 ± 1.4			**		
		T	4.6 ± 1.6	4.9 ± 1.4	5.4 ± 1.2	4.2 ± 1.8	4.6 ± 1.5	4.5 ± 1.7	4.7 ± 1.6					
	Hop	M	4.7 ± 1.6	4.4 ± 1.8	5.0 ± 1.5	4.1 ± 1.3	4.6 ± 1.5	4.3 ± 1.3	4.4 ± 1.5	0.62	0.00	0.48	0.01	NA
	MS = 8	F	4.0 ± 1.7	4.7 ± 1.8	4.5 ± 1.5	4.3 ± 1.3	4.5 ± 1.3	4.6 ± 1.4	4.4 ± 1.5					
		T	4.3 ± 1.7	4.5 ± 1.8	4.7 ± 1.5	4.2 ± 1.3	4.5 ± 1.4	4.4 ± 1.3	4.4 ± 1.5					
	Skip	M	2.8 ± 1.8	3.3 ± 1.5	2.9 ± 1.8	3.2 ± 1.7	3.4 ± 1.5	4.0 ± 1.4	3.3 ± 1.6	**0.001**	0.03	**0.004**	0.04	Y2<Y7/ Y4<Y7
	MS = 6	F	3.5 ± 1.2	3.9 ± 1.2	3.5 ± 1.3	4.0 ± 1.2	3.5 ± 1.2	4.2 ± 0.7	3.7 ± 1.2	**		**		
		T	3.2 ± 1.5	3.6 ± 1.4	3.2 ± 1.5	3.5 ± 1.6	3.5 ± 1.3	4.1 ± 1.1	3.5 ± 1.4					
	Slide	M	6.6 ± 1.2	6.4 ± 1.5	7.4 ± 1.1	6.8 ± 1.5	6.5 ± 1.7	6.9 ± 1.4	6.7 ± 1.5	**0.001**	0.03	0.06	0.03	NA
	MS = 8	F	5.8 ± 1.3	6.3 ± 1.5	6.5 ± 1.0	6.7 ± 1.6	6.5 ± 1.5	6.1 ± 1.2	6.3 ± 1.4	**				
		T	6.1 ± 1.3	6.4 ± 1.5	6.9 ± 1.2	6.8 ± 1.5	6.5 ± 1.6	6.6 ± 1.4	6.5 ± 1.4					
	HJ	M	4.3 ± 2.1	5.0 ± 1.9	5.2 ± 1.9	5.1 ± 1.8	5.1 ± 1.7	5.6 ± 1.9	5.1 ± 1.9	0.61	0.00	0.75	0.01	NA
	MS = 8	F	5.1 ± 1.6	4.9 ± 2.1	4.9 ± 1.8	4.9 ± 1.5	5.4 ± 1.4	4.6 ± 1.7	5.0 ± 1.7					
		T	4.8 ± 1.8	5.0 ± 2.0	5.0 ± 1.8	5.0 ± 1.7	5.2 ± 1.6	5.0 ± 1.9	5.0 ± 1.8					
	LM ST	M	28.6 ± 5.8	29.1 ± 5.4	31.4 ± 5.6	28.2 ± 5.2	28.9 ± 4.7	31.1 ± 6.0	29.4 ± 5.5	0.50	0.00	0.15	0.02	NA
	MS = 46	F	28.3 ± 5.2	30.2 ± 4.5	29.5 ± 3.7	28.6 ± 4.9	29.8 ± 4.3	28.9 ± 4.9	29.3 ± 4.6					
		T	28.4 ± 5.4	29.6 ± 5.0	30.3 ± 4.7	28.3 ± 5.1	29.3 ± 4.5	30.1 ± 5.6	29.3 ± 5.1					

TGMD-3	T-H	M	5.8 ± 2.2	6.1 ± 2.0	6.5 ± 2.4	7.1 ± 2.0	7.0 ± 1.8	6.9 ± 2.1	6.6 ± 2.1	**<0.001**	0.14	**<0.001**	0.1	Y2<all/ Y3<Y5/
Ball	Strike	F	3.1 ± 1.2	4.7 ± 1.9	4.5 ± 2.3	5.8 ± 2.3	5.4 ± 2.4	5.8 ± 2.0	4.8 ± 2.2	*******		*******		Y4<Y5
Skills	*MS = 10*	T	4.2 ± 2.1	5.5 ± 2.0	5.3 ± 2.5	6.6 ± 2.2	6.3 ± 2.2	6.4 ± 2.1	5.7 ± 2.3					
	FH	M	4.1 ± 2.0	5.0 ± 1.9	5.2 ± 1.7	6.4 ± 1.8	5.1 ± 1.9	5.8 ± 1.9	5.3 ± 2.0	**<0.001**	0.12	**<0.001**	0.11	Y2<all/
	Strike	F	2.2 ± 1.4	3.7 ± 1.8	3.7 ± 2.1	4.4 ± 2.1	4.1 ± 2.5	4.6 ± 2.2	3.7 ± 2.1	*******		*******		Y3<Y5+Y7/
	MS = 8	T	3.0 ± 1.9	4.4 ± 2.0	4.3 ± 2.1	5.6 ± 2.2	4.6 ± 2.2	5.3 ± 2.1	4.6 ± 2.2					Y5<Y6/Y5>Y6
	Kick	M	5.0 ± 2.1	6.2 ± 1.8	6.7 ± 1.7	5.9 ± 1.9	5.8 ± 1.9	6.2 ± 1.6	6.0 ± 1.9	**<0.001**	0.21	**<0.001**	0.07	Y2<all
	MS = 8	F	3.3 ± 1.2	3.9 ± 0.9	4.5 ± 1.2	4.1 ± 1.3	4.8 ± 1.6	4.9 ± 2.0	4.2 ± 1.5	*******		*******		
		T	4.0 ± 1.8	5.1 ± 1.9	5.4 ± 1.8	5.2 ± 1.9	5.3 ± 1.8	5.6 ± 1.9	5.1 ± 1.9					
	OH	M	5.4 ± 1.8	5.7 ± 1.9	6.3 ± 1.8	6.5 ± 1.6	6.2 ± 1.8	6.1 ± 2.2	6.1 ± 1.9	**<0.001**	0.17	**0.01**	0.04	Y2<all
	Throw	F	3.4 ± 1.6	4.7 ± 2.0	5.0 ± 2.1	4.4 ± 2.0	4.4 ± 1.4	4.2 ± 1.8	4.4 ± 1.9	*******		*****		
	MS = 8	T	4.2 ± 1.9	5.3 ± 2.0	5.5 ± 2.1	5.7 ± 2.0	5.4 ± 1.9	5.3 ± 2.2	5.2 ± 2.1					
	UH	M	5.8 ± 1.8	6.3 ± 1.5	6.1 ± 1.4	6.6 ± 1.4	6.6 ± 1.5	6.3 ± 1.4	6.3 ± 1.4	**0.03**	0.01	**0.002**	0.05	Y2<Y5+Y6
	Throw	F	5.3 ± 1.6	5.6 ± 1.6	6.0 ± 1.4	6.4 ± 1.3	6.4 ± 1.3	6.1 ± 1.3	5.9 ± 1.5	*****		******		
	MS = 8	T	5.5 ± 1.5	6.0 ± 1.6	6.0 ± 1.4	6.6 ± 1.4	6.5 ± 1.4	6.2 ± 1.3	6.1 ± 1.5					
	Catch	M	3.5 ± 1.2	4.5 ± 1.3	5.0 ± 1.4	4.3 ± 1.2	4.6 ± 1.1	4.8 ± 0.9	4.5 ± 1.2	0.82	0.00	**<0.001**	0.16	Y2<all
	MS = 8	F	3.1 ± 1.4	4.4 ± 1.3	4.9 ± 1.3	4.7 ± 1.1	4.7 ± 1.3	5.1 ± 0.9	4.4 ± 1.4			*******		
		T	3.2 ± 1.3	4.4 ± 1.3	4.9 ± 1.3	4.5 ± 1.2	4.6 ± 1.2	4.9 ± 0.9	4.4 ± 1.3					
	Dribble	M	2.6 ± 1.7	3.5 ± 1.6	4.4 ± 1.2	4.9 ± 1.4	4.9 ± 1.4	4.9 ± 1.1	4.2 ± 1.6	**0.006**	0.02	**<0.001**	0.3	Y2<all/ Y3<Y5,
	MS = 8	F	2.1 ± 1.6	3.0 ± 1.7	3.1 ± 1.4	4.7 ± 1.3	4.7 ± 1.1	4.9 ± 1.2	3.6 ± 1.8	******		*******		Y6+Y7/
		T	2.3 ± 1.7	3.3 ± 1.7	3.7 ± 1.5	4.6 ± 1.2	4.8 ± 1.3	4.9 ± 1.1	3.9 ± 1.7					Y4<Y5,Y6+Y7
	BS ST	M	32.2 ± 7.5	37.3 ± 6.9	40.3 ± 6.5	41.5 ± 5.9	40.2 ± 5.7	41.2 ± 5.7	39.0 ± 6.9	**<0.001**	0.26	**<0.001**	0.27	Y2<all/
	MS = 54	F	22.6 ± 4.7	30.0 ± 6.4	31.7 ± 5.9	34.6 ± 5.5	34.4 ± 5.0	35.6 ± 5.8	31.1 ± 7.1	*******		*******		Y3<Y5,Y6+Y7/
		T	26.5 ± 7.6	34.0 ± 7.6	35.3 ± 7.4	38.9 ± 6.6	37.6 ± 6.1	38.7 ± 6.3	35.2 ± 8.1					Y4< Y5+Y7

TGMD-3	**Total**	M	60.8 ± 11.7	66.4 ± 10.9	71.7 ± 10.2	69.7 ± 9.5	69.1 ± 8.7	72.3 ± 8.5	68.5 ± 10.4	**<0.001**	0.26	**<0.001**	0.16	Y2<all/
	MS =	F	50.9 ± 8.1	60.2 ± 8.7	61.2 ± 7.7	63.2 ± 8.3	63.2 ± 8.3	64.5 ± 9.8	60.3 ± 9.6	*******		*******		Y3<Y7
	100	T	54.9 ± 10.8	63.6 ± 10.4	65.6 ± 10.2	67.2 ± 9.6	66.9 ± 8.7	68.8 ± 9.9	64.6 ± 10.8					
Additional	VJ	M	7.2 ± 2.1	7.6 ± 2.0	8.6 ± 1.9	7.0 ± 2.2	7.8 ± 2.8	8.6 ± 2.5	7.7 ± 2.3	0.79	0.00	**0.03**	0.03	Y2<Y7
Skills	*MS = 12*	F	7.1 ± 1.9	7.5 ± 2.2	7.0 ± 1.9	8.2 ± 2.2	8.6 ± 2.5	8.1 ± 2.4	7.7 ± 2.2			*****		
		T	7.1 ± 2.0	7.6 ± 2.1	7.6 ± 2.1	7.5 ± 2.3	8.2 ± 2.6	8.4 ± 2.5	7.7 ± 2.3					
	Balance	M	6.6 ± 2.2	7.4 ± 2.6	8.4 ± 1.7	7.3 ± 2.3	7.5 ± 1.9	7.9 ± 1.9	7.5 ± 2.2	**0.001**	0.03	**<0.001**	0.16	Y2<Y3+Y4/
	MS = 10	F	6.9 ± 2.5	8.5 ± 1.8	8.8 ± 1.4	8.4 ± 1.7	8.6 ± 1.2	8.2 ± 1.9	8.2 ± 1.9	******		*******		Y4>Y6+Y7
		T	6.8 ± 2.4	7.9 ± 2.3	8.6 ± 1.5	7.7 ± 2.1	8.0 ± 1.7	8.0 ± 1.8	7.8 ± 2.1					

Note: **S:** Sex, **M:** Male, **F:** Female, **T:** Total, η_p^2**:** Partial eta squared, **LM ST:** Locomotor skills subtest, **BS ST:** Ball skills subtest, **MS:** Max Score, **HJ:** Horizontal jump, **T-H Strike:** Two-hand strike, **FH Strike:** Forehand strike, **OH Throw:** Overhand throw, **UH throw:** Underhand throw, **T-H Catch:** Two-hand catch, **VJ:** Vertical jump, **Y:** Year, *****$p < 0.05$, ******$p < 0.01$, *******$p < 0.001$

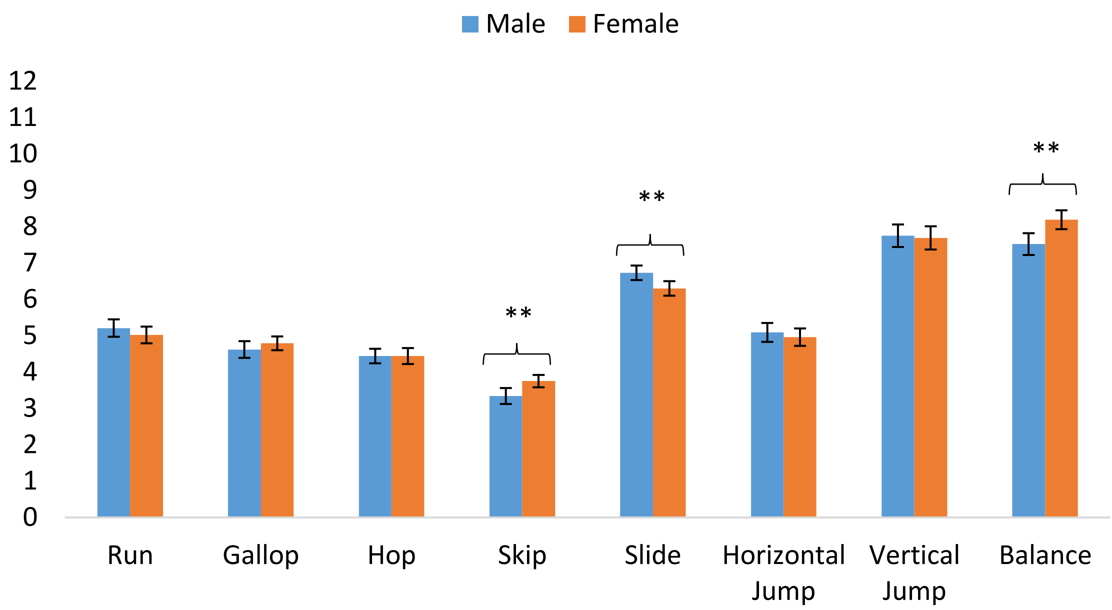

Figure 3.5 Mean score differences between males and females for individual locomotor skills
Note: ** p<0.01

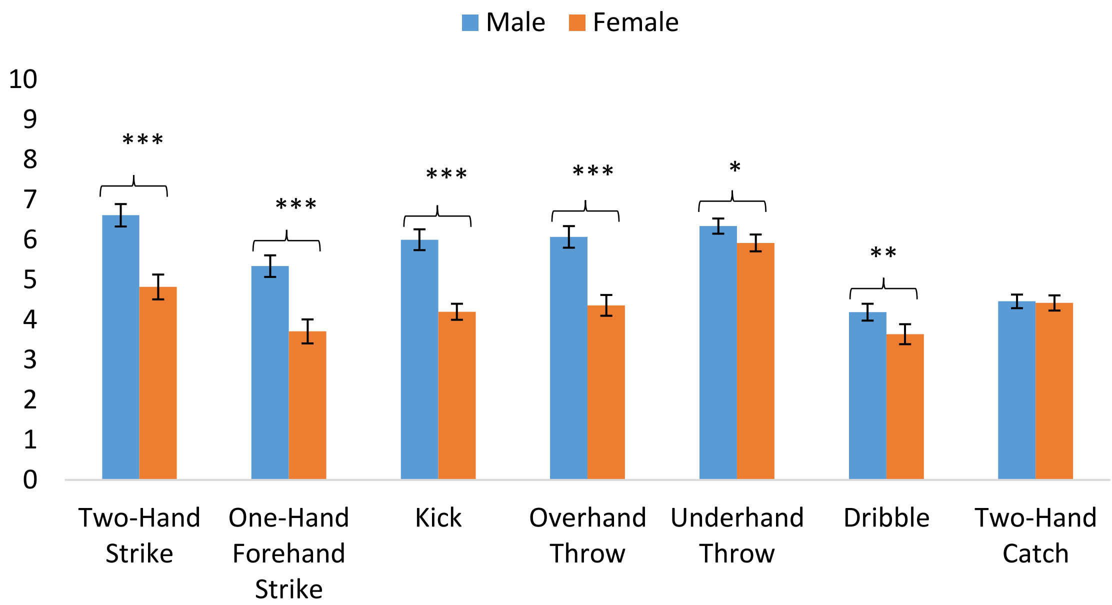

Figure 3.6 Mean score differences between males and females for individual ball skills
Note: * p<0.05, ** p<0.01, *** p<0.001

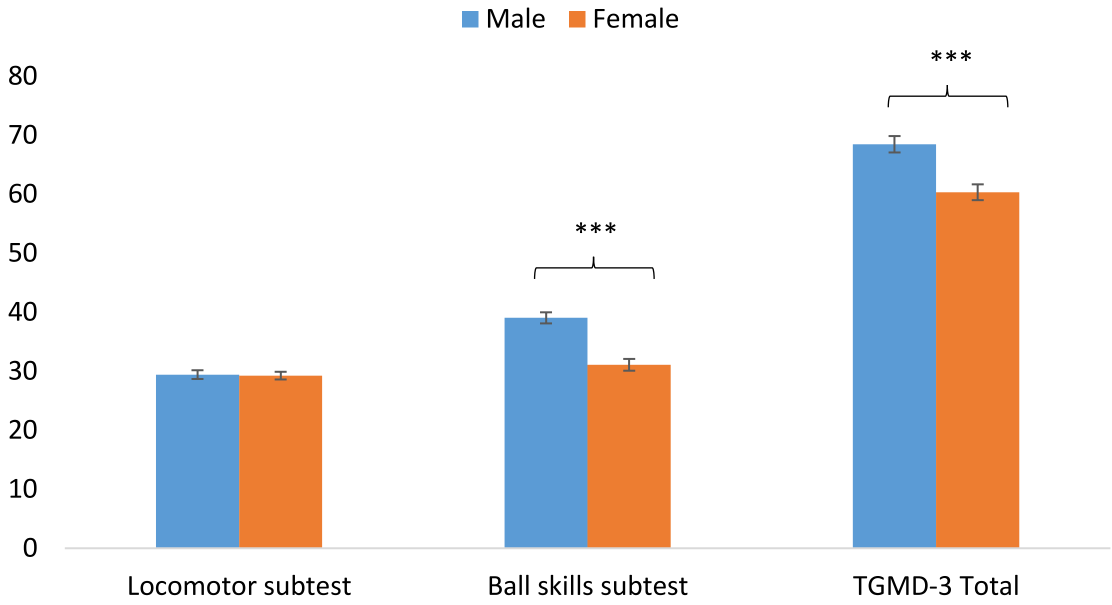

Figure 3.7 Mean score differences between males and females for locomotor subtest, ball skills subtest and TGMD-3 total scores
Note: *** p<0.001

3.4.4 FMS proficiency and weight status

The percentage of participants classified as overweight/obese increased from Year 2 to Year 7 (Figure 3.8). Table 3.6 summarises the differences in mean scores for each skill, locomotor subtest, ball skills subtest and total TGMD-3 between overweight/obese (n=95/22.9%) and non-overweight (n=319/77.1%) participants. Non-overweight participants performed significantly better than overweight participants in the locomotor subtest ($p<0.001$, d=0.7), ball skills subtest ($p=0.03$, d=0.3) and total FMS score ($p<0.001$, d=0.5) (Figure 3.12). Non-overweight participants were significantly better than overweight participants in 7 skills with medium effect sizes for the run ($p<0.001$, d=0.7) and horizontal jump ($p<0.001$, d=0.5), and small effect sizes for the hop ($p=0.01$, d=0.3), slide ($p=0.004$, d=0.3), vertical jump ($p=0.002$, d=0.4), kick ($p=0.009$, d=0.3) and two-hand strike ($p=0.003$, d=0.3) (Table 3.6).

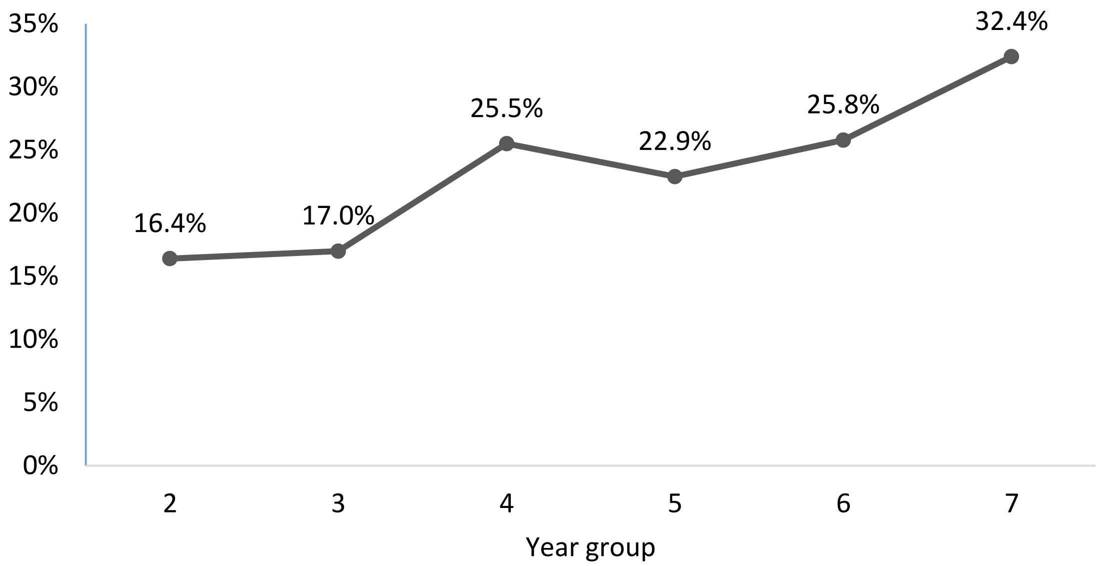

Figure 3.8 Percentage of participants classified as overweight/obese in each class group

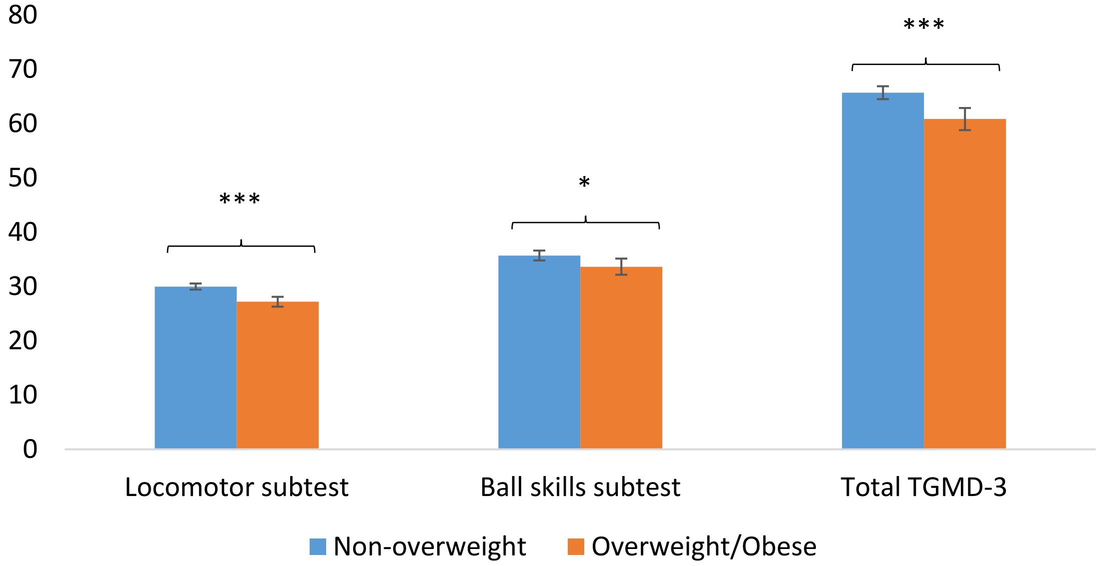

Figure 3.9 Difference in mean scores for locomotor subtest, ball skills subtest and total TGMD-3 scores between non-overweight (n=319) and overweight/obese (n=95) participants

Note: *****p<0.05, ******* p<0.001

Table 3.6 Difference in mean FMS scores between overweight/obese (n=95) and non-overweight (n=319) participants

	Skill	Weight status	Mean (raw score) ± SD	95% CI	P	Cohens-d
TGMD-3 LM skills	Run	N-OW	5.36 ± 1.7	-1.41, -0.73	**<0.001**	**0.7**
		OW/O	4.29 ± 1.4		***	
	Gallop	N-OW	4.67 ± 1.56	-0.24, 0.48	0.53	0.08
		OW/O	4.79 ± 1.60			
	Hop	N-OW	4.54 ± 1.58	-0.74, -0.08	**0.01**	**0.3**
		OW/O	4.13 ± 1.36		*	
	Skip	N-OW	3.54 ± 1.49	-0.36, 0.29	0.82	0.02
		OW/O	3.51 ± 1.21			
	Slide	N-OW	6.63 ± 1.41	-0.82, -0.15	**0.004**	**0.3**
		OW/O	6.15 ± 1.54		**	
	HJ	N-OW	5.24 ± 1.82	-1.31, -0.49	**<0.001**	**0.5**
		OW/O	4.34 ± 1.63		***	
	LM ST	N-OW	29.99 ± 5.1	-3.94, -1.66	**<0.001**	**0.6**
		OW/O	27.19 ± 4.5		***	
TGMD-3 Ball skills	T-H Strike	N-OW	5.92 ± 2.37	-1.23, -0.26	**0.003**	**0.3**
		OW/O	5.18 ± 2.00		**	
	FH Strike	N-OW	4.67 ± 2.29	-0.97, 0.01	0.05	0.2
		OW/O	4.21 ± 1.94			
	Kick	N-OW	5.26 ± 1.96	-0.96, -0.11	**0.009**	**0.3**
		OW/O	4.72 ± 1.72		**	
	OH Throw	N-OW	5.27 ± 2.05	-0.54, 0.41	0.78	0.03
		OW/O	5.20 ± 2.13			
	UH Throw	N-OW	6.19 ± 1.48	-0.55, 0.13	0.22	0.1
		OW/O	5.98 ± 1.47			
	Dribble	N-OW	3.95 ± 1.70	-0.48, 0.31	0.66	0.05
		OW/O	3.86 ± 1.74			
	T-H Catch	N-OW	4.44 ± 1.33	-0.28, 0.33	0.86	0.01
		OW/O	4.46 ± 1.29			
	BS ST	N-OW	35.71 ± 8.25	-3.91, -0.21	**0.03**	**0.3**
		OW/O	33.65 ± 7.30		*	
TGMD-3	**Total FMS**	N-OW	65.70 ± 10.8	-7.30, -2.41	**<0.001**	**0.5**
		OW/O	60.84 ± 10.0		***	
Additional Skills	VJ	N-OW	7.91 ± 2.32	-1.35, -0.30	**0.002**	**0.4**
		OW/O	7.08 ± 2.08		**	
	Balance	N-OW	7.93 ± 2.09	-0.89, -0.07	0.09	0.2
		OW/O	7.53 ± 2.06			

Note: **N-OW:** Non-overweight, **OW/O:** Overweight/obese, **CI:** Confidence interval, **LM ST:** Locomotor subtest, **BS ST**: Ball skills subtest, **HJ:** Horizontal jump, **T-H Strike:** Two-hand strike, **FH Strike:** Forehand strike, **OH Throw:** Overhand throw, **UH throw:** Underhand throw, **T-H Catch:** Two-hand catch, **VJ:** Vertical jump, ***** p<0.05, ****** p<0.01, ******* p<0.001

3.5 Discussion

The current study offers a comprehensive and up-to-date analysis of the status of FMS proficiency in Irish children in recent years by evaluating a broad range of FMS, including participants across a longer age span and using BMI percentiles to assess weight status. The low percentage of Irish primary school children achieving mastery in this study is similar to previous national (Bolger et al., 2018) and international investigations (Bardid et al., 2016; Bryant et al., 2014; van Beurden et al., 2002). The largest improvements in FMS mean scores occurred between Year 2 (age 6-7) and Year 3 (age 7-8), after which scores began to plateau and decline slightly, especially after Year 5 (age 9-10). In addition, males were significantly better than females in the ball skils subtest and non-overweight participants had significantly better locomotor subtest and balls skills subtest scores than their overweight/obese counterparts. These findings will be discussed in the following paragraphs.

The proportion of participants who achieved mastery (i.e. maximum score for a skill) across 15 FMS ranged from 1.4% (gallop) to 35.7% (slide). These scores are lower than Bolger et al. (2018), where the proportion of Year 2 (age 6) and Year 6 (age 10) Irish school children achieving mastery was between 12.3% (horizontal jump) and 79.4% (run). Bolger et al. (2018) reported higher mastery levels in the run (13% vs 79.4%), gallop (1.4% vs 53.1%), kick (20% vs 59%) and hop (2.4% vs 28.4%) but a similar proportion of participants achieved mastery in the horizontal jump, catch and overhand throw. However, the current sample had a higher percentage of overweight/obese participants (22.9% vs 13.8%) which may suggest that they are less physically active (Slotte et al., 2017) and hence less likely to have developed proficient levels of FMS compared to children who are more active (Robinson et al., 2015). As PA levels were not measured in either study, this suggestion is speculatively based on the developmental model proposed by Stodden et al. (2008) where FMS mastery, PA levels, weight status and perceived motor competence are likely all interlinked with each other. They suggest that young children who fail to partake in regular PA are limiting their opportunities to practice and learn FMS and are therefore more likely to have poor FMS competence. Consequently, as children get older, poor FMS competence is likely to reduce confidence and motivation to willingly participate in regular PA (Stodden et al., 2008) and combined with excessive calorie consumption, promotes weight gain beyond what is deemed healthy or normal for an individual's height and age.

These poor mastery levels are consistent with international investigations where less than 50% of English (Bryant et al., 2014), Australian (van Beurden et al., 2002; Hume et al., 2008; Hardy et al., 2013), US (Butterfield et al., 2012), Singaporean (Mukherjee et al., 2017), Brazilian (Valentini et al., 2007; Spessato et al., 2013), South African (Pienaar, Vidagie, and Leonard, 2015) and Belgian (Bardid et al., 2016) school children between 6 and 12 years old achieved mastery across a broad range of FMS. However, differences found among individual skills are not directly comparable due to cultural influences and variations in assessment tools used across studies. For example, children in America are more likely to practice and play baseball and American football compared to Irish children who are more likely to play the national sports hurling and Gaelic football. It is therefore not surprising that approximately 50% of American children aged 5 to 14 displayed mastery in the strike and overhand throw (Butterfield et al., 2012) compared to 12% and 22.7% respectively in the current study. Although hurling requires a two-hand striking action, the grip is often opposite to that displayed in baseball batting. As the TGMD is developed based on an American population the performance criteria are created according to what is expected for correct batting in baseball. Furthermore, the number of performance criteria required to achieve mastery in a particular skill can vary according to the assessment tool being used. For example, the skill of running requires correct execution of either 4 or 6 criteria to achieve mastery depending on whether the TGMD or the Process Orient Checklist is being used. Mastery is likely more achievable in studies using the TGMD assessment tool and must be taken into consideration when comparing and contrasting results from different studies. In the present study, the vertical jump was divided into 6 performance criteria, twice as many as the skip, catch and dribble and so might explain why only 7.5% achieved mastery despite it being a common skill requirement in the sport of Gaelic football and hurling.

A cross-sectional study by Bolger et al, (2018) found that Irish school children in Year 6 (age 10) demonstrated higher locomotor and object-control subtest scores than those in Year 2 (age 6), whilst Behan et al. (2019) reported improvements among Irish school children from age 5- to 10-years-old. It was therefore expected that FMS proficiency levels of older children would be better than younger children. However, no significant differences were reported across any class group from Year 2 (age 6) to 7 (age 12) for the locomotor subtest score. A large significant improvement in ball skills subtest scores occurred between Year 2 (age 6) and 3 (age 7) after which smaller improvements were observed but only until Year 5 (age 9). Similarly, Belgian (Bardid et al., 2016) and Brazilian

(Valentini et al., 2016) school children aged 3-8 and 3-10 years respectively, showed no significant improvements in locomotor subtest scores after age 6 (Bardid et al., 2016) and Brazilian school children's object-control subtest scores began to plateau by age 8 (Valentini et al., 2016). Since Bardid et al. (2016) only included children up to age 8, it is unknown if a similar plateau would have occurred had older children been included in that study.

As outlined in the literature review, skill acquisition is a complex process with children progressing at various rates depending on individual, task and environmental constraints (Newell, 1986). Exposure to new skills that have not been encountered before are likely to demonstrate large improvements initially (Karni et al., 1998), which may be represented by the large improvements seen in ball skills between Year 2 and 3. However, further improvements are more difficult to achieve as one becomes more skilled. Most children are exposed to, and practice, locomotor skills from a younger age compared to object-control/ball skills which may only be introduced to some children for the first time during primary school PE lessons (Haywood and Getchell, 2009; Webster et al., 2019). This might explain why locomotor skills did not improve at all, and why ball skills did improve, but only until Year 5.

A concerning fact is that the plateau in skill performance occurred without achieving mastery. From an Ecological Dynamics perspective, this may represent a period where children are experimenting with movement patterns and learning to control and co-ordinate more degrees of freedom, which might look like a drop in skill performance (Bernstein, 1967). The expectation would then be that with further practice and experimentation, the body would self-organise to create a more controlled and improved movement pattern. However, the lack of significant improvements over the 6-year period for locomotor skills and between Year 5 to 7 for ball skills subtest scores would say otherwise. In addition, Irish adolescents between 12- and 16-years-old have repeatedly represented poor mastery levels across most FMS (O'Brien et al., 2016b; Lester et al., 2017) suggesting that support structures are warranted to ensure Irish children and adolescents continue to progress and learn FMS to mastery level.

Increasing pressure is placed upon Irish primary school teachers who already struggle to keep up with curriculum demands. Most have very limited PE teacher-training hours and therefore often lack the confidence and motivation to successfully teach FMS within the curriculum (Fletcher and Mandigo, 2012). Current skill acquisition practitioners highlight the need to move away from old style skill and drill based activities and move towards a more experimental approach to skill development. Class groups consist of up to 30 children and so creating a learning environment that caters for the large inter-individual variability in one-session is difficult for a teacher with limited training (Smith, 2016). Children's motivation to learn and engage with the PE activities is highly variable and may be influenced by a large number of factors such as sex and weight status as will be discussed next.

In this study, males were significantly better than females in the ball skills category ($p<0.001$, $\eta_p^2=0.27$) which is supported by previous research (Bolger et al., 2017; Bardid et al., 2016; van Beurden et al., 2002). Additionally, when comparing the POMP scores for locomotor and ball skills subtest scores, males scored on average 8% higher on ball skills (64% LM vs 72% OC), whereas females scored on average 6% higher on locomotor skills (64% LM vs 58% OC). These findings are similar to two studies conducted in Canadian primary schools (Field and Temple, 2017; Crane et al. 2017) where 7- (Crane et al., 2017) and 9-year-old (Field and Temple, 2017) males scored 5% and 6% higher in the TGMD-2 object-control subtest compared to their locomotor subtest, respectively, whereas in both studies females scored on average 10% higher in the locomotor subtest compared to their object-control subtest. As pre-pubescent males and females are biologically similar, this divide is likely influenced by socio-cultural factors (Garcia, 1994; Thomas and French, 1985). Highly competitive invasion games are reportedly the most dominant activity in Irish primary PE lessons (Woods et al., 2018). However, females are more likely to disengage from these highly competitive activities due to the issues of perceived sex roles and the idea that they should act in a more caring, less competitive manner (Spencer, Rehman and Kirk, 2015). Therefore, while games are essential to the development of object-control skills, they must be organised in a way that allows all children to fully engage with the activity to facilitate object-control skill development for both males and females.

Evidence for sex differences in locomotor skill proficiency is less consistent with some studies reporting female superiority (Bolger et al., 2017; Hardy et al., 2010), and others supporting the current findings of no significant differences between males and females (O'Connor et al., 2018; O'Brien et al., 2016b; Foulkes et al., 2015; Bardid et al., 2016; Goodway et al., 2010). These variations may be influenced by the amount and type of locomotor skills assessed in a study, as females are more often significantly better at balance and skipping skills (Okely and Booth, 2004), potentially due to greater female engagement in activities such as dance and gymnastics (Garcia 1994; Thomas and French, 1985; Woods et al., 2018; Blachford et al., 2003). However, regardless of sex, less than 50% of participants achieved mastery or near-mastery in the majority of skills, and so these findings merely highlight the need to accommodate inter-individual variability within intervention programmes.

Non-overweight participants had higher locomotor subtest scores than overweight participants, which supports previous research that noted a 2-4 times higher chance of this occurring (Okely and Booth, 2004). The largest difference was observed for the run, a skill which overweight children are consistently less competent at (Bryant et al., 2014; Hume et al., 2008). Children with higher BMI are more likely to have excess adipose tissue surrounding joints, thus making it more difficult to physically move body limbs or to achieve full range of motion (Bryant et al., 2016). The criteria 'non-support leg bent to 90 degrees' for the run is an example of one component that may be largely affected by higher BMI and adipose tissue. Apart from the kick, the object-control skills investigated in the current study did not require whole-body locomotion and thus might explain the small effect size reported for the difference between overweight and non-overweight children in the object-control subtest. Primary schools provide an ideal setting to educate all children on the importance of PA and focusing on FMS development may increase their confidence and motivation to become more physically active both within and outside school (Hands 2012; Rainer and Jarvis 2020) .

3.6 Strengths and limitations

The strengths of this study are the large sample size and the inclusion of children across a broad age range. However, comparing FMS proficiency across class groups is limited by the cross-sectional design, while weight classification is limited by using only BMI. A longitudinal study could more accurately determine whether children improve their FMS competence throughout the primary school years. Having excess adipose tissue explains why overweight children are less proficient at locomotor skills than non-overweight children, however, BMI does not differentiate between lean mass and fat mass. Future investigations should therefore aim to include more accurate measurements of body composition such as DEXA, waist-hip circumference and skin-fold measurements.

3.7 Conclusion

The current study highlights the inadequate FMS proficiency levels among Irish school children, with new insights uncovered regarding age and weight-related differences. Males were more proficient than females in the ball skills subtest and non-overweight children were more proficient than overweight children in the locomotor and ball skills subtests. Thus, future intervention programmes should be tailored to the specific needs of the child, particularly at an age when teaching and practicing FMS is optimal for learning. Although some improvement in skill performance was observed throughout the early years, this plateaued or slightly declined after Year 5. Given that primary school offers an ideal setting for FMS development, future research should aim to understand how all children can be facilitated in acquiring a proficient level of FMS, regardless of sex, age or weight-status.

3.8 Summary

The findings of this investigation highlight a number of key issues regarding FMS development of Irish primary school pupils. Irish primary school children are not reaching a level that will provide them with the confidence and competence to maintain lifelong engagement in PA. It is therefore necessary to use this information to design and implement FMS based intervention programmes within a primary school setting. Efforts must be made to ensure the programme is enjoyable, motivating and appropriate for all children regardless of age, sex or weight status.

Chapter 4: Immediate and long-term effects of a fundamental movement skills intervention: A cluster crossover study with 13-month follow-up

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4.1 Abstract

Introduction: A large proportion of Irish school children exhibit poor mastery across a broad range of FMS. Due to the potential health implications associated with having poor FMS, potential strategies that may facilitate the learning and acquisition of FMS among children should be explored.

Methods: This study examined the immediate and long-term effects of an 8-week FMS intervention programme on 255 Year 3 and 4 Irish school children's (50% male, 7.4±0.6yr) FMS proficiency levels. Participants were conveniently recruited from four schools and randomly assigned to the intervention-control (Group I-C: 2 schools, n=134) or control-intervention (Group C-I: 2 schools, n=121) sequence. Group I-C completed the intervention (two 45-minute FMS classes per week for 8-weeks) in phase 1 and the control condition (routine PE lessons for 8-weeks) in phase 2, and vice-versa for Group C-I (2 schools, n=121). Phase 1 and phase 2 were separated by a 4-week period where neither group took part in PE or the intervention. FMS proficiency assessed using the TGMD-3, and weight status (BMI), were recorded at five time points: pre and post phase 1, pre and post phase 2 and at 13 months post-intervention.

Results: Linear mixed models revealed significant group × time interaction effects for locomotor subtest, ball skills subtest and total FMS scores (all $p<0.001$) following engagement in the FMS intervention. No significant changes were observed for the control condition (all $p>0.05$). Significant improvements for locomotor, ball skills and total FMS scores were reported for both groups at 13-month post-intervention compared to baseline (all $p<0.001$). No significant group × time × sex or group × time × weight status interaction effects were reported (all $p>0.05$). The proportion of participants who improved from poor-mastery to mastery/near-mastery was significant for eight skills, immediately following the intervention and from baseline to 13-month post-intervention.

Conclusion: Significant improvements in FMS proficiency were observed following a short-duration intervention that was delivered by an instructor with specialist FMS knowledge and an ability to create a mastery-oriented climate during lessons. Although the long-term effectiveness remains unclear, it is likely that mastery-oriented PE lessons could facilitate greater improvements in FMS development for children of all abilities compared to traditional PE lessons. Future studies should explore if primary teachers feel they have sufficient confidence and pedagogical skills to support children's FMS development during PE.

4.2 Introduction

With the global rise in childhood obesity levels and the subsequent risk of acquiring preventative obesity-related diseases such as type-2 diabetes and heart disease (British Heart Foundation National Centre, 2013; Hills, Anderson and Byrne, 2011), the establishment of protective measures to improve the health and wellbeing of today's youth is warranted (Sahoo et al., 2015). Although obesity is a complex phenomenon, regular engagement in PA is proven to enhance physical and psychological wellbeing and increases the chances of maintaining a healthy weight status (Hills, Anderson and Byrne, 2011; Booth, Roberts and Laye, 2012). Evidence suggests that health-related behaviours learned in childhood transfer to adulthood (Kelder et al., 1994), however, only 17% and 10% of Irish primary and secondary school children and adolescents, respectively, are achieving the recommended levels of 60 minutes moderate to vigorous PA each day (Woods et al., 2018). Low levels of perceived and actual FMS competence is often reported as a reason for avoiding PA (Woods et al., 2010; Crane and Temple, 2014; Boiche and Sarrazin, 2009), however, improving the quality of FMS instruction and practice opportunities for children may be a viable method to enhance children's enjoyment of and adherence to regular PA (Bremer et al., 2018). This is supported by a study where children with high FMS competence were 2.4 times more likely to meet the recommended daily PA guidelines, compared to children with low FMS competence (De Meester et al., 2018). Furthermore, younger children are more likely to perceive their FMS ability to be greater than it actually is, which is why they are often more willing to try new activities and engage in different forms of PA. However, as they get older, they can more accurately predict their actual level of competence, which can result in PA avoidance and dropout by less skilled individuals (Goodway and Rudisill, 1997; Harter, 1999; Robinson et al., 2015; Stodden et al., 2008). Gallahue, Ozmun and Goodway (2012) also predict that between the ages of 3 and 8 presents the ideal window of opportunity for children to learn FMS and therefore suggest that FMS interventions delivered during the primary school years may be most beneficial.

In addition to being the ideal time for FMS development, primary schools also offer the potential to reach a large proportion of children (Bailey, 2006; Sallis and McKenzie, 1991). All children under the age of 16 are lawfully obliged to attend school in Ireland. Therefore, school-based programmes provide the opportunity to include some of the most at-risk children that may not have access to such programmes outside of school. For example, girls often portray poorer object-control skill competence than boys (Kelly et al., 2019;

Bolger et al., 2018), and are also more likely to drop out of sport during adolescence (Woods et al., 2010; Woods et al., 2018; Lunn et al. 2013). The Irish primary school PE curriculum is often dominated by the games strand (Woods et al., 2018; Hardman, 2008) which often centres around a competitive, ego-centric environment. Although potentially preferred by boys and highly skilled individuals, such competitive and ego-oriented environments may be perceived as too challenging, unenjoyable and embarrassing for girls, less-skilled individuals and children with lower levels of perceived competence (Women in Sport, 2012; Cairney et al., 2012). However, when presented in a relevant and appealing way, girls can enjoy PE as much as boys (Sabo et al., 2004). These differences must be considered when delivering intervention programmes to groups of children with different interests and varying levels of skills and abilities.

Quality instruction and feedback opportunities are essential for FMS development (Gallahue et al., 2012; Morgan et al. 2013; Chan et al. 2016; Robinson et al. 2012) with much evidence highlighting the benefits of pedagogical practices that emphasise a mastery-oriented climate to enhance intrinsic motivation (Standage, Duda and Ntoumanis, 2003) and maximise student engagement in (Solmon 1996) and enjoyment of PE lessons (Vasconcellos et al. 2019; Ntoumanis and Biddle 1999). A mastery-motivational climate can be achieved by ensuring the learner's basic needs of competence, autonomy and relatedness are met during lessons (Deci and Ryan, 2000). Short-duration interventions emphasising a mastery-motivational climate have led to significant improvements in FMS proficiency among pre-school aged children, compared to non-mastery climates (Wick et al., 2017; Robinson and Goodway 2009; Valentini and Rudisill, 2004). In the study by Valentini and Rudisill, (2004), improvements in FMS were maintained at 6-month follow-up compared to post-intervention scores, however, Robinson and Goodway (2009) reported a significant decline in FMS at 9-week follow-up compared to post-intervention, but scores remained significantly higher than baseline. In the same study, FMS scores did not significantly change at post-intervention or at 9-week follow-up for the control group compared to baseline. These studies suggest that an instructional climate that fosters student autonomy and emphasises self-improvement rather than competition and winning can promote lasting FMS improvements. The theory behind a mastery-motivational climate suggests that children should be encouraged to take ownership of their learning experience by focusing on self-improvement and avoiding peer comparison and competition (Ames 1992). This provides more opportunities to experience success thus increasing intrinsic motivation and persistence to learn (Robinson et al., 2012).

Both national (Bolger et al., 2019) and international investigations (Lai et al., 2014; Tompsett et al., 2017; van Beurden et al., 2003, Mitchell et al., 2013) have reported significant improvements in children's FMS proficiency levels following engagement in school-based intervention programmes. However, to-date, only one study has been conducted in an Irish primary school setting (Bolger et al., 2019). An FMS intervention programme delivered by a qualified professional over 26 weeks (one academic year), supplemented by on-going teacher professional development and home exercises, led to significant improvements in locomotor, object-control and total FMS scores immediately post-intervention compared to a control group (Bolger et al., 2019). Although effective, this multi-component approach requires co-operation between pupils, teachers, parents and specialist coaches, which may be cost and labour intensive. Considering Irish primary schools already struggle to keep up with large curriculum demands (Irish National Teachers Organisation, 2015), national buy-in to these multi-component intervention programs may be negatively affected. Furthermore, follow-up analyses are lacking for the majority of FMS intervention studies (Lai et al., 2014) with only two known FMS interventions including follow-up analysis in Australian primary school settings (Salmon et al., 2008; Barnett et al., 2009). No follow-ups have yet been investigated in Irish primary schools. True learning of a skill, which is described as a relatively permanent change in performance as a result of practice (Magill, 2007), can only be assessed through the use of a retention test and should therefore be included when assessing the effectiveness of intervention programmes.

Study one reports how Irish primary school children are not reaching their developmental potential for FMS proficiency, with less than 40% achieving mastery across 15 skills (Kelly et al., 2019). Combined with the evidence from Bolger et al. (2018) and Behan et al. (2019), where the proportion of Irish school children achieving mastery or mastery/near mastery ranged from 12.3% to 79.4%, the necessity to target FMS development of Irish school children is undisputable. However, intervention programmes need to be feasible and attractive for schools. Although long-duration (i.e. full academic year), multi-component interventions have led to significant improvements in primary school children's FMS proficiency levels, limited evidence exists to understand the effectiveness of short-duration interventions that focus primarily on specialist FMS instruction.

Therefore, the aim of this study is to examine the effectiveness of an 8-week, school-based FMS intervention programme on FMS proficiency levels immediately post-intervention and at a 13-month follow-up. A secondary aim is to examine intervention effects according to sex and weight status.

4.3 Methods

A longitudinal cluster crossover design was employed to investigate the effects of an 8-week FMS intervention programme on FMS proficiency levels immediately post-intervention and at 13-months post-intervention. The crossover design ensured that all participants in each school were provided with the opportunity to participate in the FMS programme which was critical for the recruitment process. Ethical approval was granted by the Institute's research ethics board.

4.3.1 Study participants and setting

An a priori sample size calculation was used to determine the study size using the standard deviation of a previously conducted study with a similar study design (Draper et al. 2012). With α=0.05, power=0.8, detectable difference=1 and standard deviation=2.4, the projected sample size required minimally 186 participants (93 for control group and 93 for intervention). To account for a drop-out rate of 15%, a minimum of 214 participants had to be recruited for this study.

Participants (N=255) were conveniently recruited from Year 3 (Age: 6.9±0.4 yrs.) and Year 4 (Age: 7.9±0.4 yrs.) mainstream classes, from 4 schools in the midlands of Ireland. As the principal investigator was delivering all lessons, only four schools could be accepted into the study. Schools were informed that acceptance to the study would be granted on a first come basis, whilst others would be held as reserves should any issues arise prior to the study commencing. Preceding baseline data collection, informed consent by legal guardians and assent by eligible participants were provided (Appendix D and E). Children who failed to return signed consent forms or those with a musculoskeletal injury, disability or medical condition that limited their ability to participate in PA were excluded. Children with mild learning disabilities who had no difficulty following instructions were included in the study. The class teacher planned and supervised alternative activities for children who did not participate in the testing.

4.3.2 Study procedure and outcomes

At baseline, all participants in two schools were randomly assigned to the intervention-control (I-C) sequence and all participants in the remaining two schools to the control-intervention (C-I) sequence. Group I-C completed the intervention in phase 1 (P1) and the control condition (i.e. normal PE) in phase 2 (P2) and vice versa for Group C-I. The intervention was implemented in place of usual PE lessons. Each phase was separated by a 4-week period where both groups were on school holidays and, therefore, not engaging in PE or the intervention.

Figure 4.1 outlines the study process and the number of participants with complete TGMD-3 data at each time point. Reasons for missing data included illness, injury and family holidays. Outcome measures were assessed for all participants at five time points where time 1 (T1) was baseline/phase 1 pre-test, time 2 (T2) phase 1 post-test, time 3 (T3) post 4-week washout/phase 2 pre-test, time 4 (T4) phase 2 post-test and time 5 (T5) was at 13-months post-intervention.

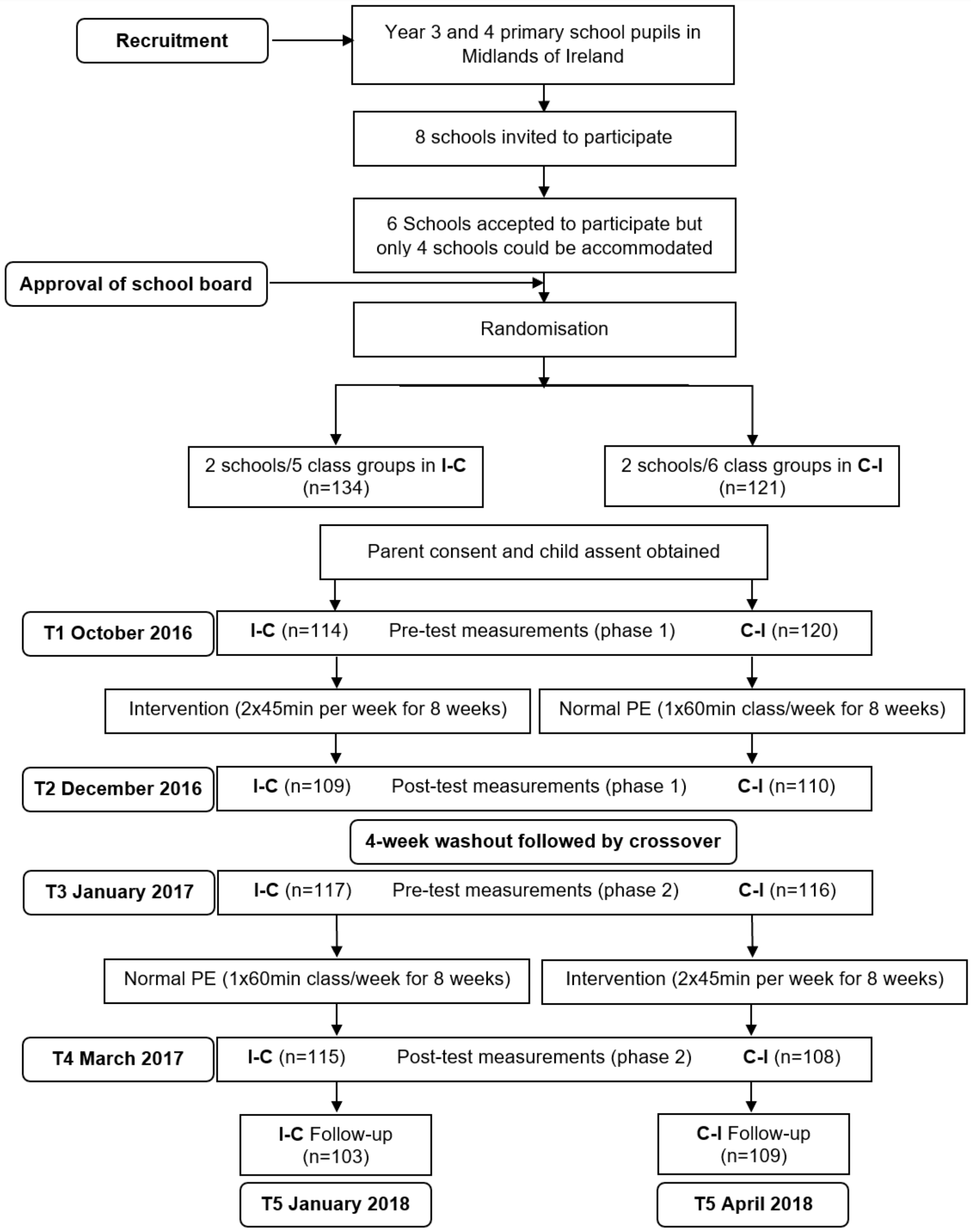


Figure 4.1 Participant recruitment (n values refer to those who have full TGMD-3 data) *Note:* **I-C:** Intervention-control group, **C-I:** Control-intervention group, **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** Follow-up (i.e. 13-months post intervention)

FMS were assessed using the valid (Temple and Foley 2017; Valentini, Zanell and Webster 2016) and reliable (Rintala, Sääkslahti and Iivonen 2017) Test of Gross Motor Development-Third Edition (TGMD-3) which includes 13 skills, namely the run, gallop, hop, skip, slide and horizontal jump in the locomotor skills category and the two-hand strike, forehand strike, kick, catch, dribble, overhand throw and underhand throw in the ball skills category (formerly object-control skills) (Ulrich 2019).

Anthropometric measurements were also recorded at each time point. Height was measured, to the nearest 0.1 cm, using a portable height stadiometer (SECA 217, SECA ltd., Leicester, UK) and body mass, to the nearest 0.1 kg, using a portable SECA heavy-duty scale (SECA colorata 760, SECA ltd., Leicester, UK). Body Mass Index (BMI) was derived using the equation: body mass (kg)/height (m^2). Participants were categorised as either overweight/obese or non-overweight according to the age- and gender-specific International Obesity Task Force (IOTF) cut-off points (Cole et al. 2000). Although weight status in chapter 3 was classified using the extended IOTF cut-offs (Cole and Lobstein, 2012), only 12% of participants were classified as Grade 3 and Grade 2 thinness (i.e. underweight) which was too small to analyse underweight as a separate category. Consequently, the cut-offs used for analysing weight status effects in Chapter 3 were the same as the original IOTF cut-offs for non-overweight and overweight/obese used in the current chapter (Cole et al., 2000).

4.3.3 FMS assessment and scoring

Participants were video recorded performing two trials of each skill which were retrospectively scored by the principal investigator. Scores for the six locomotor skills and seven ball skills were summed to determine the locomotor subtest and ball skills subtest scores, respectively. Both subtest scores were added to give the total FMS score. The full testing and scoring procedures are detailed in chapter 3.

Although intra-rater reliability for scoring the skills was established for study 1, this was completed prior to scoring the videos for the current study also. Previous research by Cano-Cappellacci et al. (2015) was utilised to identify the standard deviation required to estimate a suitable sample size for determining the reliability of scoring the skills. With $\alpha = 0.05$, power = 0.8, detectable difference = 1 and standard deviation = 1.4, the projected sample size required was 32. Similar to Birch et al., (2016) who conducted intra-rater reliability on 30 participants, the principal investigator completed intra-rater reliability by assigning scores to a randomly selected subset of videos from 32 participants

(16 from Group I-C and 16 from Group C-I) performing each of the 13 skills two weeks after baseline data collection. The same videos were rescored two-weeks later (Koo and Li, 2016). ICC scores were classified as poor (<0.5), moderate (0.5 – 0.75), good (0.75 – 0.9) or excellent (>0.9) (Koo and Li, 2016). As highlighted in Table 4.1, intra-rater reliability was good for the run and gallop and excellent for all other skills with ICC values ranging from 0.76 to 0.96.

Table 4.1 Reliability values for each skill

Skill	ICC	95% Confidence Interval
Run	0.76	0.61-0.87
Gallop	0.83	0.67-0.91
Hop	0.91	0.82-0.95
Skip	0.94	0.88-0.97
Slide	0.94	0.88-0.97
Horizontal Jump	0.93	0.86-0.96
Two-hand strike	0.90	0.81-0.95
Forehand strike	0.93	0.87-0.97
Kick	0.95	0.93-0.96
Overhand throw	0.91	0.82-0.95
Underhand throw	0.90	0.81-0.95
Dribble	0.94	0.89-0.96
Catch	0.96	0.91-0.98

Note: **ICC**: Intra-class correlation

4.3.4 Intervention design

The principal investigator with over eight years' experience coaching children (mainly in athletics) and a certificate in Coaching Children from Coaching Ireland (focusing on physical literacy), delivered all intervention sessions in each schools' indoor hall. The intervention replaced PE lessons and consisted of two 45-minute sessions per week over 8 weeks (total: 16 sessions, 720 minutes). The class teacher arranged and supervised alternative activities for non-participating children and did not assist with the intervention in any way. Similar to the structure of a previous community-based intervention, three skills were targeted during each lesson (Bardid et al. 2017).

Although the TGMD-3 includes 13 skills, overhand and underhand throwing were grouped together, allowing for each skill to be included four times throughout the 8-week intervention. Each lesson started with a warm-up, which also included a quick discussion on the skills being targeted in the session (10 minutes), two or three separate games/activities (30 minutes) and a cool-down which also incorporated some questioning and discussion on the skills just practiced (5 minutes). A lesson plan was created for each of the sixteen intervention sessions (Appendix F) and were delivered in the same order for each class group.

During the control condition, teachers were asked to continue with their usual PE routine. This typically involved one 60-minute class per week focusing on one of the six strands in the Irish PE curriculum (athletics, dance, gymnastics, aquatics, outdoor and adventure, and games). The exact content, duration or frequency of the control condition for each school was not monitored. Teachers were advised not to change anything about their usual approach to teaching PE during the study.

4.3.4.1 Theoretical influence of how the intervention was delivered

Achievement goal theory (Nicholls, 1989) and self-determination theory (Deci and Ryan, 2008) guided the pedagogical approach for the intervention. Achievement goal theory proposes that learners are motivated to engage with lessons by either an ego- or task/mastery-oriented climate. Ego-based climates are characterised by social comparison, external rewards and aiming to be the best with as little effort as possible. Teachers who promote competition and winning and who publicly recognise the best performance within the class are more likely to create an ego-oriented climate. In contrast, mastery-oriented lessons are created by rewarding hard work and effort, focusing on self-improvement and avoiding peer comparison. The TARGET acronym (task, authority, recognition, grouping, evaluation and time) promoted by Ames (1992) was used to guide the principal investigator in facilitating a mastery-motivational climate during each lesson.

4.3.4.2 Application of the TARGET principles to create a mastery-motivational climate

Tasks were structured to maximise engagement and create an inclusive environment. This meant that for each activity, different variations were provided to allow children to choose the option that suited their perceived level of ability. *Authority* was seen as a collaborative process between the instructor and the children. In line with self-determination theory, learners who feel they have choice or autonomy over their actions are more intrinsically motivated to engage in the learning process (Deci and Ryan, 1985; Ntoumanis, 2001). Consequently, children were involved in setting rules at the start of the intervention period, they were given choices over the level of difficulty of the tasks they were engaging in and to some extent were allowed to choose the time to spend on certain activities. As such, the lesson plans outlined in Appendix F include three main activities, however, in some lessons only two of the three activities were completed as a result of children enjoying an activity and choosing to continue with it for longer. Peer teaching was also encouraged to further promote student-centred learning and minimise teacher-led direct-instruction. *Recognition* within a mastery-oriented climate places emphasis on self-referenced improvements and effort rather than peer comparison and winning. The instructor provided individualised feedback and encouragement to children in private. A primary goal was to ensure that each child experienced a sense of success or achievement within each lesson. *Grouping* can have important implications in fostering a sense of relatedness among children. Although mastery-motivational theory recognises the importance of individual learning goals, it is also imperative that children learn to support each other and create a sense of belonging within the group. Children were encouraged to understand how their personal effort would benefit the group as a whole, but also how their support and encouragement towards their peers could also be of value. Various grouping arrangements were used throughout the lessons which included, allowing children to self-select their partners or groups, creating small mixed ability groups and quick re-grouping between tasks to ensure children developed interpersonal skills needed to co-operate with different peers. *Evaluation* was informal but ongoing for both the instructor and the children. The instructor evaluated lesson content and delivery to determine the aspects that could be improved for future lessons. For children, questioning was used to promote self-evaluation. For example, during a throwing and catching activity, questions like "what way would you recommend throwing a ball to make it easier for your partner to catch it?" and "how would you throw the ball if you want to throw it really far?", were asked. Peer evaluation was also encouraged where children provided supportive feedback to their peers during some tasks in order to figure out ways of helping each other to improve their skills. *Time* on task varied according to the needs of individuals and the overall class. Although lesson plans were created for each intervention session, they were designed to act as a guide for targeting the specific skills in a flexible manner rather than being used as a strict step by step process.

4.3.5 Data analysis

All data were analysed using IBM SPSS software version 25 (SPSS Inc. Chicago, IL). Significance was set at $p<0.05$. All data were determined to be normally distributed. Independent T-tests were used to assess the differences in age, locomotor subtest, ball skills subtest and total FMS mean scores between Groups I-C and C-I at baseline. Additionally, Chi-square analysis were run to compare the distribution of participants according to sex and weight-status in each group at baseline. Raw scores for locomotor subtest, ball skill subtest and total FMS were reported at each time point using means and standard deviations. Additionally, percentage of maximum possible (POMP) scores were calculated using the equation ([(observed score − minimum score)/(maximum score − minimum score)] × 100) (Cohen, 1999) to allow direct comparison between locomotor and ball skill subtest scores.

The intention-to-treat principle was applied as it limits the risk of bias and provides a more accurate estimate of the effects of the intervention compared to a per protocol analysis (McCoy 2017). Linear mixed models were conducted to assess the effects of the intervention programme on FMS outcome measures (locomotor subtest score, ball skills subtest score and total FMS score) over time. Group (I-C, C-I), time (pre-phase 1[T1], post-phase 1[T2], pre-phase 2 [T3], post-phase 2 [T4], 13 months post-intervention [T5]) and group-time interaction formed the base of the model as fixed effects. Class group (Year 3/Year 4) was included as a random effect using the variance components covariance matrix. The individual participants as part of each school cluster were assessed as a repeated effect using the unstructured covariance matrix. Additionally, a group-time-sex interaction was included to investigate potential sex effects and a group-time-weight status interaction was included to investigate any weight status effect. Bonferroni adjustments for multiple comparisons were applied to limit the risk of type-1 error. Effect sizes were calculated using Cohen's d where $d = 0.2$, 0.5 and 0.8 represented small, medium and large effect sizes, respectively (Cohen 1988).

Finally, a binary variable was computed to define mastery/near-mastery (MNM) or poor mastery (PM) for each skill (O'Brien et al. 2016a; 2016b). Mastery was assigned when a maximum score was achieved for a skill with near mastery assigned when all but one skill criteria was correctly performed over two trials. Poor mastery was assigned when more than one skill criteria was incorrect/absent over the two trials (O'Brien et al. 2016b; van Beurden et al. 2002). McNemar tests were run to identify if the proportion of participants achieving MNM for each skill significantly improved from pre to post phase 1, pre to post phase 2 and from baseline to follow-up. Effect sizes were determined by calculating the Odds Ratio and classified as small (1.5), medium (3.5) and large (9.0) (Cohen 1988).

4.4 Results

Baseline characteristics are outlined in Table 4.2 and mean FMS scores for each time point are displayed in Table 4.3. Both I-C and C-I groups were similar at baseline for age, locomotor subtest, ball skills subtest and total FMS scores ($p>0.05$). Additionally, the distribution of participants by sex and weight-status were similar across both groups.

Table 4.2 Baseline characteristics of study participants

Variable	Total			Group I-C			Group C-I		
	All (n=255)	**Male (n=127)**	**Female (n=128)**	**All (n=134)**	**Male (n=64)**	**Female (n=70)**	**All (n=121)**	**Male (n=63)**	**Female (n=58)**
Age (years) (M±SD)	7.4±0.6	7.5±0.6	7.4±0.7	7.5±0.7	7.5±0.7	7.4±0.7	7.4±0.6	7.5±0.6	7.3±0.6
Mass (kg) (M±SD)	26.2±5.8	26.6±5.7	25.7±5.8	26.6±6.3	26.9±6.1	26.2±6.4	25.8±5.2	26.3±5.3	25.2±5.1
Height (cm) (M±SD)	125.4±6.2	125.9±6.0	124.9±6.4	125.8±6.8	126.7±6.2	125.1±5.6	124.9±5.4	125.1±5.6	124.7±5.3
Weight status (% Non-ow/ow-ob)	79/21	78.5/21.5	79.5/20.5	78/22	77/23	79/21	81/19	81/19	81/19
Run n=241 (M±SD) (% m/nm)	4.3±1.8 (6.3/16.5)	4.1±1.7 (4.2/16.0)	4.4±1.8 (9.0/18.9)	4.4±1.8 (5.8/23.3)	4.3±1.7 (5.4/21.4)	4.5±1.8 (6.3/25.0)	4.1±1.8 (7.4/11.6)	3.9±1.7 (3.2/11.1)	4.4±1.9 (12.1/12.1)
Gallop n=250 (M±SD) (% m/nm)	3.1±2.0 (0/14.4)	3.1±2.1 (0/14.6)	3.1±2.0 (0/14.2)	3.0±2.0 (0/11.5)	3.2±2.1 (0/16.4)	2.8±2.0 (0/7.2)	3.2±2.1 (0/17.5)	3.0±2.1 (0/12.9)	3.4±2.0 (0/22.4)
Hop n=240 (M±SD) (% m/nm)	3.4±1.6 (1.3/8.3)	3.3±1.5 (0.9/6.0)	3.6±1.6 (1.6/10.6)	3.5±1.7 (2.5/9.2)	3.3±1.7 (1.9/7.4)	3.7±1.7 (3.1/10.8)	3.4±1.4 (0/7.4)	3.2±1.4 (0/4.8)	3.5±1.4 (0/10.3)
Skip n=240 (M±SD) (% m/nm)	3.2±1.4 (0.4/64.7)	3.0±1.4 (0/61.5)	3.4±1.3 (0.8/75.6)	3.4±1.3 (0.8/73.1)	3.2±1.4 (0/68.5)	3.6±1.1 (1.5/76.9)	3.0±1.5 (0/64.5)	2.9±1.4 (0/55.6)	3.2±1.4 (0/74.1)
Slide n=240 (M±SD) (% m/nm)	5.7±2.0 (27.9/26.7)	5.7±2.1 (30.8/21.4)	5.7±2.0 (25.2/31.7)	5.6±1.9 (24.4/26.9)	5.6±2.2 (31.5/16.7)	5.6±1.7 (30.2/25.4)	5.7±2.1 (31.4/26.4)	5.8±2.0 (30.2/25.4)	5.7±2.2 (32.8/27.6)
H jump n=254 (M±SD) (% m/nm)	4.5±1.6 (4.0/24.9)	4.6±1.7 (4.8/27.0)	4.4±1.5 (3.1/22.8)	4.4±1.4 (0.8/24.1)	4.5±1.4 (0/29.7)	4.4±1.3 (1.4/18.8)	4.5±1.9 (7.5/25.8)	4.6±2.0 (9.7/33.9)	4.4±1.8 (5.2/27.6)
Strike n=255 (M±SD) (% m/nm)	5.8±1.8 (2.0/17.3)	6.3±1.9 (3.9/21.3)	5.4±1.7 (13.3/86.7)	6.1±1.9 (3.7/22.4)	6.5±2.0 (7.8/23.4)	5.8±1.8 (0/21.4)	5.5±1.6 (0/11.6)	6.1±1.6 (0/19.0)	4.9±1.4 (0/3.4)
FHS n=255 (M±SD) (% m/nm)	3.3±2.2 (2.7/14.9)	3.9±2.3 (4.7/21.3)	2.7±1.9 (0.8/8.6)	3.2±2.2 (2.2/14.9)	3.8±2.3 (4.7/18.8)	2.6±2.0 (0/11.4)	3.4±2.2 (3.3/14.9)	4.0±2.3 (4.8/23.8)	2.7±1.8 (1.7/5.2)

OHT n=254 (M±SD) (% m/nm)	3.9±1.9 (6.7/14.2)	4.3±2.1 (10.2/18.9)	3.4±1.7 (3.1/9.4)	4.4±1.9 (9.0/18.8)	4.9±1.9 (12.5/25.0)	3.8±1.8 (5.8/13.0)	3.3±1.8 (4.1/9.1)	3.6±2.1 (7.9/12.7)	3.0±1.4 (0/5.2)
UHT n=254 (M±SD) (% m/nm)	5.3±1.6 (10.6/35.8)	5.2±1.6 (9.4/32.3)	5.3±1.6 (11.8/39.4)	5.3±1.6 (9.8/40.6)	5.1±1.6 (7.8/34.4)	5.5±1.5 (11.6/46.4)	5.2±1.7 (11.6/30.6)	5.3±1.6 (11.1/30.2)	5.1±1.7 (12.1/31.0)
Kick n=255 (M±SD) (% m/nm)	3.8±1.6 (3.1/12.9)	4.5±1.8 (6.3/22.8)	3.1±1.2 (0/3.1)	3.6±1.6 (2.2/11.2)	4.4±1.7 (4.7/21.9)	2.9±1.1 (0/1.4)	4.0±1.7 (4.1/14.9)	4.6±1.8 (7.9/23.8)	3.4±1.2 (0/5.2)
Dribble n=254 (M±SD) (% m/nm)	3.3±1.7 (11.0/33.5)	3.5±1.7 (15.0/34.6)	3.0±1.7 (7.1/32.3)	3.2±1.7 (12.0/28.6)	3.6±1.7 (18.8/29.7)	2.8±1.8 (5.8/27.5)	3.3±1.7 (9.9/38.8)	3.4±1.7 (11.1/39.7)	3.2±1.6 (8.6/37.9)
Catch n=255 (M±SD) (% m/nm)	4.0±1.4 (18.0/42.7)	3.9±1.3 (15.0/48.0)	4.0±1.4 (21.1/37.5)	4.0±1.3 (15.7/46.3)	4.0±1.3 (17.2/48.4)	3.9±1.3 (14.3/44.3)	4.0±1.4 (20.7/38.8)	3.9±1.3 (12.7/47.6)	4.2±1.5 (29.3/29.3)
LM subtest n=234 (M±SD)	24.3±5.6	23.8±5.5	24.8±5.6	24.6±5.4	24.3±5.7	24.8±5.3	24.1±5.7	23.4±5.4	24.7±6.0
BS subtest n=252 (M±SD)	29.4±6.5	31.7±6.8	27.1±5.2	29.9±6.8	32.5±6.9	27.6±5.7	28.8±6.2	30.9±6.7	26.5±4.6
Total FMS n=234 (M±SD)	53.6±9.8	55.6±10.6	51.7±8.7	54.5±9.9	57.4±10.7	52.1±8.5	52.8±9.7	54.2±10.3	51.3±8.9

Note: **M±SD**: Mean ± standard deviation, **I-C:** Intervention-control group, **C-I:** Control-intervention group, **% non-ow/ow-ob:** % Non-overweight/overweight-obese, **%m/nm:** % Mastery/near-mastery where mastery = correct performance of all skill criteria over two trials and near-mastery = correct performance of all but one skill criteria over two trials **H jump:** Horizontal jump, **FHS:** Forehand strike, **OHT:** Overhand throw, **UHT:** Underhand throw, **LM:** Locomotor, **BS:** Ball skills

Table 4.3 Raw and percentage of maximum possible (POMP) scores for locomotor subtest (n=234), ball skills subtest (n=252) and total FMS (n=234) across time

	T1	**T2**	**T3**	**T4**	**T5**
LM subtest (M±SD)	24.3±5.6	26.2±5.5	26.1±5.5	28.1±5.1	26.7±5.6
Group I-C (M±SD)	24.6±5.4	27.9±4.6	26.8±5.1	27.4±4.6	27.0±5.2
POMP (%)	53.4	60.7	58.3	59.5	58.7
Group C-I (M±SD)	24.0±5.7	24.5±5.9	25.5±5.7	28.8±5.5	26.4±5.9
POMP (%)	52.2	53.3	55.4	62.2	57.3
BS subtest (M±SD)	29.4±6.5	32.5±7.6	32.1±6.9	33.8±6.9	35.0±6.4
Group I-C (M±SD)	29.9±6.8	36.3±6.5	32.3±7.1	32.9±6.4	34.8±6.7
POMP (%)	55.4	67.2	59.8	60.9	64.5
Group C-I (M±SD)	28.8±6.2	28.7±6.6	31.8±6.7	34.8±7.2	35.1±6.1
POMP (%)	53.3	53.2	58.9	64.4	65.0
Total FMS (M±SD)	53.6±9.8	58.6±11.0	58.2±10.5	62.0±10.0	61.6±10.0
Group I-C (M±SD)	54.5±9.9	64.1±8.7	59.0±10.5	60.3±8.4	61.5±9.6
POMP (%)	54.5	64.1	59.0	60.3	61.5
Group C-I (M±SD)	52.8±9.7	53.0±10.2	57.4±10.5	63.8±11.2	61.7±10.3
POMP (%)	52.8	53.0	57.4	63.8	61.7

Note: **LM:** Locomotor, **BS:** Ball skills, **I-C:** Intervention-control group, **C-I:** Control-intervention group, **M**: Mean, **SD**: standard deviation, **POMP:** Percentage of maximum possible score, **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** 13-month follow-up

Phase 1 (T1 to T2)

Linear Mixed Models revealed significant group by time interaction effects for the locomotor subtest (Figure 4.3), ball skills subtest (Figure 4.4) and total FMS scores (Figure 4.5). Group I-C showed a medium significant improvement from T1 to T2 for the locomotor subtest ($p<0.001$, $d=0.6$), and a large significant improvement for the ball skills subtest and total FMS scores (both $p<0.001$, $d=1.0$). FMS scores did not change significantly for Group C-I during phase 1.

Washout (T2 to T3)

The 4-week washout phase was implemented between T2 and T3. The locomotor subtest [mean difference: 1.2, (95% CI: 0.2, 2.1) $p=0.02$], ball skills subtest [mean difference: 3.8, (95% CI: 2.8, 4.8), $p<0.001$] and total FMS [mean difference: 5.0, (95% CI: 3.5, 6.5),

$p<0.001$] scores significantly decreased for Group I-C, however, all remained significantly higher than baseline scores. There was no significant change in the locomotor subtest score for Group C-I during the washout phase ($p>0.05$), but their ball skills subtest [mean difference: -2.9 (95% CI: -4.0, -1.9), $p<0.001$] and total FMS scores [mean difference: -4.0 (95% CI: -5.5, -2.5), $p<0.001$] significantly increased. Locomotor subtest, ball skills subtest and total FMS scores for Group C-I were significantly higher than baseline values after the washout phase. Groups I-C and C-I had similar locomotor subtest, ball skills subtest and total FMS scores after the washout phase (all $p>0.05$).

Phase 2 (T3 to T4)

A medium significant improvement for the locomotor subtest and total FMS scores (both $p<0.001$, $d=0.6$), in addition to a small significant improvement in the ball skills subtest scores ($p<0.001$, $d=0.4$) was observed for Group C-I after the intervention (T4 vs T3). FMS scores for Group I-C did not change significantly from T3 to T4.

13-month follow-up

Compared to baseline scores, both groups maintained a significant improvement in their locomotor, ball skills and total FMS scores at 13-month follow-up. The effect size was small for both groups in the locomotor subtest scores (I-C: $p=0.02$, C-I: $p<0.001$, both $d=0.4$), whilst for the ball skills subtest and total FMS scores, Group I-C revealed medium effect sizes (both $p<0.001$, $d=0.7$) and Group C-I displayed large effect sizes (both $p<0.001$, $d=1.0$ and 0.9 respectively).

Sex and weight status effects

Linear mixed models revealed no significant sex-group-time interaction effects or sex-time interaction effects for the locomotor subtest, ball skills subtest or total FMS scores (all $p>0.05$). There was however a significant main effect for sex, for the ball skills subtest [mean difference: 4.6, (95% CI: 3.4, 5.8), $p<0.001$] and total FMS scores [mean difference: 3.8, (95% CI: 1.8, 5.9), $p<0.001$] with males outperforming females in both. There was no significant difference between males and females for the locomotor subtest scores ($p>0.05$).

There were no significant weight status-group-time interaction effects for either subtest or total FMS scores. However, overweight/obese participants had significantly lower total FMS scores than non-overweight participants, which was consistent over time [mean difference: 2.6, (95% CI: 0.8, 4.4), p=0.005]. Non-overweight participants had significantly higher locomotor subtest scores (p<0.001), however, there was also a significant time-weight status interaction effect (p=0.04). Pairwise comparison revealed that non-overweight participants had significantly higher locomotor subtest scores than overweight/obese participants at each time point apart from T2 where the difference was not significant, but still higher for the non-overweight participants. Overweight and non-overweight participants did not differ significantly at any time point for the ball skills subtest scores (p>0.05). The percentage of participants in each group classified as overweight/obese at each time point is displayed in Figure 4.2.

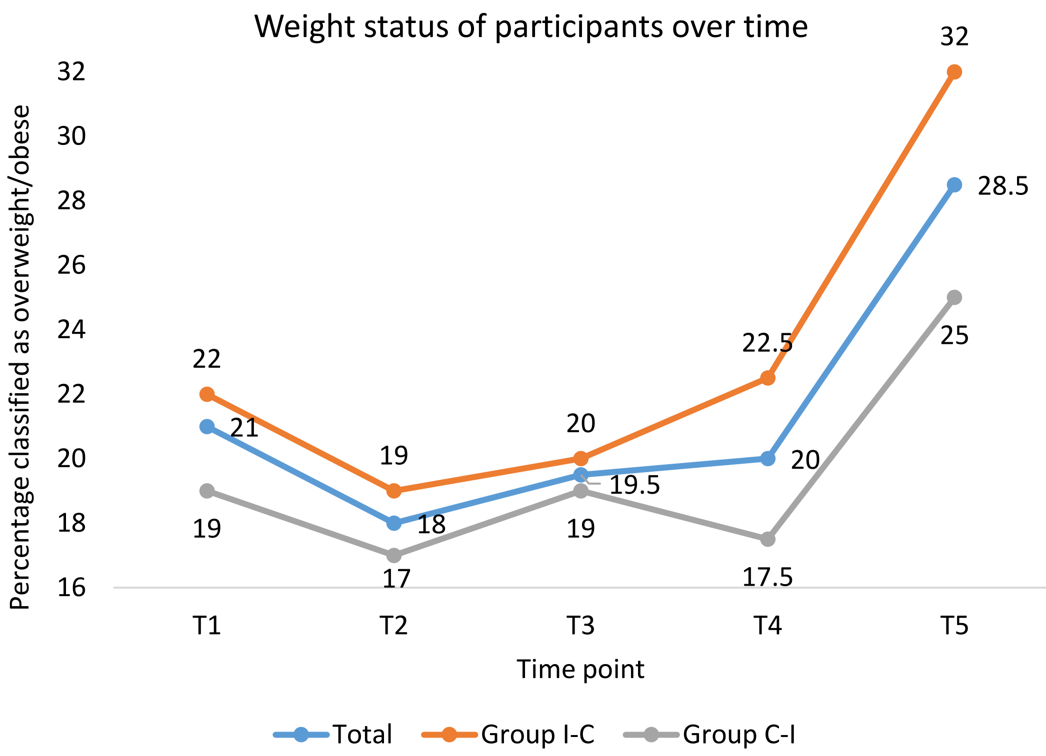
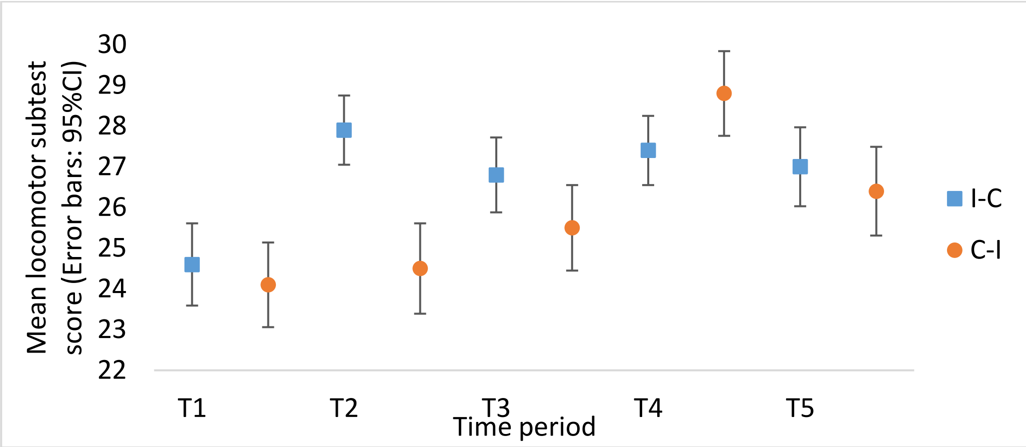


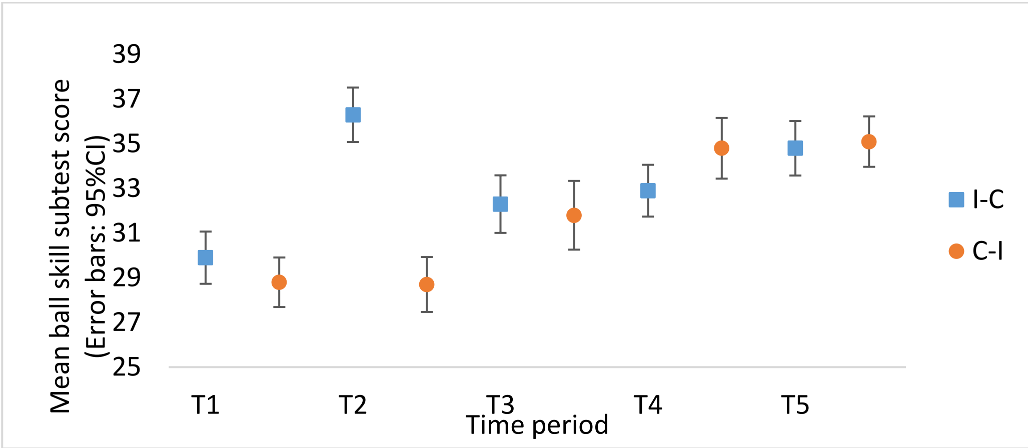
Figure 4.2 Percentage of participants classified as overweight/obese at each time point. *Note:* **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** 13 month follow-up



Group	Phase 1: Within group change					Phase 2: Within group change					Follow-up: Within group change from baseline			
	T1 Mean (SD)	T2 Mean (SD)	*P* [a]	AMD (95% CI) [d]	ES	T3 Mean (SD)	T4 Mean (SD)	*P* [b]	AMD (95% CI) [d]	ES	T5 Mean (SD)	*P* [c]	AMD (95% CI) [d]	ES
I-C	24.6 (5.4)	27.9 (4.6)	<0.001	-3.3 (-4.7, -1.9)	0.6	26.8 (5.1)	27.4 (4.6)	1.00	-0.3 (-1.4, 0.8)	0.1	27.0 (5.3)	0.02	-1.7 (-3.3, -0.2)	0.4
C-I	24.1 (5.7)	24.5 (5.9)	1.00	-0.4 (-1.8, 1.0)	0.1	25.5 (5.7)	28.8 (5.5)	<0.001	-3.2 (-4.3, -2.1)	0.6	26.4 (5.9)	<0.001	-2.5 (-3.9, -1.0)	0.4
Between group differences (I-C minus C-I)														
	T1	**T2**				**T3**	**T4**				**T5**			
P [e]	0.61	<0.001				0.08	0.01				0.60			
ES	0.1	0.6				0.2	0.3				0.1			
AMD (95% CI) [f]	0.4 (-1.0, 1.8)	3.3 (2.0, 4.6)				1.2 (-0.1, 2.5)	-1.7 (-3.0, -0.4)				-0.4 (-1.7, 1.0)			

Figure 4.3 Within group and between group changes in locomotor subtest scores

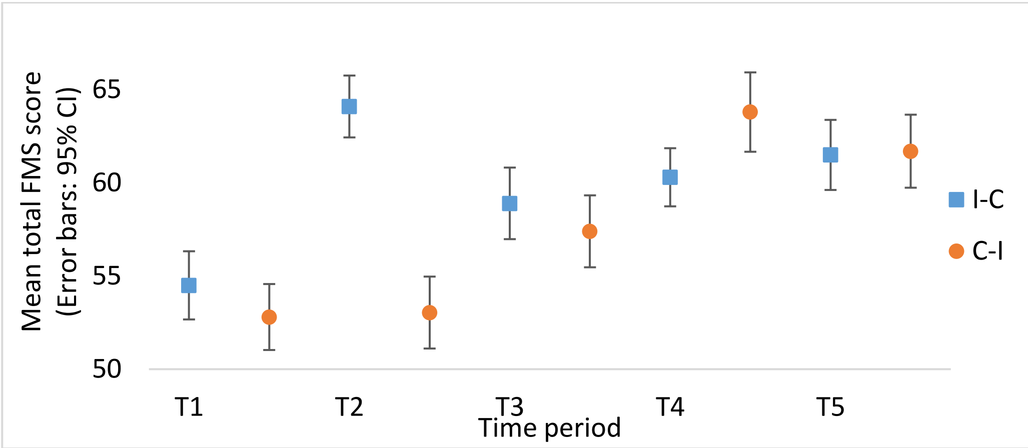
Note: **a:** Within group change for phase 1, **b:** Within group change for phase 2, **c:** Within group change from baseline to 13-month follow-up, **d:** Adjusted mean difference (**AMD**) and 95% CI; results from linear mixed model with random effect for class group, **e:** group-time interaction from mixed model with class group as random effect, **f:** Adjusted mean difference and 95% CI between each respective I-C and C-I group (I-C minus C-I); results from linear mixed model with random effect for class group, **I-C:** Intervention-control group, **C-I:** Control-intervention group, **ES:** Effect size (Cohen's d), **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** 13-month follow-up



Group	Phase 1: Within group change					Phase 2: Within group change					Follow-up: Within group change from baseline			
	T1 Mean (SD)	T2 Mean (SD)	*P* [a]	AMD (95% CI) [d]	ES	T3 Mean (SD)	T4 Mean (SD)	*P* [b]	AMD (95% CI) [d]	ES	T5 Mean (SD)	*P* [c]	AMD (95% CI) [d]	ES
I-C	29.9 (6.8)	36.3 (6.5)	<0.001	-6.4 (-7.8, -5.0)	1.0	32.3 (7.1)	32.9 (6.4)	1.0	-0.2 (-1.7, 1.1)	0.1	34.8 (6.7)	<0.001	-4.8 (-6.3, -3.2)	0.7
C-I	28.8 (6.2)	28.7 (6.6)	1.00	-0.0 (-1.4, 1.4)	0.0	31.8 (6.7)	34.8 (7.2)	<0.001	-3.2 (-4.6, -1.7)	0.4	35.1 (6.1)	<0.001	-6.2 (-7.8, -4.7)	1.0
Between group differences (I-C minus C-I)														
	T1	**T2**				**T3**	**T4**				**T5**			
P [e]	0.21	<0.001				0.44	0.01				0.59			
ES	0.2	1.2				0.1	0.3				0.1			
AMD (95% CI) [f]	1.0 (-0.6, 2.6)	7.4 (5.8, 9.1)				0.67 (-1.0, 2.4)	-2.2 (-3.9, -0.5)				-0.4 (-2.0, 1.2)			

Figure 4.4 Within group and between group changes in ball skill subtest scores

Note: **a:** Within group change for phase 1, **b:** Within group change for phase 2, **c:** Within group change from baseline to 13-month follow-up, **d:** Adjusted mean difference (**AMD**) and 95% CI; results from linear mixed model with random effect for class group, **e:** Group-time interaction from mixed model with class group as random effect, **f:** Adjusted mean difference and 95% CI between each respective I-C and C-I group (I-C minus C-I); results from linear mixed model with random effect for class group, **I-C:** Intervention-control group, **C-I:** Control-intervention group, **ES:** Effect size (Cohen's d), **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** 13-month follow-up



Group	Phase 1: Within group change					Phase 2: Within group change					Follow-up: Within group change from baseline			
	T1 Mean (SD)	T2 Mean (SD)	*P* [a]	AMD (95% CI) [d]	ES	T3 Mean (SD)	T4 Mean (SD)	*P* [b]	AMD (95% CI) [d]	ES	T5 Mean (SD)	*P* [c]	AMD (95% CI) [d]	ES
I-C	54.5 (9.9)	64.1 (8.8)	<0.001	-9.5 (-11.6, -7.3)	1.0	59.0 (10.5)	60.3 (8.4)	1.00	-0.6 (-2.4, 1.2)	0.1	61.5 (9.6)	<0.001	-6..2 (-8.6, -3.9)	0.7
C-I	52.8 (9.7)	53.0 (10.2)	1.00	-0.3 (-2.4, 1.8)	0.0	57.4 (10.5)	63.8 (11.2)	<0.001	-6.4 (-8.1, -4.6)	0.6	61.7 (10.3)	<0.001	-8.7 (-10.9, -6.4)	0.9
Between group differences (I-C minus C-I)														
	T1	**T2**				**T3**	**T4**				**T5**			
P [e]	0.20	<0.001				0.19	0.001				0.49			
ES	0.2	1.2				0.1	0.3				0.0			
AMD (95% CI) [f]	1.6 (-0.8, 4.0)	10.7 (8.3, 13.1)				1.7 (-0.8, 4.3)	-4.0 (-6.4, -1.6)				-0.8 (-3.4, 1.6)			

Figure 4.5 Within group and between group changes in total FMS scores

Note: **a:** Within group change for phase 1, **b:** Within group change for phase 2, **c:** Within group change from baseline to 13-month follow-up, **d:** Adjusted mean difference (**AMD**) and 95% CI; results from linear mixed model with random effect for class group, **e:** Group-time interaction from mixed model with class group as random effect, **f:** Adjusted mean difference and 95% CI between each respective I-C and C-I group (I-C minus C-I); results from linear mixed model with random effect for class group, **I-C:** Intervention-control group, **C-I:** Control-intervention group, **ES:** Effect size (Cohen's d), **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, **T5:** 13-month follow-up

Individual skill changes

McNemars test indicated that mastery levels changed in the direction of poor mastery (PM) to mastery/near mastery (MNM) for eight skills from pre- to post-intervention (Table 4.4) and from baseline to 13-month follow-up (Table 4.5). Significant improvements were reported for the gallop, horizontal jump, forehand strike, overhand throw, dribble, kick, underhand throw and run for Group I-C in phase 1 and for the gallop, horizontal jump, forehand strike, overhand throw, dribble, hop, skip and slide for Group C-I in phase 2 (Table 4.4). A decrease in the proportion of participants achieving MNM was observed for the horizontal jump for Group C-I in phase 1, and for the overhand throw for Group I-C in phase 2 (Table 4.4). From baseline to 13-month follow-up, mastery levels significantly changed in the direction of PM to MNM for the gallop, skip, two-hand strike, forehand strike, kick, underhand throw, catch and dribble (Table 4.5).

Table 4.4 Percentage change and actual percentage achieving mastery/near mastery and poor mastery in each skill for phase 1 and phase 2 for each group

	Phase 1							Phase 2						
Skill Group	**n**	**%MNM – PM [a]**	**%PM – MNM [b]**	**%MNM T1/T2 [c]**	**p[†]**	**Chi-square**	**OR**	**N**	**%MNM - PM [a]**	**%PM – MNM [b]**	**%MNM T3/T4 [c]**	**p[†]**	**Chi-square**	**OR**
Run														
I-C	116	11	23	26/37	0.04	4.20	2.09	110	21	15	42/32	0.43	0.62	0.71
C-I	113	13	25.5	19/31	0.04	4.00	1.96	112	12	17	32/36	0.38	0.78	1.42
Gallop														
I-C	112	4	23	11/26	<0.001	14.7	5.75	109	17	15	31/26	0.86	0.03	0.88
C-I	112	11	9	17/15	0.83	0.04	0.82	110	11	27	20/35	0.009	6.88	2.45
Hop														
I-C	114	10	5	10/7	0.33	0.16	0.50	111	10	5	11/7	0.33	0.94	0.50
C-I	112	6	7	7/8	1	0.00	1.17	112	4	16	12/22	0.01	6.26	4.00
Skip														
I-C	114	9	17	66/71	0.14	2.20	1.89	111	12	13	72/71	1	0.00	1.08
C-I	113	9	13	64/64	0.42	0.64	1.45	113	8	23	66/80	0.007	7.31	2.87
Slide														
I-C	114	20	28	45/53	0.28	1.16	1.40	108	11	16	58/58	0.46	0.55	1.45
C-I	113	23	14	58/46	0.16	1.93	0.60	113	3	16	73/83	0.002	9.33	5.33
H jump														
I-C	115	9	29	25/39	0.001	11.25	3.22	111	16	12	23/18	0.47	0.52	0.75
C-I	111	23	10	33/17	0.02	5.29	0.43	112	10	25	25/38	0.01	6.56	2.50
Strike														
I-C	119	14	17	26/27	0.74	0.11	1.21	108	12	19	16/24	0.23	1.44	1.58
C-I	113	8	11	12/12	0.66	0.19	1.37	111	14	22	31/35	0.27	1.22	1.57
FHS														
I-C	117	9	21	17/26	0.04	4.11	2.33	111	9	12	15/18	0.68	0.17	1.33
C-I	113	11.5	4	18/9	0.05	3.76	0.35	112	5	21	12/27	0.002	9.63	4.20
Kick														
I-C	116	2	19	13/26	<0.001	15.04	9.50	111	10	13.5	25/28	0.56	0.35	1.35
C-I	113	4	8	19/22	0.42	0.64	2.00	111	4.5	9	26/29	0.3	1.07	2.00

OHT														
I-C	115	3	28	27/44	<0.001	20.25	9.33	111	22	4.5	35/17	0.001	11.17	0.20
C-I	112	8	3	13/7	0.15	2.08	0.37	112	5	16	14/24	0.02	5.04	3.20
UHT														
I-C	115	4	35	50/70	<0.001	25.69	8.75	111	22	22.5	45/43	1	0.00	1.02
C-I	112	21	26	42/45	0.49	0.48	1.24	111	16	20	59/62	0.63	0.22	1.25
Dribble														
I-C	118	6	35	40/61	<0.001	22.69	5.83	110	15	21	61/65	0.31	0.62	1.40
C-I	113	13	19	49/50	0.4	0.69	1.46	110	5	21	53/65	0.003	8.83	4.20
Catch														
I-C	116	16	13	62/52	0.73	0.12	0.81	110	15	21	49/51	0.43	0.62	1.40
C-I	112	25	18	60/48	0.31	1.02	0.72	112	14	14.5	60/60	1	0.00	1.03

Note: **I-C:** Intervention-control group, **C-I:** Control-intervention group, **MNM**: Mastery/near mastery, **PM**: Poor mastery, **a**: Proportion of participants who change from MNM to PM, **b**: Proportion of participants who change from PM to MNM **c**: Actual % of participants who display MNM, **T1:** Pre phase 1, **T2:** Post phase 1, **T3:** Pre phase 2, **T4:** Post phase 2, † Represents percentage change from McNemar test, **OR:** Odds Ratio, **H jump:** Horizontal jump, **FHS:** Forehand strike, **OHT:** Overhand throw, **UHT:** Underhand throw

Table 4.5 Percentage change and actual percentage achieving mastery/near mastery and poor mastery for all participants from baseline to 13-month follow-up

			Baseline to 13-month follow-up				
Skill	**N**	**%MNM -PM** [a]	**%PM-MNM** [b]	**%MNM BL/FU** [c]	**p** †	**Chi-Square**	**OR**
Run	219	12	20	23/29	0.07	3.21	1.67
Gallop	228	11	23	14/26	0.001	10.18	2.09
Hop	220	8	9	9/10	0.87	0.03	1.12
Skip	220	11	23	65/73	0.004	8.22	2.09
Slide	220	14	22	51/60	0.07	3.24	1.57
H jump	229	16	24	29/35	0.05	3.92	1.50
Strike	232	12	29	19/32	<0.001	15.20	2.42
FHS	232	9	22	18/26	0.001	10.12	2.44
Kick	232	4	22	16/31	<0.001	26.23	5.50
OHT	231	14	16	21/21	0.72	0.13	1.14
UHT	231	13	30	46/58	<0.001	14.30	2.31
Dribble	231	6	32	44/65	<0.001	41.38	5.33
Catch	232	14	25	61/68	0.008	6.94	1.78

Note: **MNM**: Mastery/near mastery, **PM:** Poor mastery, **a:** Proportion of participants who change from MNM to PM from baseline to follow-up, **b**: Proportion of participants who change from PM to MNM from baseline to follow-up, **c**: Actual % of participants who display MNM at baseline/follow-up, †represents percentage change from McNemar test, **OR:** Odds Ratio, **BL:** Baseline, **FU:** Follow-up, **H jump:** Horizontal jump, **FHS:** Forehand strike, **OHT:** Overhand throw, **UHT:** Underhand throw

4.5 Discussion

This is the first study to examine if a short-duration FMS intervention programme can provide immediate and long-term improvements in Irish primary school children's FMS proficiency levels, and internationally is among the first of its kind to include older children who are attending primary school rather than pre-school. The findings support the hypothesis that an FMS intervention programme, delivered by a specialist over 8 weeks, can improve FMS proficiency immediately post-intervention for children with varying levels of ability. However, further studies are needed to clarify if improvements can be maintained over time.

Similar to previous research (Gallahue et al., 2012; Palmer et al. 2017; Logan et al. 2012; Morgan et al. 2013; Chan et al. 2016; Robinson and Goodway, 2009; Robinson et al. 2012), the current study suggests that children may be more likely to master FMS if they receive developmentally appropriate specialist instruction and practice opportunities. Large and medium effect sizes were reported for the within-group change in total FMS scores following engagement in the intervention in phase 1 and 2, respectively. Despite the difference in the magnitude of improvement, both groups had similar mean FMS scores after their respective intervention phases (Group I-C at T2: 64.1 vs Group C-I at T4: 63.4). The difference in effect sizes were likely due to Group C-I having a higher FMS score before starting their intervention (57.4 at T3) compared to that of Group I-C prior to their intervention (54.5 at T1). Logan et al. (2013) similarly found that lower skilled children improved more than higher skilled children following a 9-week object-control skill intervention indicating that improvements are more difficult to obtain as skill levels improve. Although a ceiling effect is possible when assessing FMS using the TGMD (Logan et al. 2018), this was unlikely in the current study as no child achieved a maximum FMS score at any time point.

In contrast, 8 weeks of routine PE lessons did not lead to any significant change in FMS scores in either phase 1 or 2 in the current study. Although the content of the PE lessons is unknown, previous research in both Ireland (Bolger et al. 2019) and Australia (Cohen et al. 2015) similarly found no improvements in FMS proficiency levels following 8 months of usual PE. In many countries, PE is delivered by generalist teachers, most of whom have limited PE specific training (Hardman 2007). Consequently, generalist teachers tend to revert to their own experiences of PE as a child to guide their teaching (Morgan and Hansen 2008) with many overemphasising the games strand of the PE curriculum (Woods et al. 2018; Hardman 2007). Games based PE lessons can be beneficial if delivered in a non-competitive setting (Smith 2016), however, they are traditionally associated with competition and winning. Overemphasis on competition and winning facilitates an ego-based motivational climate (Ames 1992) which can lead to disengagement, amotivation and negative emotional experiences among lower skilled children (Garcia-Gonzales et al., 2019; Braithwaite, Spray and Warburton, 2011). Although speculative, this may be a reason why Irish primary school children struggle to develop their FMS proficiency during typical PE lessons. Further research is needed to clarify what is taught in PE and how it is taught, but perhaps teachers require upskilling on how to deliver lessons through a mastery-oriented climate (i.e. encouraging children to focus on self-improvement, rewarding individual effort and progress and avoiding social comparison and overly competitive environments) in order to facilitate FMS improvements.

Following the 4-week washout phase (at T3), FMS scores were not significantly different between the two groups. Compared to T2, FMS scores at T3 significantly decreased for Group I-C. Regular practice is essential to learning (Wulf, Shea and Lewthwaite 2010; Wulf 1991), thus, this decrease may be due to an absence of practice opportunities. The 4-week washout coincided with Christmas school holidays, during which time participants were not engaging in any PE or FMS intervention, and non-school based sport and PA opportunities were likely low. Despite also being on school holidays and having not yet received the intervention, FMS scores for Group C-I significantly increased from T2 to T3 which may suggest the presence of a learning effect from repeatedly using the TGMD-3 assessment tool. FMS scores were not assessed 4 weeks after Group C-I completed the intervention. Thus, it is unknown if FMS proficiency levels decreased similar to that of Group I-C after the 4-week washout period. This may be worth considering in future studies to gain further insight into the potential non-linear nature of skill development.

During assessment sessions, children observed both expert (from the demonstrator) and novice (from peers) demonstrations of each skill. Individually, each strategy can support learning (Martens, Burwitz and Zuckerman 1976; Sigmundsson et al. 2017; McMorris 2004); however, combined expert and novice observation has been shown to significantly enhance motor learning compared to observing either an expert or novice alone (Rohbanfard and Proteau 2011). Observational learning can engage similar cognitive processes that occur during physical practice (Blandin, Lhuisset and Proteau 1999). The learner can formulate an ideal movement pattern in their mind from observing an expert, whilst observing a novice performer helps the learner to detect and correct errors in the movement patterns prior to physically attempting the skill him-/herself (Adams 1986). This may explain why Group C-I improved their FMS during the washout period (i.e. from T2 to T3). Future intervention studies may consider using a familiarisation session for the FMS assessment procedure, particularly when assessments are conducted over a short period of time.

A limitation of many FMS intervention studies is the absence of follow-up assessments to determine their long-term effectiveness (Lai et al. 2014). Although a follow-up was included in the current study, the lack of a true control group limits the interpretation of the findings. Both groups had higher FMS scores at follow-up compared to baseline, but the improvements cannot be definitively attributed to the intervention programme. Cross-sectional studies looking at differences in FMS proficiency across age give mixed results. Behan et al. (2019) found improvements in FMS scores up to age 10 among Irish primary school children, which might suggest that the follow-up scores observed in the current study may have occurred as part of normal growth and development. In contrast, plateaus in total FMS scores were reported at approximately age 7 and 8 among Belgian (Bardid et al. 2016) and Irish (Kelly et al. 2019) primary school children, respectively. The current sample were 7- to 8-years old at baseline and aged 8- to 9-years old at follow-up, thus the findings of Kelly et al. (2019) and Bardid et al. (2016) suggest that the improvements may not have occurred in the absence of specialist instruction and practice opportunities provided during the FMS intervention. Furthermore, studies by Robinson and Goodway (2009), Valentini and Rudisill (2004) and Robinson et al. (2017) previously noted how mastery-oriented instructional climates that aimed to improve FMS proficiency among pre-school aged children consistently facilitated immediate improvements in FMS proficiency, but evidence for sustained improvements were mixed. Whilst Valentini and Rudisill (2004) reported sustained improvements at 6-month follow-up compared to post-intervention scores, children in the other two studies had significantly lower FMS scores at 9-week follow-up compared to their post-intervention scores. The inconsistent results may be due to the varying characteristics of the participants (i.e. children in two studies were classed as developmentally delayed and were also younger than children in the current sample), and the length of time between post-intervention and follow-up assessments (i.e. 9-weeks and 6-months post-intervention compared to 13-months in the current study).

The concept of assessing FMS learning is difficult due to the non-linear nature of skill acquisition and the multiple personal, environmental and task related factors that may impact a performance at a given moment (Newell 1986). The changes in mastery/near mastery levels for the individual skills highlights this difficulty. Despite each class group receiving the same intervention over the two 8-week intervention phases, differences were observed in relation to the specific skills that improved over time. It also provides evidence for the individual nature of motor learning (Clarke and Metcalfe, 2002) and the fact that there is no one size fits all approach to teaching FMS. The variation in skill improvements could be interpreted as one of the strengths of adopting a mastery-oriented instructional climate, as it allows each individual to take control of his/her learning experience (Ames 1992). Perhaps the skills that improved were perceived as being more important to one group compared to another. Future studies should aim to understand the factors that contribute to variations in skill improvements by including the learner's perception of what skills they perceive to be important and why.

Previous research highlights that overweight children (Rodrigues et al., 2016; Lima et al. 2018; D'Hondt et al. 2013) and females (Coppens et al. 2019) are less likely to improve their motor competence over time compared to non-overweight children and males, respectively. FMS proficiency is a sub-component of motor competence; thus, it was important to determine if those 'at risk' children benefited from participating in the current intervention programme. Similar rates of improvement were observed for participants regardless of weight status or sex; however, consistent with previous research, we found that males remained significantly better than females in performing object-control skills (Bolger et al. 2018; Kelly et al. 2019; Behan et al. 2019) whilst non-overweight children were consistently more proficient than overweight children at locomotor skills (Kelly et al. 2019; Cliff et al. 2012).

The current results suggest that delivering interventions through a mastery-oriented climate as opposed to an ego-oriented climate may support children of all abilities to experience success and to improve their skill levels at an individualistic and developmentally appropriate rate (García-González et al. 2019). Given that females continued to demonstrate poorer object-control skill proficiency than males across all five time points, future research may consider whether a gender-specific approach to FMS instruction could eliminate this divide. Additionally, low levels of perceived competence is often mentioned as a barrier to PA and sport participation among females (Woods et al. 2010; Mitchell, Gray and Inchley 2015) and overweight children (Morrison et al. 2018), thus, the inclusion of measures of perceived competence would offer valuable insight into the effectiveness of future intervention programmes. Finally, it is important to mention that although the participants had better FMS proficiency at follow-up compared to baseline, the proportion of children classified as overweight or obese at follow-up increased by 7% (i.e. 28% at follow-up vs 21% at baseline). Obesity is a complex issue and can be affected by diet, genetics, activity levels, socio-cultural factors and psychological factors (Sahoo et al. 2015). Thus, although both overweight and non-overweight participants significantly improved their FMS following the intervention, when weight-maintenance or weight-loss is the goal, additional measures to those that facilitate FMS development must be considered.

Raw scores for the locomotor subtest cannot be directly compared to the ball skills subtest due to the different number of skills and maximum possible scores that can be achieved for each subtest (i.e. 46 for locomotor subtest vs 54 for ball skills subtest). Consequently, the POMP scores were calculated and revealed that from baseline (T1) to follow-up (T5), locomotor skills improved by on average 5% (52.5% to 57.5%) whereas ball skills improved by on average 10.5% (54.5% to 65%). Whilst these findings may suggest that the intervention was more effective for ball skills and less effective for locomotor skills, it is important to consider the presence of potential issues with scoring the skills. Process oriented measures of FMS assign scores based only on the presence or absence of specific performance criteria and subtle improvements in performances may not be identified using this form of assessment. In some cases, children may have improved their execution of specific performance criteria which could have resulted in greater power output allowing them to run faster or jump further. However, such improvements can only be identified using product-oriented assessments that measure for example, the speed of a run and distance of a jump. Recent systematic reviews therefore recommend the use of both process and product-oriented assessments to more accurately assess FMS proficiency levels (Hulteen et al., 2020; Bardid et al., 2019).

This intervention was delivered in an ideal situation where the instructor had specialist FMS knowledge and an understanding of mastery-motivational theory. However, many primary school teachers in Ireland have received limited training for teaching PE (Fletcher and Mandigo 2012) and therefore, may not have the pre-requisite theoretical knowledge that was used to inform this intervention. Previous studies indicate that teachers can be upskilled to improve the quality of their PE lessons and consequently FMS proficiency levels of their class group (Rudisill and Johnson, 2018). The aim of this study was to determine the role of specialist instruction on FMS proficiency levels and acts as a steppingstone to identifying the most appropriate strategies that should be undertaken to improve the quality of PE teaching within the primary school setting. The findings suggest that specialist knowledge is important to support FMS development. However, it is unknown if generalist teachers are willing to upskill to improve the quality of their PE lessons or if they would prefer to employ PE specialists to either solely teach PE or work alongside them as a means of improving their PE teaching ability. These factors and their feasibility should be addressed in future studies.

4.6 Strengths and limitations

This study has some strengths and limitations. The inclusion of older children (age 7-8 yrs. at baseline) is novel and fills a gap in the literature as to the authors knowledge, previous studies with similar aims were conducted in pre-school settings (age 3-5 yrs.) (Wick et al., 2017; Robinson and Goodway 2009; Valentini and Rudishill, 2004). As all groups received the intervention, it helped to avoid bleed-over and contamination. Additionally, the longitudinal design and inclusion of a 13-month follow-up provided a more comprehensive analysis of FMS development over time. However, limitations include the lack of a true control group at follow-up and the absence of information about what was covered in typical PE lessons, which prevents an accurate interpretation of the long-term effectiveness of the intervention. Although a large number of skills were assessed, none specifically assessed the stability division of FMS. Balance is an underlying requirement to efficiently execute many locomotor and object-control skills, however, future studies could be strengthened by assessing balance skills separately. Additionally, there was a risk of bias in scoring the FMS, as the principal investigator was not blinded to participant allocation. The number of children with mild learning disabilities was not recorded and may also be seen as a limitation. Lesson fidelity was not recorded during the study; however, the principal investigator delivered all lessons to all class groups allowing for consistency throughout the study. The findings may not be generalisable to the national and international primary education settings as the intervention was delivered in ideal circumstances by an instructor with specialist FMS knowledge and an understanding of how to facilitate a mastery-motivational climate. Future research should aim to determine the fidelity and feasibility of upskilling teachers to deliver PE lessons using the concepts undertaken in the current study. The inclusion of additional measures such as children's enjoyment of and motivation to participate in PE, and teacher's experiences of adopting mastery-motivation pedagogy to teach PE in terms of ease of administration and the impact on student learning outcomes would increase the strength of conclusions in future studies.

4.7 Conclusion

The results of this study suggest that a short-duration FMS intervention, focusing on specialist FMS instruction, can significantly improve locomotor and ball skills at post-intervention. The long-term effectiveness is inconclusive and warrants further investigation. Typical primary school PE classes include children with a range of skill levels, interests and abilities, thus maximising engagement by all children is essential to ensure each child is provided with an equal opportunity to experience success. This may be possible where PE lessons are taught by teachers with both specialist FMS knowledge and an understanding of how to create a mastery-motivational climate as regular incentive may be needed for children to attain adequate long-term skill improvements.

4.8 Summary

This chapter identified the potential positive impact that specialist FMS instruction and practice opportunities can have on FMS proficiency levels. Even after a short duration of eight weeks, children significantly improved locomotor subtest, ball skills subtest and total FMS scores. The improvements were similar for males and females and for overweight and non-overweight children. In both phases of the intervention, the PE group failed to display significant improvements in FMS proficiency levels, which may suggest that PE teachers do not possess the skills required to sufficiently improve FMS during their usual PE routines. However, there is a significant dearth of research regarding teachers' perceptions, attitudes and perceived confidence to teach PE in Irish primary schools. Previous studies have recommended that teachers should be upskilled on how to teach FMS during PE, and that those with FMS knowledge feel more confident in their ability to teach PE (Tompsett et al., 2017; Breslin et al., 2012; Lander et al., 2017; Lander et al., 2015). As PE in Irish primary schools is taught by the non-specialist teacher, many of whom have limited training in PE, it would be useful to know what characteristics may or may not contribute to differences in attitudes and perceptions around PE teaching. Such factors may include gender and type of training or upskilling undertaken by the teacher (e.g. whether they received training in FMS or not). Chapter 5 will address this gap in the literature and aims to identify specific areas that could be targeted to enhance the quality of PE lessons in Irish primary schools.

Chapter 5: Developing an understanding of Irish primary school teachers' perceptions, attitudes and perceived confidence to teach PE

5.1 Abstract

Introduction: In Ireland, generalist teachers are responsible for teaching PE to primary school children. A child's experience of PE may shape their lifelong attitudes and motivation for physical activity engagement. Despite the important role the teacher plays in shaping the child's PE experience, very little is known about teacher's perceptions, attitudes and perceived confidence to teach the primary PE curriculum in Ireland.

Methods: A questionnaire to investigate teachers' perceptions, attitudes and perceived confidence to teach PE in Irish primary schools was developed and validated using a modified Delphi technique. Four hundred and six teachers completed the online questionnaire which consisted of 41 questions pertaining to background information, feelings about teaching PE, perceived confidence to teach PE, perceptions of teacher training for PE and barriers to teaching PE.

Results: Teachers had generally positive attitudes towards teaching PE with 98.5% agreeing that PE is an important component of the curriculum. However, only 4% felt confident to teach all aspects of the PE curriculum without any external assistance with teachers feeling most confident to teach games and least confident to teach aquatics, gymnastics and dance. Seventy-six percent would welcome assistance from a PE specialist either full-time (17%), part-time (30%) or on an occasional consultative basis (29%). Only 20% agreed or strongly agreed that their pre-service teacher training prepared them to teach PE effectively and 65% completed at least one form of in-service training for PE. Forty percent of teachers completed FMS-based in-service training and were more likely to agree or strongly agree that the training improved their ability to teach PE compared to non-FMS trained teachers. FMS-trained teachers had significantly better attitudes towards teaching PE and were more likely to feel that students experienced a sense of achievement in their PE lessons. The largest perceived barriers to the delivery of PE were demands to teach other subject areas, lack of time, inadequate pre-service teacher training and large class sizes.

Conclusion: Irish primary school teachers do not feel confident to teach all strand areas of the primary PE curriculum equally, which may be limiting children's opportunities to develop their FMS. Different strategies may need to be investigated to determine the best way to improve teacher confidence to teach PE and consequently the quality of PE lessons. This may require changes to pre-service and in-service teacher training and/or the employment of specialist PE teachers to assist teachers on a needs specific basis.

5.2 Introduction

The PE curriculum in Irish primary schools consists of six strand areas (athletics, dance, games, gymnastics, outdoor and adventure and aquatics) and is taught by a generalist teacher. The current guidelines, published 11 years ago in 1999, recommend the provision of 60 minutes of PE time per week where each strand area should be given equal attention so that children are afforded the opportunity to develop a broad range of FMS (NCCA, 1999). However, the delivery of PE is unregulated and actual implementation varies by school and teacher. Many Irish primary school teachers dedicate more time to teaching games at the expense of other strand areas (Woods et al., 2018, Hardmann, 2008). In 2018, the CSPPA study revealed that while 98% of primary school children had exposure to the games strand, only 56%, 43% 41%, 25% and 20% had access to athletics, aquatics, dance, gymnastics and outdoor and adventure strands, respectively (Woods et al., 2018). Furthermore, 18% of Irish primary school children receive a maximum of only 30 minutes of PE per week (Woods et al., 2018). These inconsistencies may limit children's opportunities to practice and learn a broad range of FMS and therefore contribute to inadequate FMS proficiency, low levels of perceived competence and consequently, decreased motivation for PE (Sallis, 2000).

Given that physical inactivity is now the fourth leading risk factor for global deaths (WHO, 2010), and that PE provides an opportunity for all children in primary school to engage in structured PA (NASPE, 2012), the quality of PE lessons is more important than ever before. However, PE lessons are more likely to be dropped before other more academic subjects like languages and mathematics (Harris, Cale and Musson, 2012; MacPhail and Halbert, 2005) thus highlighting a potential inferior view given to the subject in schools. This may be detrimental to the future health and wellbeing of children and may also negatively impact academic performance (NASPE 2004). Teachers are often regarded as role models by children (Spencer 1998) and can influence children's experiences of and motivation for PE and PA (Bandura 1977; Bandura 1986; Sandholtz 2002). These early experiences have the potential to carry through to adulthood (Whitehead 2013; Carslon 1995) and should therefore be considered an optimal opportunity to support children in developing a lifelong love for PA.

Generalist teachers tend to report low levels of confidence for teaching PE (Fletcher and Mandigo 2012; Morgan and Bourke, 2008). This can be due to negative experiences developed from personal PE experiences as a child (Morgan and Bourke, 2008) and insufficient training for PE during their initial teacher training courses (McGuinness and Shelly, 1995; Deenihan, 2007; Irish National Teachers' Organisation, 2007). In Ireland, PE is typically taught by a generalist teacher and the amount of PE specific training received varies depending on what training route they opted for. The undergraduate Bachelor in Primary Education increased from a 3- to a 4-year programme in 2012. Trainee teachers on the 4-year programme complete a minimum of two core modules (i.e. 48 hours) for PE (Marron et al., 2018; Crawford et al., 2016). The first module focuses on content related to games, athletics and dance, introduces FMS and PA promotion and helps teachers to prepare for teaching PE on school placement. Module two builds on the learnings related to games, athletics and dance for more senior classes and introduces content related to aquatics, outdoor and adventure and gymnastics. Teachers are also introduced to concepts of skill acquisition, differentiation and inclusion and assessment in PE (Marron et al., 2018).

Since 2013, approximately 25 teachers from each teacher training college can opt to specialise in PE by completing an additional 120 hours (five modules) of PE specific training on top of the compulsory 48 hours (two modules) that are completed by all teachers (Marron et al., 2018). Teachers on the PE specialism programme, further develop their pedagogical practices, cover each strand area in more depth, develop a deeper understanding of FMS and learn how to become subject leaders and advocates for PE in their schools. While it is promising to see these developments being made for PE specific training, teachers who have completed the three year bachelor of education prior to 2012, or a postgraduate teacher training course are likely to have received at most 30 to 50 hours of PE specific training (Murphy, 2012), much less than 1200 hours completed by second level PE teachers (Murphy, 2007). Despite the differences in the level of PE specific training that any teacher has completed, all are expected to teach children the entire PE curriculum once employed in a mainstream setting (NCCA, 1999). Consequently, there is large heterogeneity in relation to the quality of PE lessons experienced by Irish school children (Kirk et al., 2009).

Nationally and internationally, PE curricula delivered by generalist teachers tend to be dominated by sports and competitive games (Alfrey et al., 2012; Woods et al., 2018; Griggs and Ward, 2013). The competitive nature of these activities can lead to dis-engagement and negative emotional experiences for children who are less skilled (Coulter et al., 2020; Hardmann, 2008). This is especially true for females who repeatedly demonstrate poorer levels of FMS proficiency (Kelly et al., 2019; Bolger et al., 2018; Behan et al., 2019; O'Brien et al., 2016b), are more likely to drop out of sport during adolescence (Woods et al., 2018; Lunn et al., 2013) and report lower levels of perceived ability for PE compared to males (Flintof and Scraton, 2006; Telford et al., 2016). Some evidence suggests that PE lessons delivered by specialist PE teachers are better structured and of higher quality compared to lessons by generalist teachers (Gordon and Inder 2000; McKenzie et al. 2001). However, others argue that generalist teachers are best positioned to teach PE as they have a better understanding of the individual needs of each child and can facilitate curriculum integration based on what is being taught in other subject areas (Coulter et al., 2009; Fletcher and Mandigo, 2012). These factors along with financial and feasibility issues means there is hesitancy to employ specialist PE teachers (Coulter, 2012) to take responsibility for teaching PE in the primary school setting. Instead, generalist teachers who wish to improve their confidence to teach PE rely on in-service training opportunities.

Efforts are being made to upskill Irish teachers in PE, with particular emphasis given to the development of FMS throughout the different strand areas (PDST, 2017). As part of the National Physical Activity Plan (Healthy Ireland, 2016), the Move Well Move Often initiative was implemented in 2017 (PDST, 2017). The initiative includes national seminars, workshops, summer courses and free online resources to upskill teachers on how to deliver PE lessons through the lens of FMS (Scoilnet, 2019). The number of teachers who have availed of these opportunities and whether or not they find them beneficial remains unclear. However, previous research suggests that training teachers in FMS can significantly improve their instruction and assessment practices (Lander et al. 2015; Breslin et al., 2012) and can also enhance their students' physical self-perceptions compared to students who were taught by teachers with no FMS based teacher training (Breslin et al. 2012). Therefore, training teachers to teach PE through the lens of FMS may increase the uptake of PA and reduce the high drop-out rates that are currently prevalent as children get older (Woods et al. 2010; 2018; Lunn et al. 2013).

The way in which individuals perceive and interpret different events are influenced by their attitudes, which will consequently affect their actions (Branch et al., 1984, p. 117). As such, teachers' attitudes and perceptions of PE will influence their behaviours and subsequent ability to motivate and create meaningful experiences for students in PE (Beni et al., 2017). Students are more likely to enjoy PE (Silverman and Subramaniam, 1999) and feel intrinsically motivated to participate in PE when the teacher is enthusiastic, confident and caring (Whittle et al., 2018; Pan, 2014; Larson, 2006). Previous research suggests that a child's experience of PE can shape their attitudes towards and perceptions of PA and health behaviours as adults (Morgan and Bourke, 2008; Carlson, 1995) and can also influence their future intentions to remain physically active (MacPhail et al., 2019). It is therefore important that generalist teachers portray positive attitudes and behaviours when teaching PE.

To the author's knowledge, there is currently no published research about Irish primary school teachers attitudes towards and perceived confidence to teach PE, in addition to their perceptions regarding the adequacy of their pre-service training in preparing them to teach all strand areas of the PE curriculum. Although PE related professional development opportunities are being offered to teachers as part of the Healthy Ireland National Physical Activity Plan, it is unknown what proportion of primary school teachers avail of these opportunities and whether or not they are beneficial. Furthermore, there are conflicting opinions and reports about whether the mainstream teacher or a PE specialist is best positioned to teach PE (Fletcher and Mandigo, 2012), however, the opinions of those currently responsible for teaching PE (i.e. the mainstream teacher) have not yet been considered in the Irish context. Therefore, the aim of this study was to evaluate teachers' perceptions, attitudes and perceived confidence to teach PE within the Irish primary school setting. The secondary aims were to assess differences between male and female teachers and between teachers who completed FMS based in-service training and non-FMS based in-service training.

5.3 Methods

5.3.1 Questionnaire selection

Ethical approval for this study was granted by the Institute's Research Ethics Board. An extensive literature search revealed no suitable questionnaire for assessing the perceptions, attitudes and perceived confidence to teach PE in Irish primary schools. However, Morgan (2003) developed and validated a questionnaire for use in an Australian setting. Permission was granted from the authors to utilise and adapt the survey to suit an Irish population. The principal investigator modified the questionnaire in line with the current PE curriculum in Irish primary schools and refined it using a Modified Delphi technique. The principal investigator was not formally trained in using the Modified Delphi Technique. However, relevant published literature and a supervisor with previous experience in using the Delphi technique were consulted to ensure the process was appropriately adhered to.

The Delphi method is an iterative process whereby feedback/opinions are gathered from a panel of experts through a series of structured questionnaires. The questionnaire is amended after each round based on the feedback and is anonymously reported back to the panel. This continues until consensus is reached (Hasson et al., 2000). The pre-defined target for reaching consensus was set as ≥ 80% agreement between the panel members (Green et al., 1999).

5.3.2 Delphi process

Seventeen experts were purposively sampled to contribute to the development of the questionnaire. Experts included published researchers, experienced PE teachers and PE teacher educators with knowledge in areas of PE teacher education, motor learning and development, FMS development and/or PE pedagogy. After initial contact, eight experts agreed to contribute, two did not respond and seven were not able to fully engage with the project. Therefore, eight experts were emailed a copy of the modified questionnaire and instructions on how to complete the Delphi procedure. Table 5.1 outlines the areas of expertise for each of the panel members and the response rates for both rounds. For each item, experts were asked to rate on two 11-point Likert scales from 0 (disagree) to 10 (agree) whether 1) they believe the item should be included in the final tool and 2) the degree of agreement with the formulation of the item (Benhamou et al., 2013). Qualitative feedback was encouraged, especially where there was disagreement with wording/formulation of a question. Suggestions for new questions were also welcome. With the aim of gaining consensus in the next round, items were either kept, eliminated, modified or added based on scores and qualitative feedback from round 1. Any item with a median relevance score of ≤7 was eliminated after round 1. For round 2, feedback was provided to the experts through an anonymous summary of results, and a modified questionnaire which needed to be re-rated.

Table 5.1 Expertise and responses from the Delphi panel

Expert	**Area of expertise**	**R1**	**R2**
1	Motor learning and development	✓	✓
2	Motor learning and development	✓	✓
3	FMS development	✓	✓
4	PE Pedagogy	✓	✓
5	Motor learning and development	X	X
6	PE Pedagogy	X	X
7	PE Pedagogy, PE curriculum development	✓	✓
8	Research in students' experiences of PE/External providers for PE	✓	X

Note: **R1:** Round 1, **R2:** Round 2, **X:** No response received, **✓:** Response received

Consensus was reached after round 2 with greater than 80% agreement between panel members (Green et al., 1999). All panel members rated each question as 10 (agree) for inclusion in the final tool, while slight word changes were recommended for 10 questions. Following the recommendations from the Delphi process, an online survey was created using SurveyMonkey (SurveyMonkey Inc) and piloted on a convenience sample of 11 primary school teachers. It took on average 30 minutes to complete the survey. Small modifications to the wording of some questions to ensure they were understandable in the Irish context were made based on feedback from the pilot study. Table 5.2 outlines the sections and number of items included in each version of the questionnaire. The final questionnaire (Appendix G) included open- and closed-ended questions.

Table 5.2 Number of items per section included in each phase of the questionnaire

Original Section	Final Section	Topic	N of items R1	N of items R2	Final questionnaire
1	**1**	**Informed consent**	1	1	1
2	**2**	**Background information**	10	9	10
3	**n/a**	**Previous PE experiences**	7	Removed	0
4	**3**	**Feelings about PE and PE teaching**	1	1	1
5	**4**	**Perceptions of PE teaching**	5	5	5
6	**5**	**Perceptions of PE content in pre-service and in-service teacher training**	8	9	11
7	**6**	**Perceptions of PE teaching experiences**	16	12	12
8	**7**	**Factors influencing the delivery of PE**	1	1	1
9	**8**	**Final comments**	1	1	1
		Total number of items	50	39	42

Note: **R1:** Round 1, **R2:** Round 2, **n/a:** not applicable (items deleted)

5.3.3 Questionnaire content, questions and administration

The questionnaire was created on Survey Monkey and the link emailed to all teachers for completion. Hardcopies were posted to teachers if requested and manually inputted by the principal investigator into Survey Monkey prior to downloading the data. Only five teachers completed hardcopies of the questionnaire.

Section 1 of the questionnaire provided participants with study information and requested informed consent in order to continue. Section 2 collected background information from the teachers and included 10 main questions regarding teacher gender, age, years of teaching experience, what class group they teach, the number of children in their classroom, school characteristics such as location, facilities, ethos and disadvantaged status, people responsible for teaching PE to their class, whether or not external providers teach PE, the number of external providers and the level of education completed by the teachers (Table 5.3). Following Round 1 of the Delphi process, only one question was deleted from the background information section. The question included 7 items from which teachers could tick as many that they felt applied to them. However, the statements were regarded as being more relevant to explaining their feelings around teaching PE and were consequently added as statements in question 12 of the questionnaire.

Table 5.3 Questions on background information

Section 2: Background information	
Question	**Questions type**
2: Gender	Tick one option
3: Age	Tick one option
4: Years of teaching experience a. Overall b. In current school	Open text boxes
5: What class group(s) are you currently teaching?	Open text box
6: How many children are in your classroom? a. Males b. Females	Open text boxes
7: Please answer the following in relation to your school a. Location b. School ethos c. Number of mainstream teachers d. Are your PE facilities adequate? e. PE facilities f. DEIS status	Drop down menus for items a, b, c and e. Teachers were asked to select one option for each. Part d: Open text box
8: Please describe your current school PE context by indicating who is responsible for teaching PE to your current class.	Likert scale question: 1: Never 2: Now & Then

Teachers asked to give an answer to 5 separate options.	3: Sometimes 4: Quite Often 5: Often 6: Always Open text box provided to allow teachers to offer further information about each option.
9: Number of external providers that teach class in a typical school year	Enter numeric value
10: Information about external providers a. Activities taught b. Qualification if known c. Number of weeks spent teaching the class	Open text boxes
11: What level of education have you completed 11 options provided	Tick all that apply Open comment field also to allow more information to be provided.

Section 3 of the questionnaire focused on teacher's feelings towards teaching PE and included a 6-point Likert scale question asking teachers to indicate to what extent they agreed or disagreed with 8 different statements (Table 5.4). In the original version of the questionnaire, section 3 included 7 questions related to teacher's previous PE experiences. However, due to concerns about the length of the questionnaire, these questions were deleted after Round 1 of the Delphi process. Although a potentially important construct in shaping teacher's current perceptions and attitudes towards teaching PE, the questions were deemed less relevant to the overall aims of the study. Furthermore, the statement included in question 12, 'I tend to revert back to my own experiences of PE as a child to guide my current approach to teaching', provided some insight into the potential influence of past PE experiences on teacher's current practices.

Table 5.4 Questions on feelings towards teaching PE

Section 3: Feelings about teaching PE	
Question	**Questions type**
12: As a teacher, please indicate the degree to which you AGREE or DISAGREE with the following statements concerning your feelings about PE 8 statements related to feelings around teaching PE	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree

Section 4 of the questionnaire included 5 items to determine teachers' perceptions of PE teaching. Questions related to confidence to teach each strand area, competence to execute various tasks associated with teaching PE (e.g. lesson planning, class management) and whether they felt a PE specialist should teach PE, were asked in this section (Table 5.5).

Table 5.5 Questions on teacher's perceptions around teaching PE

Section 4: Perceptions about teaching PE	
Question	**Questions type**
13: I feel confident teaching: Teachers asked to provide an answer for each of the 6 strand areas.	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree
14: For each aspect of teaching listed in the table below, indicate how you perceive your level of competence in relation to PE: 9 statements related to teaching PE	Likert scale question 1: Very incompetent 2: Incompetent 3: Slightly incompetent 4: Slightly competent 5: Competent 6: Very competent
15: Would you prefer a PE specialist to teach your class? 5 options provided	Tick one option. In addition, teachers could provide further details in an open text box.
16: Please outline any other subjects you would like a specialist to teach.	Open text box
17: To what extent do you agree or disagree with the following statements. 5 statements related to potential important considerations when teaching PE	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree

Section 5 included 11 questions concerning teacher's perceptions of their pre-service and in-service teacher training (Table 5.6). The original questionnaire included 8 questions. However, after Round 1 it was suggested to add the questions 'Do you use the physical literacy (Move Well, Move Often) resources on the PDST.ie website?'. Following Round

2 of the Delphi process, the question 'What is your understanding of fundamental movement skills?' was added to determine if teachers understood what FMS are. A final question was added following the pilot questionnaire as it became clear that some teachers were not responsible for teaching PE in the previous schoolyear and were therefore unable to accurately answer the remaining questions. This question asked teachers if they had input into the delivery of PE in the past year. Those who did not have any input into teaching PE finished the questionnaire at this point.

Table 5.6 Questions on teacher's perceptions of their pre-service and in-service teacher training

Section 5: Perceptions of PE content within your pre-service and in-service teacher training	
Question	**Question type**
18: Please rate the quality of your pre-service teacher education as it relates to the following PE content areas 6 strand areas outlined	Likert scale question 1: Very poor 2: Poor 3: Fair 4: Average 5: Good 6: Excellent
19: "My pre-service teacher education prepared me to teach PE effectively"	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree
20: Have you undertaken any in-service upskilling/ teacher education courses or workshops for PE?	Tick one option 1: Yes 2: No
21: If you answered yes to Q20 please specify the course(s) undertaken and duration of each.	Open text boxes
22: "In general, the in-service upskilling/ teacher education courses or workshops for PE, improved my ability to teach PE"	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree 7: N/A
23: In response to Q22, please comment on how and why the course did/did not improve your ability to teach PE	Open text box
24: What is your understanding of fundamental movement skills?	Open text box

25: Did any in-service teacher education courses/workshops focus primarily on fundamental movement skills (e.g. basic skills like running, skipping, catching, throwing, striking, balancing etc.)?	Tick one option 1: Yes 2: No 3: N/A
26: If you answered yes to Q25, please state the name of the course and if it was effective/ineffective	Open text box
27: Do you use the physical literacy (Move Well, Move Often) resources on the PDST.ie website?	Likert scale question 1: Never 2: Now & then 3: Sometimes 4: Quite often 5: Often 6: Always
28: If you have had no input to the delivery of PE for your class in the past year, please tick the 'no input' box, otherwise, click 'continue'.	Tick one option 1: No input 2: Continue

Section 6 of the questionnaire asked about teachers experiences of teaching PE (Table 5.7). The final version included 12 questions related to the type of activities taught in PE, level of commitment to teaching PE, differentiation in PE, in addition to planning, assessment, reporting and evaluation in PE. Following round 1 of the Delphi process, 4 questions were deleted from this section. Three were deleted due to some overlap and repetition from other questions. One question, which asked teachers about their understanding of theoretical models related to teaching PE was deleted as the experts felt it would not be readily understood by most generalist teachers, and that it was beyond the scope of this study.

Table 5.7 Questions on teacher's perceptions of their PE teaching experiences

Section 6: Perceptions of your PE teaching experiences	
Question	**Question type**
29: When you have taught PE lessons (in the last 12 months or so), please indicate how often your class participated in the following activities 6 strand areas outlined	Likert scale question 1: Never 2: Now & then 3: Sometimes 4: Quite often 5: Often 6: Always
30: How do you currently rate your level of commitment to teaching PE?	Likert scale question 1: Very low 2: Low

	3: Somewhat low 4: Somewhat high 5: High 6: Very high
31: List 3 specific activities you seem to spend most time teaching during PE lessons	Open text box
32. How successful do you feel your PE programmes have been in achieving student learning outcomes for the following PE strands (think about PE lessons taught in the last 12 months)? 6 strand areas outlined	1: Very unsuccessful 2: Unsuccessful 3: Somewhat unsuccessful 4: Somewhat successful 5: Successful 6: Very successful
33: On average, how many minutes per week do you teach PE? (if below 60 minutes, give a reason why)	Open text box
34: During your PE lessons, how would you most accurately describe the following statements? 8 statements related to teaching PE	Likert scale question 1: Never 2: Now & then 3: Sometimes 4: Quite often 5: Often 6: Always
35: To what extent do you agree/disagree with the following statements? 6 statements related to confidence to differentiate PE lessons for children	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree
36: To what extent do you reinforce the seven key considerations when planning a programme of PE 7 statements related to the key considerations outlined in the primary PE curriculum	Likert scale question 1: Never 2: Now & then 3: Sometimes 4: Quite often 5: Often 6: Always
37: Please indicate the degree to which you agree or disagree with the following statements with reference to planning your PE programme: 6 statements related to planning PE	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree
38: Please indicate the degree to which you agree or disagree with the following statements with reference to assessment (i.e. monitoring the effectiveness of the PE lessons in achieving student learning outcomes) in your pe programme:	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree

9 statements related to assessment in PE	6: Strongly agree
39: Please indicate the degree to which you agree or disagree with the following statements with reference to reporting in your PE programme: 2 statements related to reporting in PE	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree
40: Please indicate the degree to which you agree or disagree with the following statements with reference to evaluation in your PE programme (i.e. judging the effectiveness of your overall PE programme): 3 statements related to evaluation in PE	Likert scale question 1: Strongly disagree 2: Disagree 3: Disagree slightly 4: Agree slightly 5: Agree 6: Strongly agree

Section 7 outlined 18 factors that may act as barriers to the delivery of PE in schools (Table 5.8). Teachers were asked to rate from 1 (no barrier) to 6 (major barrier), the extent to which they felt each option prevented adequate delivery of their PE programmes. Options related to personal (e.g. low levels of personal interest in PE), administrative (e.g. lack of departmental assistance, i.e. in-service training opportunities), financial (e.g. lack of money budgeted to programmes) and environmental factors (e.g. inadequate facilities) were included.

Table 5.8 Questions on potential factors that influence the delivery of PE

Section 7: Factors influencing the delivery of PE	
Question	**Questions type**
41: Please indicate the degree to which the following act as barriers to the delivery of your class PE programmes: 18 options outlined	Likert scale question Teachers asked to rate each option from 1 (no barrier) to 6 (major barrier). An option for 'not applicable' was also provided.

The final section included one open-ended question to encourage teachers to offer any final comments regarding their experiences in PE as a teacher.

5.3.4 Sampling strategy and data collection

Similar to the Growing up in Ireland study (ESRI, 2010) and the New Zealand Council for Educational Research (NZCER), a two-stage sampling design was adopted where schools were the primary sampling unit and teachers in the schools the secondary sampling unit. A list of all mainstream primary schools was retrieved from the Department of Education and Skills for the 2017/2018 schoolyear which included 3111 primary schools. At the time of recruitment, two schools had amalgamated with another two schools, leaving a total of 3109 primary schools. A sample size was calculated for schools and teachers, where the population of schools was N=3109 and teachers N=22,430. With an estimated margin of error of 5% and confidence interval of 95% the required sample size was 370 schools or 383 teachers (Krejcie and Morgan, 1970). Survey response rates are typically low, however, response rates less than 85% may provide results that are non-representative of the target population. With a target response rate of 85%, a minimum of 436 schools were included in the first target sample of schools. Only mainstream schools in the Republic of Ireland were included in the target population. Special schools and private schools were excluded. Mainstream class teachers with a minimum of 1-year of PE teaching experience in Ireland were included. Learning support teachers and administrative principals were excluded.

5.3.5 Stratified sampling procedure

Schools were divided by region and disadvantaged (DEIS) status. DEIS (Delivering Equality of Opportunity in Schools) was introduced by the Department of Education and Skills in 2005 to address the educational needs of children from disadvantaged communities. Schools under the DEIS scheme receive additional supports including extra staffing, funding and access to literacy and numeracy programmes. Criteria for inclusion in the scheme include, level of unemployment, public housing and eligibility for the free book grant scheme (McCoy, Quail and Smyth, 2012). With 8 regions (Border, Dublin, Mideast, Midwest, Southwest, Midlands, West and Southeast) and 4 levels of disadvantaged status (DEIS urban band-1, DEIS urban band-2, DEIS rural, Non-DEIS), the sample frame was divided into 32 mutually exclusive groups/strata from which an independent sample was drawn e.g. group 1 included schools in the border region with DEIS urban band 1 status, group 2 included schools in the border region with DEIS urban band 2 status etc. A school residing in a settlement area with a population of over 1500 was classified as urban (Central Statistics Office, 2012). The proportion of schools required by region and disadvantaged status was calculated (Appendix H) and is summarised in Table 5.9. Schools were randomly selected from each stratum using the random number generator in excel.

Table 5.9 Proportion of schools recruited by region and disadvantaged status. Data presented as n (%)

Region	n (%) [a]	DEIS-UB1	DEIS-UB2	DEIS-R	Non-DEIS	Total [b]
Border	484 (16)	3 (3.5)	2 (3)	20 (28)	46 (65)	**71**
Dublin	445 (14)	20 (31)	4 (6)	0 (0)	39 (63)	**63**
Mideast	294 (9.5)	1 (1)	2 (3.5)	2 (2.5)	39 (93)	**44**
Midwest	400 (13)	3 (5)	2 (2)	3 (5.5)	50 (87.5)	**58**
West	481 (15.5)	2 (2)	2 (2)	18 (26)	48 (78)	**70**
Midlands	241 (8)	2 (6)	2 (4)	3 (8)	29 (82)	**36**
Southwest	474 (15)	3 (4.5)	2 (3)	5 (7)	57 (85.5)	**67**
Southeast	290 (9)	2 (3)	2 (5)	3 (7)	34 (84)	**41**
Total	3109 (100)	36 (8)	18 (4)	54 (12)	342 (76)	**450**

Note: **a:** Total in overall population, **b:** Total number of schools recruited, **UB1:** Urban band 1, **UB2:** Urban band 2, **R:** Rural

5.3.6 Contacting schools

An invitation email (Appendix I) was initially sent to 450 school email addresses provided by the Department of Education and Skills seeking the permission of the principal to distribute the questionnaire to the teachers in the school. Schools willing to participate, were sent the link to the survey in a follow-up email (n=440) (Appendix J). Due to privacy laws, the direct email addresses for individual teachers were not obtained, and therefore it was not possible to determine the number of teachers per school who completed the questionnaire.

Although approximately 3267 mainstream teachers should have received the study information, the exact number could not be determined as recipients may have disregarded or deleted the email without circulating it to all teachers in the school. Budget and time constraints limited options such as travelling to each school and offering incentives to complete the survey. Three reminder emails were sent to the schools to encourage administrators/principals to remind any teachers who had not yet completed the questionnaire to consider doing so, and to thank those that had already completed it. However, following low response rates after 4 weeks, a decision was made to invite all schools to participate. A link to the survey was emailed to all mainstream primary schools in Ireland and shared on social media platforms Twitter, Facebook and LinkedIn. Post-stratification was conducted to ensure the sample was representative of the Irish primary school population. Teachers were asked about background characteristics of their schools, including the region where their school resides and the DEIS status. The proportions from the completed questionnaires as outlined in Table 5.10 were compared to the pre-calculated targets outlined in Table 5.9.

5.3.7 Data analysis

Data was downloaded to and screened using Microsoft Excel and then analysed using SPSS version 24. Statistical significance was set at $p<0.05$. Teachers were required to complete all questions in a section before they could move to the next section. Furthermore, to ensure consistency in numbers when looking at differences between FMS trained and non-FMS trained teachers, only teachers who completed the full questionnaire were to be included in the final analysis. However, the final section only included one question (Question 41). Thus, to maximise the number of participants for analysis, data from teachers who completed all questions up to Question 40 were included for analysis.

Descriptive statistics (means, standard deviation, frequencies and percentages) were used to summarise demographic information, independent variables and the proportion of responses to Likert scale questions. Dichotomous variables were created for responses to feelings about PE (1=Disagree, 2=Agree) and confidence to teach PE (1=Not confident, 2=Confident). Chi squared tests were run to identify differences in outcome variables by gender and status of FMS in-service training.

A dichotomous variable was also created for the frequency of using the online Move Well Move Often physical literacy resources (1=Never/Now&Then/Sometimes, 2=Often/Quite Often/Always). Chi squared analysis were run to determine if teachers who used the resources more frequently had better attitudes towards teaching PE and if they felt more confident in their ability to teach each strand area of the PE curriculum. Phi (φ) values of 0.1, 0.3 and 0.5 represent small, medium and large effect sizes, respectively (Cohen, 1988). Chi square tests assume that 80% of cells have expected counts of 5 or more, thus where this assumption was violated, significance values for Fishers Exact Test were reported.

Independent samples t-tests were used to identify if approaches to teaching PE and perceived barriers to the delivery of PE were significantly different for male and female teachers and for teachers with or without FMS based in-service training. Cohen's d values of 0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen, 1988).

5.4 Results

5.4.1 Background information

Background information was completed by 629 teachers, however, only 406 (65%) completed all sections of the questionnaire up to question 40 and 397 (63%) teachers completed question 41. Demographic information for the 406 teachers is presented in Table 5.10. Teachers taught on average 66 minutes of PE per week. Male teachers spent on average 7 minutes more time teaching PE than female teachers (71.3±19.0 vs 64.7±21.2, p=0.01, d=0.3).

Table 5.10 Demographic information for teachers with full questionnaire data (n=406)

Variable		**N**	%
Sex	Male	86	21.2
	Female	320	78.8
Age (yrs.)	21-25	19	4.7
	26-30	58	14.3
	31-35	68	16.7
	36-40	71	17.5
	41-45	58	14.3
	46-50	46	11.3
	51+	86	21.2
Teaching experience (yrs.)	Overall	17.3±10.6	R: 1-42
	In current school	11.8±9.0	R: 0.5-39
Weekly PE (minutes)		66.1±20.9	R: 20-180
30 minutes or less		19	4.7
31-60 minutes		265	65.3
More than 60 minutes		122	30.0
Children in class (n)	Total	24.2±5.9	R: 6-38
School details	Rural	189	46.6
Location	Small town	69	17.0
	Large town	77	19.0
	City	71	17.5
Region	Border	57	14.0
	Dublin	69	17.0
	Mideast	40	9.9
	Midwest	60	14.8
	Southwest	38	9.4
	Midlands	46	11.3

	West	53	13.1
	Southeast	43	10.6
Teachers in the school (n)	1	1	0.2
	2	44	10.8
	3	34	8.4
	4	43	10.6
	5	20	4.9
	6	19	4.7
	7	24	5.9
	8	33	8.1
	9	12	3.0
	10+	176	43.3
Disadvantaged Status	DEIS Urban band 1	28	6.9
	DEIS Urban band 2	14	3.4
	Rural DEIS	40	9.9
	Non-DEIS	324	79.8
Qualification	BEd Primary Teaching (3-yrs)	199	49.0
	BEd Primary Teaching (4-yrs)	34	8.4
	PG Dip in Primary Education	126	31.0
	PG Master's in Education Primary	23	5.7
	Cert in Primary PE	4	1.0
	Dip in Primary PE	4	1.0
	Master's in Education	57	14.0
	PhD	3	0.7
	Training outside Ireland	10	2.5
	Other	29	7.1

Note: **R:** Range, **yrs.:** Years, **BEd:** Bachelor of Education, **PG:** Postgraduate, **Cert:** Certificate, **Dip:** Diploma, **PE:** Physical Education

5.4.2 Feelings about teaching PE

Table 5.11 displays the proportion of teachers who agree or disagree with a number of statements related to teaching PE. Teachers had mostly positive feelings towards teaching PE as 89% enjoy teaching PE and 98.5% perceive it to be an important subject within the primary school curriculum. However, significant differences were observed between male and female teachers and between teachers who completed FMS based in-service training compared to teachers with non-FMS based in-service training. Compared to female teachers, a significantly higher proportion of male teachers would like to teach PE every day ($P<0.001$, $\varphi=-0.2$), enjoyed teaching PE ($P<0.001$, $\varphi=-0.2$), were enthusiastic about teaching PE ($p=0.002$, $\varphi=-0.2$) and felt confident to teach PE ($P<0.001$, $\varphi=-0.2$). However, male teachers were also more likely to agree that their PE teaching expertise comes from their personal interest in sport and exercise ($p<0.001$, $\varphi=-0.2$). Additionally, compared to teachers with non-FMS based in-service training, a significantly higher proportion of teachers with FMS based in-service training would like to teach PE every day ($P=0.001$, $\varphi=-0.2$), enjoyed teaching PE ($P=0.002$, $\varphi=-0.2$), were enthusiastic about teaching PE ($p=0.006$, $\varphi=-0.2$) and felt confident to teach PE ($P=0.007$, $\varphi=-0.2$).

Table 5.11 Teacher's (n=406) attitudes towards teaching PE, overall perspectives (total), differences between male (n=86) and female (n=320) teachers and differences between FMS (n=163) and non-FMS (n=102) trained teachers

Survey statement		M±SD	Agree (%)	Disagree (%)	P	χ^2 (φ)	95% CI
I would like to teach PE everyday	**Total**	3.6±1.5	58.4	41.6			0.54, 0.63
	Male	4.5±1.3	80.2	19.8	**<0.001**	20.3 (-0.2)	0.72, 0.89
	Female	3.4±1.5	52.5	47.5			0.47, 0.58
	FMS-Yes	4.1±1.4	73.6	26.4	**0.001**	10.8 (-0.2)	0.67, 0.80
	FMS-No	3.5±1.5	53.9	46.1			0.44, 0.64
I enjoy teaching PE	**Total**	4.8±1.1	89.2	10.8			0.86, 0.92
	Male	5.4±0.6	100.0	0.0	**<0.001**	11.9 (-0.2)	1.00, 1.00
	Female	4.6±1.2	86.3	13.8			0.82, 0.90
	FMS-Yes	5.1±0.9	96.9	3.1	**0.002**	9.3 (-0.2)	0.94, 0.99
	FMS-No	4.7±1.2	87.3	12.7			0.80, 0.94
I am generally enthusiastic about teaching PE	**Total**	4.8±1.1	88.9	11.1			0.86, 0.92
	Male	5.5±07	98.8	1.2	**0.002**	9.6 (-0.2)	0.96, 1.00
	Female	4.6±1.1	86.3	13.8			0.82, 0.90
	FMS-Yes	5.1±0.9	95.7	4.3	**0.006**	7.6 (-0.2)	0.93, 0.99
	FMS-No	4.7±1.1	86.3	13.7			0.80, 0.93
PE is an important component of the curriculum	**Total**	5.6±0.7	98.5	1.5			0.97, 0.99
	Male	5.7±0.8	97.7	2.3	0.61	0.5 0.04	0.94, 1.00
	Female	5.6±0.7	98.8	1.3			0.97, 1.00
	FMS-Yes	5.7±0.6	99.4	0.6	0.16	n/a (-0.1)	0.98, 1.00
	FMS-No	5.6±0.8	97.1	2.9			0.94, 1.00
I am very confident in my ability to teach PE	**Total**	4.4±1.3	79.3	20.7			0.75, 0.83
	Male	5.1±1.0	94.2	5.8	**<0.001**	13.6 (-0.2)	0.89, 0.99
	Female	4.3±1.2	75.3	24.7			0.71, 0.80
	FMS-Yes	4.8±1.1	89.6	10.4	**0.007**	7.2 (-0.2)	0.85, 0.94
	FMS-No	4.4±1.2	77.5	22.5			0.69, 0.86

I have limited knowledge for teaching PE	**Total**	2.6±1.4	30.3	69.7			0.26, 0.35
	Male	1.9±1.1	12.8	87.2	**<0.001**	14.8 (0.2)	0.06, 0.20
	Female	2.8±1.4	35	65			0.30, 0.40
	FMS-Yes	2.2±1.3	20.2	79.8	0.06	3.5 (0.1)	0.14, 0.26
	FMS-No	2.7±1.4	30.4	69.6			0.21, 0.39
My PE teaching expertise comes from my personal interest in sport and exercise	**Total**	4.3±1.4	72.7	27.3			0.68, 0.77
	Male	5.1±1.0	93.0	7.0	**<0.001**	21.4 (-0.2)	0.88, 0.98
	Female	4.1±1.4	67.2	32.8			0.62, 0.72
	FMS-Yes	4.5±1.4	77.9	22.1	0.09	2.8 (0.1)	0.72, 0.84
	FMS-No	4.1±1.5	68.6	31.4			0.60, 0.78
I tend to revert back to my experiences of PE as a child to guide my current teaching	**Total**	2.4±1.3	20.9	79.1			0.17, 0.25
	Male	2.5±1.4	29.1	70.9	**0.04**	3.8 (-0.1)	0.19, 0.39
	Female	2.4±1.3	18.8	81.3			0.14, 0.23
	FMS-Yes	2.2±1.3	19.0	81.0	0.63	0.0 (-0.1)	0.13, 0.25
	FMS-No	2.3±1.3	16.7	83.3			0.09, 0.24

Note: **M**: Mean (Statements ranked on a 6-point Likert scale with 1 = Strongly disagree and 6 = Strongly agree), χ^2: chi square, φ: phi, **95% CI**: 95% Confidence interval for the proportion who agree with each statement, **FMS-Yes**: Completed in-service training with FMS focus, **FMS-No:** Completed in-service training with no FMS focus, **n/a:** Not applicable as more than 80% of cells had expected counts <5 meaning Fishers Exact Test had to be used instead

Teachers felt most confident to teach the games strand of the PE curriculum and least confident to teach aquatics (Table 5.12). Male teachers felt more confident than female teachers to teach games ($p=0.03$, $\varphi=0.1$) while female teachers felt more confident than male teachers to teach dance ($p<0.001$, $\varphi=0.2$). There was no significant difference in confidence to teach PE between teachers with FMS in-service training and teachers without FMS in-service training. Additionally, male teachers spent more time teaching games compared to females (5.0±0.8 v 4.8±0.8: $p=0.02$, $d=0.3$, 95% CI: 0.03, 0.41) whereas females spent more time teaching dance compared to males (3.6±1.3 v 3.0±1.6, $p=0.001$, $d=0.4$, 95% CI: -1.0, -0.3).

Table 5.12 Confidence to teach PE

I feel confident teaching:	**M±SD**	**Confident (%)**	**Not Confident (%)**	**P**	**χ^2 (φ)**	**95% CI**
Games (n=405)	5.1±1.1	92.8	7.2			0.90, 0.95
Male (86)	5.6±0.6	98.8	1.2	**0.03**	4.8	0.96, 1.00
Female (319)	4.9±1.1	91.2	8.8		(0.1)	0.88, 0.94
Athletics (n=405)	4.8±1.2	88.9	11.1			0.86, 0.92
Male (86)	5.1±1.1	95.3	4.7	0.05	3.7	0.91, 0.99
Female (319)	4.7±1.2	87.2	12.8		(0.1)	0.83, 0.91
OA (n=405)	4.1±1.3	71.2	28.6			0.67, 0.76
Male (86)	4.3±1.4	75.3	24.7	0.44	0.8	0.67, 0.84
Female (319)	4.0±1.3	70.3	29.7		(0.04)	0.65, 0.75
Gymnastics (n=404)	3.2±1.6	45.8	54.2			0.41, 0.51
Male (85)	3.5±1.6	54.1	45.9	0.11	2.6	0.43, 0.65
Female (319)	3.1±1.6	43.6	56.4		(0.1)	0.38, 0.49
Aquatics (n=366)	2.3±1.7	29.2	70.8			0.24, 0.34
Male (79)	2.6±1.8	36.7	63.3	0.13	2.3	0.26, 0.47
Female (287)	2.2±1.7	27.2	72.8		(0.1)	0.22, 0.32
Dance (n=403)	3.8±1.5	66.0	34.0			0.61, 0.71
Male (85)	3.1±1.6	48.2	51.8	**<0.001**	14.2	0.37, 0.59
Female (318)	4.0±1.4	70.8	29.2		(0.2)	0.66, 0.76

Note: **n:** Refers to the number of teachers who have some responsibility for teaching the strand area as some teachers report having no responsibility for teaching certain strands. **M**: Mean (ranked on a 6-point Likert scale with 1 = Strongly disagree and 6 = Strongly agree), **OA**: Outdoor and adventure, **Not confident:** (strongly disagree, disagree, disagree slightly), **Confident:** (slightly agree, agree, agree strongly), **χ2**: Chi square, **φ:** Phi, **95% CI**: 95% Confidence interval for the proportion who felt confident to teach each strand area, bold text indicates statistical significance

5.4.3 Perceptions of who should teach PE

Of the current sample, 93% of teachers said they themselves were responsible for teaching PE to their class (quite often, often or always). However, only 4% of teachers felt happy to cover all aspects of the PE curriculum without any external assistance. Seventy six percent of teachers would welcome assistance from a PE specialist either full-time, part-time or occasionally and 24% said the teacher should cover PE but would welcome assistance from external providers for extra-curricular activities outside of PE time (Table 5.13). Teachers would mostly welcome assistance in gymnastics, aquatics and dance (Figure 5.1).

Table 5.13 Percentage of teachers (n=406) who feel PE should be taught by a specialist teacher and differences between male (n=86) and female (n=320) teachers

Should PE be taught by a specialist teacher?	%	P	χ^2 (φ)	95% CI
Yes- full-time basis				
Total	16.7			0.13, 0.20
Male	7.0	**0.01**	6.6 (-0.1)	0.02, 0.12
Female	19.4			0.15, 0.24
Yes-Part-time basis				
Total	29.8			0.25, 0.34
Male	20.9	0.06	3.6 (-0.1)	0.12, 0.29
Female	32.2			0.27, 0.37
Yes-Occasional consultative basis				
Total	29.3			0.25, 0.34
Male	33.7	0.38	0.7 (0.1)	0.24, 0.44
Female	28.1			0.23, 0.33
No-I am happy to cover the full PE curriculum				
Total	4.2			0.02, 0.06
Male	9.3	**0.02**	5.6 (0.1)	0.03, 0.15
Female	2.8			0.01, 0.05
No-but welcome EP's for extracurricular activities				
Total	24.1			0.20, 0.28
Male	34.9	**0.01**	6.2 (0.1)	0.25, 0.45
Female	21.3			0.17, 0.26

Note: p values represent differences between male and female teachers, **EP's**: External providers, **χ2:** Chi square, **φ:** Phi, **95% CI**: 95% Confidence interval, bold text indicates statistical significance

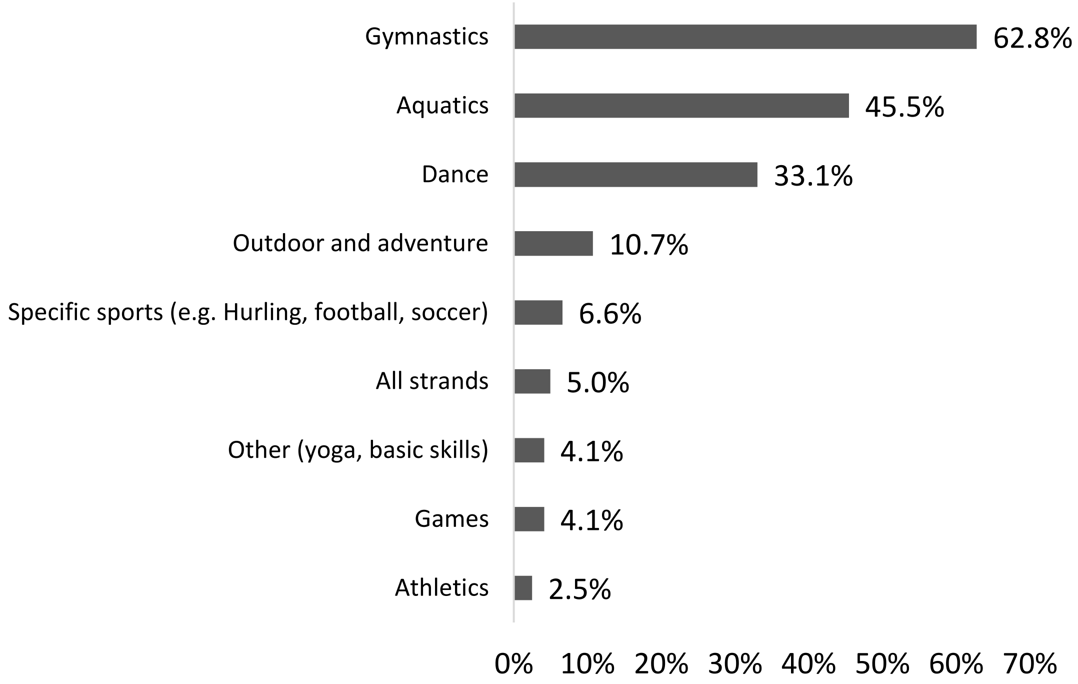


Figure 5.1 Teachers responses to what strand areas they would like assistance with from a part-time specialist
Note: Data presented as percentages based on the number of teachers who selected "yes-part time basis" in Table 5.13 (n=121)

5.4.4 Perceptions of pre-service and in-service teacher training

Only 20% of teachers agreed or strongly agreed that their pre-service teacher education prepared them to teach PE effectively. Forty-three percent rated their pre-service teacher education as good or excellent for games but only 10% rated it good or excellent for the aquatics strand. Differences between male and female teachers were not significant ($p>0.05$).

Overall, 65% of teachers reported completing at least one form of in-service training for PE. This included 71% of males in the sample and 64% of females. Of the teachers who completed in-service upskilling for PE, 96% at least slightly agreed that the course improved their ability to teach PE, however only 5% felt happy to cover all aspects of the PE curriculum without any external assistance. Positive aspects of in-service training included exposure to new content and ideas that enhance teaching confidence, practical experience and access to good quality resources (Figure 5.2).

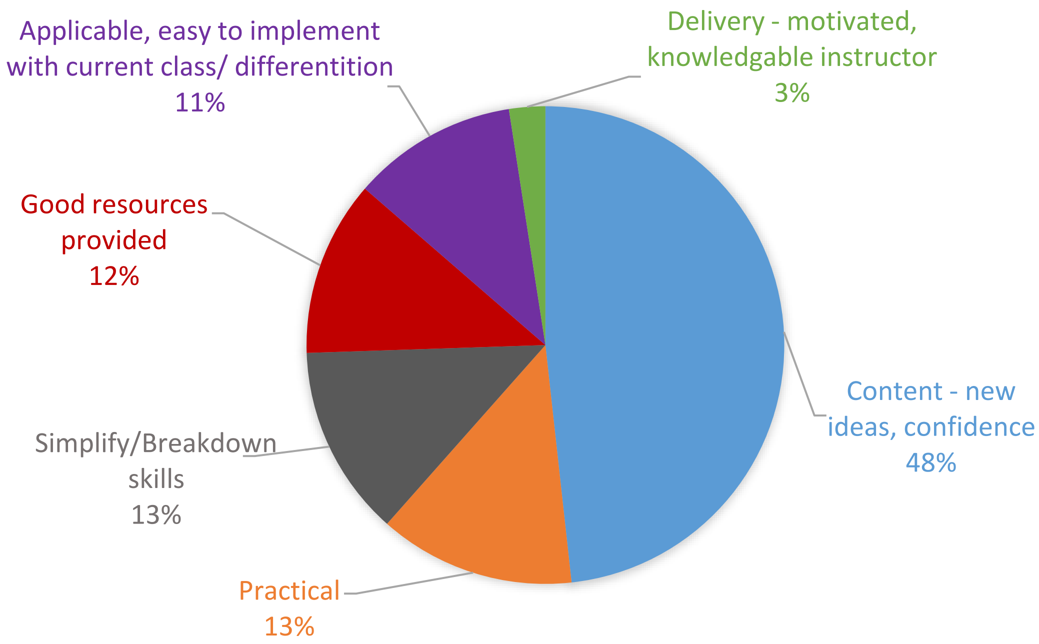


Figure 5.2 Positive aspects of in-service teacher training for PE

Of those that completed in-service training, 61.5% completed at least one course where FMS was a focus. Approximately 25% completed at least one of the Move Well Move Often courses provided by the Professional Development Service for Teachers (PDST) (PDST, 2017). Eighty-three percent of teachers who completed FMS based in-service training agreed or strongly agreed that it improved their ability to teach PE compared to 70% of teachers who completed in-service training without an FMS focus ($p=0.01$, $\chi^2=6.3$, $\varphi=0.2$). Forty-one percent of teachers that completed FMS based in-service training used the physical literacy resources on the PDST website quite often, often or always, compared to only 19% of teachers who completed non-FMS based in-service training ($p<0.001$, $\chi^2=33.3$, $\varphi=0.3$).

Overall, 26% of teachers used the online Move Well Move Often physical literacy resources quite often, often or always, 43% never used them and 31% used them only now and then or sometimes. Compared to teachers who used the resources never, now and then or sometimes, teachers who used them quite often, often or always felt more confident in their ability to teach PE (91% vs 75%, $p=0.001$, $\chi^2=11.4$, $\varphi=0.2$), were more likely to want to teach PE everyday (70% vs 54%, $p=0.004$ $\chi^2=8.2$, $\varphi=0.1$), were more likely to enjoy teaching PE (95% vs 87%, $p=0.02$, $\chi^2=5.7$, $\varphi=0.1$) and were more likely to feel enthusiastic about teaching PE (96% vs 86%, $p=0.005$, $\chi^2=7.9$, $\varphi=0.1$).

Additionally, compared to teachers who used the resources never, now and then or sometimes, teachers who used the resources quite often, often or always were more likely to feel confident in their ability to teach five of the six strand areas including games (99% vs 91%, $p=0.004$, $\chi^2=8.5$, $\varphi=0.1$), athletics (94% vs 87%, $p=0.03$, $\chi^2=4.5$, $\varphi=0.1$), gymnastics (60% vs 41%, $p=0.001$, $\chi^2=11.5$, $\varphi=0.2$), aquatics (38% vs 26%, $p=0.02$, $\chi^2=5.0$, $\varphi=0.1$) and dance (75% vs 63%, $p=0.02$, $\chi^2=5.4$, $\varphi=0.1$). The difference for the outdoor and adventure strand did not reach significance but was also higher for teachers who used the Move Well Move Often resources more frequently (78% vs 69%, $p=0.057$, $\chi^2=3.6$, $\varphi=0.1$).

5.4.5 Approaches to teaching PE

Table 5.14 describes how often teachers use various approaches to teach their PE lessons. Compared to non-FMS trained teachers, FMS trained teachers were more likely to make FMS an important focus of their lessons ($p<0.001$, $d=0.4$) and were more likely to feel that all students in their class experience a sense of achievement from their PE lessons ($p=0.01$, $d=0.3$). Male and female teachers had mostly similar approaches to how they structured PE, however, males were more likely than females to focus on competition and winning ($p=0.03$, $d=0.2$).

Table 5.14 Approaches adopted by teachers (n=406) when teaching PE, differences between male (n=86) and female (n=320) teachers and differences between FMS trained (n=163) and non-FMS trained (n=102) teachers. Data presented as frequencies (%)

Statement	N (%)	N&T (%)	S (%)	QO (%)	O (%)	A (%)	M±SD	P	95% CI	Cohens d
I focus mostly on competition and winning	36.9	39.4	19.5	13.2	1.0	0	1.9±0.9			
Male							2.1±0.9			
Female							1.9±0.9	**0.03**	0.0, 0.4	0.2
FMS trained							1.9±0.9			
Non-FMS trained							1.9±0.9	0.74	-0.2, 0.2	0.0
I use skill practices to teach FMS	1.0	1.7	39.6	29.8	36.5	21.4	4.6±1.0			
Male							4.7±0.8			
Female							4.6±1.1	0.45	-0.1, 0.3	0.1
FMS trained							4.8±0.9			
Non-FMS trained							4.6±0.9	0.24	-0.1, 0.5	0.2
I use small sided games to teach FMS	0.5	6.4	14.3	32.0	32.5	14.3	4.3±1.1			
Male							4.5±1.1			
Female							4.3±1.1	0.12	-0.1, 0.5	0.2
FMS trained							4.5±1.1			
Non-FMS trained							4.3±1.1	0.14	-0.1, 0.5	0.2
I let children in the class choose the activities for PE	21.2	41.4	31.0	4.9	1.2	0.2	2.2±0.9			
Male							2.1±0.9			
Female							2.3±0.9	0.14	-0.4, 0.0	0.2
FMS trained							2.2±0.9			
Non-FMS trained							2.3±0.8	0.78	-0.2, 0.2	0.1

I use a combination of skill practices and games	0.2	2.2	12.6	32.8	36.2	16.0	4.5±1.0			
Male							4.5±0.9			
Female							4.5±1.0	0.58	-0.2, 0.3	0.0
FMS trained							4.6±0.9			
Non-FMS trained							4.5±1.0	0.67	-0.2, 0.3	0.1
FMS are an important focus of the lesson	2.0	4.2	11.8	28.3	32.0	21.7	4.5±1.2			
Male							4.5±1.1			
Female							4.5±1.2	0.71	-0.2, 0.3	0.0
FMS trained							4.7±1.0			
Non-FMS trained							4.2±1.2	**0.001**	0.1, 0.7	0.4
All children experience a sense of achievement	0	3.4	13.1	30.3	39.9	13.3	4.5±1.0			
Male							4.4±0.9			
Female							4.5±1.2	0.39	-0.3, 0.1	0.1
FMS trained							4.6±0.8			
Non-FMS trained							4.3±1.1	**0.01**	0.1, 0.6	0.3
Focus on self-improvement rather than competition	0	0.5	6.4	16.7	33.0	43.3	5.1±0.9			
Male							5.0±0.9			
Female							5.1±0.9	0.27	-0.3, 0.1	0.1
FMS trained							5.2±0.9			
Non-FMS trained							5.1±0.9	0.10	-0.0, 0.4	0.1

Note: **N**: Never, **N&T**: Now and then, **S**: Sometimes, **QO:** Quite often, **O:** Often, **A**: Always, **M±SD**: Mean ± Standard Deviation of the 6-point Likert scale where 1=Never and 6=Always, **95% CI:** 95% Confidence interval, bold text represents statistical significance

5.4.6 Barriers to teaching PE

When ranked on a 6-point Likert scale (1=no barrier to 6=major barrier), teachers rated demands to teach other subjects (4.1±1.9), lack of time (3.6±1.8), inadequate pre-service teacher training (3.5±1.6) and large class sizes (3.5±1.9) as the main barriers to adequate delivery of PE. Male teachers reported inadequate facilities (3.7±2.0 v 3.2±2.0, p=0.04, d=0.3) and negative parental attitudes (2.1±1.5 v 1.7±1.3, p=0.02, d=0.3) as bigger barriers to the delivery of PE than female teachers. Teachers with no FMS based in-service training reported low levels of teaching confidence (2.6±1.5 v 3.2±1.6, p<0.001, d=0.4) and lack of CPD opportunities (3.0±1.8 v 3.7±1.8, p=0.006, d=0.4) as significantly larger barriers to the delivery of PE compared to teachers with FMS based in-service training.

5.5 Discussion

This study is the first to investigate Irish primary school teachers' perceptions, attitudes and perceived confidence to teach PE. Overall, teachers have generally positive attitudes towards teaching PE and perceive it to be an important subject in the primary school curriculum. However, many feel inadequately prepared to teach all components of the curriculum following their pre-service teacher education. It is also evident that differences exist between male and female teachers and between teachers with FMS based in-service training and non-FMS based in-service training.

5.5.1 Time spent teaching PE

Consistent with international literature (Morgan and Hanson, 2008; Barroso, 2005; Hardman, 2008; UNESCO, 2014), time constraints and other curriculum demands were among the top ranked barriers preventing adequate delivery of PE. Current guidelines recommend that Irish primary school children receive a minimum of 60 minutes of PE lessons per week (DES, 1999). Encouragingly, teachers in the current study taught PE for an average of 66 minutes per week, with male teachers teaching significantly more than female teachers by approximately 7 minutes. Despite remaining below the European and global averages of 103 (European Commission 2013) and 112 (UNESCO 2014) minutes respectively, teachers in this study reported teaching PE for 20 minutes more than the average time of 46 minutes noted by Woods et al., (2010). Furthermore, only 5% of teachers in the current sample taught PE for 30 minutes or less in comparison to the 18% of pupils reporting access to 30 minutes or less of PE in the most recent CSPPA report (Woods et al., 2018). However, teachers who are more enthusiastic about teaching PE may have been more likely to complete the survey and so the actual average time Irish school teachers spend teaching PE may be less than 66 minutes. While increasing the time devoted to PE in schools is a positive step, the quality of PE lessons, which is largely dependent upon the individual teachers, may be a more important factor to consider (UNESCO, 2014).

5.5.2 Feelings towards and perceived confidence to teach PE

Over 85% of teachers in this study enjoy teaching PE, are enthusiastic about teaching PE and perceive PE to be an important component of the curriculum. This was a positive finding as teachers' perceptions guide their behaviours which can subsequently influence students' motivation and feelings towards PE (Dagkas and Stathi, 2007) and their PA habits outside school and over the life course (Chatzisarantis, Hagger and Brickell, 2008; Sallis et al., 1999). However, having a positive attitude towards PE does not guarantee quality PE lessons, evidenced by the fact that only 4% of teachers in this study felt confident to teach all strand areas of the PE curriculum without any external assistance. Compared to female teachers, male teachers were more likely to enjoy teaching PE, felt more confident in their ability to teach PE and were more enthusiastic about teaching PE. They were also more likely to feel that their PE teaching expertise came from their own personal interest in sport and exercise. This has been highlighted as a potential concern when children are taught PE by non-specialists, as teachers who don't enjoy sport and PA outside of school, or those who perceive their previous PE experiences negatively (Morgan and Bourke, 2008) may be less confident and therefore less motivated to teach PE (McKenzie and Kahan, 2008; McKenzie et al., 1999). Although male teachers report better attitudes than female teachers, males only constitute 15% of the overall primary teacher population in Ireland (DES, 2019). Therefore, the majority of Irish school children are being taught PE by less confident female teachers. Consequently, PE teacher education programmes may need to prioritise strategies that will boost female teachers' confidence to teach PE.

Interestingly, male teachers were more confident in their ability to teach games whereas, females felt more confident than males to teach dance. Similarly, Russell-Bowie, (2013) found that among a sample of 926 pre-service teachers from Australia, Namibia, South Africa, the USA and Ireland, females felt significantly more confident than males to teach dance. The differences in teacher confidence to teach strand areas like games or dance are similar to the types of activities that males and females prefer to engage with as children (Beni et al., 2017; Thomas and French, 1985; Hargreaves, 1994), suggesting that childhood experiences carry through to influence adult perceptions and habits (Bourdieu, 1990; Spittle et al., 2009; Morgan and Bourke, 2008). In addition, the perceived socio-cultural norms that reportedly influence the types of activities that children engage with growing up, i.e. ego-centric, competitive forms of activities for males and more individual, non-competitive activities for females (Johnson et al., 2005; Thomas and French, 1985; Garcia, 1994; Lever 1978), may explain why male teachers were more likely than female teachers to focus on competition and winning when teaching PE lessons. Consequently, although male teachers in this study felt more confident to teach PE, their lessons may be less suitable for children who dislike competitive environments. Therefore, teachers may need to dissociate their PE teaching practices from their previous PE and PA experiences in order to limit the potential gender bias that they may have accrued from their own experiences growing up. Teachers may not be aware of the potential influence that their past experiences could have on their current practices. Consequently, these factors may need to be highlighted as part of pre-service and in-service training opportunities for PE.

Confidence to teach specific strand areas was significantly correlated with how often the teacher's class participated in each strand. Consequently, where teachers lack confidence, this could reduce the range of activities that children experience and thus limit opportunities to master a broad range of FMS during primary PE lessons. Teachers felt most confident to teach games which might explain why this strand area is commonly overemphasised in primary school PE curriculums in Ireland (Woods et al., 2018) and abroad (Hardman et al., 2008). These findings highlight the need to improve the range of activities being taught in PE in Irish primary schools. However, to ensure student engagement and enjoyment of PE is maximised, consideration must also be given to how the PE lessons are taught (O'Connor et al. 2012; UNESCO 2014).

5.5.3 Approaches to teaching PE

There are concerns that competition and winning is the main focus of PE lessons when teaching games (Flanagan, 2014), however, only 14% of the teachers said competition and winning was the main focus of lessons either often or quite often. This is encouraging due to the potential negative implications that a competitive environment could have on some children's enjoyment and motivation in PE lessons (Vallerand, Ryan, and Deci, 1987; Goudas and Biddle, 1994). However, a lack of choice is evident with only 6% of teachers saying they let children choose activities in PE quite often, often or always. Previous research highlights that children value having choice in PE (Lewis, 2014; Ryan and Deci 2000; Ward et al., 2008) and along with relatedness and competency, is a key component of self-determination theory (Deci and Ryan, 2008). Self-determination theory recognises the importance of fostering intrinsic motivation rather than extrinsic motivation. If a child is intrinsically motivated to participate in PE, they are doing it because they want to and not because the teacher is telling them to. They are motivated by wanting to achieve self-directed goals (i.e. mastery motivational climate) rather than for the reward of teacher praise or being the best in the class (i.e. ego motivational climate) (Ames, 1992; Standage and Treasure, 2002). Child centred autonomy and choice is central to creating this mastery motivational climate (Epstein, 1988). Furthermore, the findings from Chapter 4 suggest that a specialist led short-duration intervention programme delivered using a mastery-motivational climate can enhance children's FMS development. Similarly, Hastie et al., (2013) in a review of 27 studies reports that child-centred autonomous PE lessons support skill development, perceived competence and PA engagement. It is therefore important that teachers develop the confidence and skills to adjust their pedagogical practices to allow for student autonomy and choice in their PE lessons.

5.5.4 Teacher training and potential role of FMS based in-service training

Only 20% of teachers agreed or strongly agreed that their pre-service teacher education prepared them to teach PE effectively, which is consistent with generalist teachers' perceptions internationally (Morgan and Bourke 2008; UNESCO, 2014; Harris et al., 2011). Prior to the 2013/2014 academic year, PE was not offered as a subject specialism for trainee primary teachers in Ireland and the average time devoted to PE specific training varied across teacher training colleges ranging from 30 to 50 hours (Flanagan, 2014). However, since 2014 approximately 25 students from each teacher training college can choose PE as a subject specialism and experience approximately 148 hours of PE related learning over the four years of pre-service training (Marron et al., 2018). Only 3% of the current sample classified themselves as specialist PE teachers, and similar to previous research (Davis et al. 2005; Breslin et al. 2012; Coles 1995), they felt better prepared to teach PE than non-specialists. Despite the possibility that the quality of PE lessons could be greatly improved by having a full-time specialist PE teacher in schools (Gordon and Inder 2000; McKenzie et al. 2001), only 17% of the 406 teachers that completed the survey felt that PE should be outsourced to a full time PE specialist.

The reasons for why a specialist should or should not teach PE were not explored in the current study, but previous research suggests that generalist teachers can integrate learning from other areas of the curriculum and better understand the individual needs of the children in their class (Wright 2002; Sloan, 2010; Coulter et al., 2009; Callcott, Miller and Wilson-Gahan, 2012). Thus, allowing a specialist teacher to take full ownership over teaching PE in isolation would present its own problems in delivering what should be an integrated school curriculum. It seems teacher educators in Ireland recognise the potential for these issues to arise and consequently a move towards the promotion of distributed expertise in schools has been encouraged (Marron et al., 2018). Distributed expertise refers to the idea of ensuring every school has at least one teacher who has undertaken specialist PE training (Lynch and Soukup, 2017). The PE expert in each school could then provide support to less confident teachers and take responsibility for the design and delivery of high-quality PE lessons throughout the whole school. Different strategies may need to be adopted depending on the school or specific needs of individual teachers, but options may include upskilling less confident teachers within their own school environment through PE workshops and/or team teaching (Coulter and Woods, 2012). In addition, for teachers who are strongly resistant to improve the quality of their PE teaching, but who feel competent to teach another subject like music or art, class swapping may be preferred and would allow children to experience better quality lessons across a range of subjects (Jones and Green, 2015; Decorby et al., 2005). Further research is needed to determine the efficacy of these options and opportunities for more teachers to access suitable training to gain "PE expert" status, may need to be considered.

Teachers appointed as the PE expert, may need specific PE leadership training. The content covered as part of the PE specialism in each of the teacher training colleges in Ireland is unclear, however, to the authors knowledge, at least one college offers a module in PE leadership. Through the PE leadership module, teachers are encouraged to become subject leaders in PE and to promote quality PE lessons and offer support to less confident teachers in the schools that they teach (Marron et al., 2018). Furthermore, given that teachers in the current study reported 'demands to teach other subjects' and 'large class sizes' as the main barriers to the delivery of quality PE, training in curriculum integration and effective strategies to deal with teaching large groups of children must also be considered. Sixty percent of teachers in the current study were interested in working alongside a specialist teacher on a part-time or occasional consultative basis, whilst a further 17% felt that PE should be taught by a full-time PE specialist, thus the appointment of a PE expert in every school may be largely welcomed in the Irish context. However, the number of teachers who currently possess PE expertise in Irish primary schools is low, and the number of pre-service teachers who can choose to specialise in PE is limited, thus in-service and professional development opportunities are essential to accelerate the provision of PE experts to all schools in Ireland (Marron et al., 2018; Talbot, 2008).

Teachers who welcomed assistance on a part-time basis, felt they needed most assistance in gymnastics, aquatics and dance, and comparable to Australian (Morgan and Bourke 2005) and English (Harris et al., 2011; Burgess and Goulding 2009) generalist teachers, they felt least confident to teach those strands. Australian school principals also reported that teaching of gymnastics and dance were most frequently outsourced compared to other strand areas (Lynch and Soukop, 2017). Among the general population, gymnastics and dance are less popular activities compared to games (ESRI, 2014). Thus, the combination of inadequate pre-service training and lack of personal engagement in these activities may contribute to teacher's low levels of perceived confidence to teach strand areas like gymnastics and dance. However, teachers should know that they do not need to be experts in each strand in order to be good teachers (Petrie, 2010), but should understand how children learn skills in general. Understanding the concepts of different motor learning theories and how they influence skill acquisition may benefit pedagogical practice within PE (Rudd et al., 2020; Renshaw et al., 2010; Di Tore et al., 2016). Teachers understanding of motor learning theories were not investigated in the current study, but due to the fact that understanding motor learning from either a behaviourist or ecologist perspective will influence how skills are taught and how practice sessions are structured (Di Tore et al., 2016; Rudd et al., 2019; 2020), it may be an important avenue to explore in future investigations.

Of the teachers who completed in-service training, 61% completed at least one course that was centred around FMS. Previous research suggests that FMS trained teachers have better instructional (Breslin et al., 2012) and assessment (Lander et al., 2015) practices compared to teachers with no specific FMS based training. Teachers in this study who completed FMS based in-service training portrayed better attitudes towards teaching PE and were significantly more likely to feel that all children in their class experience a sense of achievement during PE lessons. Experience of success is essential to foster positive self-perceptions among children and to improve their perceived confidence and competence to engage in PE, and subsequently PA and exercise outside of school (Weiller and Richardson, 1993; Baron and Downey, 2007). For example, children from Northern Ireland who were taught by FMS trained teachers portrayed significantly higher levels of scholastic competence ($p<0.001$), social acceptance ($p=0.002$), athletic competence ($p=0.001$) and global self-worth ($p=0.006$) compared to children taught by non-FMS trained teachers (Breslin et al., 2012). A potential explanation for this may be that teachers who learn about FMS gain a better understanding of how to simplify skills and how to tailor lessons to suit the skill level of the child. The child can then focus on self-improvement rather than competing with their peers and may feel more motivated to continue engaging in PE as a result of noticing improvements in their own skill performances over time.

The Move Well Move Often initiative focuses on teaching PE through the lens of FMS and may be significantly improving Irish mainstream teacher's confidence to teach PE. In addition to the practical seminars that two teachers from every school in Ireland were invited to attend, online resources are freely available for all teachers to access and use to support their PE teaching. Teachers who use the resources quite often, often or always felt significantly more confident to teach five of the six strand areas and had better attitudes towards teaching PE compared to teachers who never used them or used them less frequently. However, caution is warranted when interpreting the results as teachers who have greater interest in PE and sport may be more likely to put extra time and effort into planning and teaching PE than teachers who have less interest in PE.

It is also unclear to what extent the resources are used and for what areas (i.e. for instructional ideas, assessment of PE, differentiation, planning PE etc.). The resources available include a teacher guide and three handbooks outlining PE content ideas for 15 skills suited to infant classes (book 1), junior to middle classes (book 2) and middle to senior classes (book 3). Each book outlines stages of development for each skill, presents sample activities and how to differentiate them to target skill development, provides key messages and teaching points and gives ideas for homework tasks that children can complete. Teachers can also access sample lesson plans, seminar presentations and a book on how to use external cues to teach FMS (PDST, 2017). It is also unclear if teachers who have not attended the seminars feel confident to use these resources or if teachers who attend the seminars take on PE leadership roles to support and upskill their colleagues in teaching PE. Whilst the current study suggests the presence of some positive developments from the Move Well Move Often initiative, further research is required to maximise the efficacy and efficiency of such PE teacher training opportunities. This is particularly evident from the fact that even though 83% of FMS trained teachers in the current study agreed or strongly agreed that the in-service training improved their ability to teach PE, only 4% of the overall sample felt happy to cover all aspects of the PE curriculum themselves. Consequently, as already mentioned, there remains a need to improve PE teacher training opportunities for all teachers or to alternatively encourage teachers who have more interest in PE to upskill and become appointed as the PE expert that will lead the whole school PE curriculum and support their less confident teacher colleagues in teaching PE. Another option would be to investigate the feasibility of outsourcing PE specialists to support teachers across multiple schools on a needs specific basis.

While having a specialist deliver some PE lessons could be more enjoyable for children, it could also provide context-specific upskilling for the teacher (Fullan, 2006; Coulter and Woods 2012; Harris et al., 2011). Coulter and Woods (2012) explored the effectiveness of a 6-week on-site professional development programme for teaching the outdoor and adventure strand. Support was provided to varying degrees depending on the needs of the teacher and led to improvements in teacher content and pedagogical knowledge and increased student engagement. However, the authors concluded that continuous support would be required as six weeks was too short to ensure long-term behaviour change among the teachers. Similarly, a year-long professional development programme in New Zealand that focused more on pedagogical knowledge rather than content-knowledge led to significant improvements in teacher confidence and enthusiasm to teach PE and enhanced PE lesson quality (Petrie, 2010). One to two teachers from participating schools attended workshops to become lead teachers. The lead teachers provided workshops to other teachers in their schools and were also supported by specialist PE advisors who attended schools on a needs specific basis. The teachers developed confidence about how to deliver less teacher-directed lessons and how to give students more ownership of their lessons. Considering teachers in the current study tend to offer very limited choice to students in their PE lessons, professional development programmes that provide practical, context-specific, longer term support from more confident teachers or PE specialists, may help to improve their pedagogical practices and consequently the quality of PE lessons (Harris et al., 2011).

5.6 Strengths and limitations

This is a novel study as, to the authors knowledge, it is the first to gather information about Irish primary school teachers perceptions of the adequacy of their pre-service and in-service training for PE, in addition to their attitudes towards and confidence to teach PE in Irish primary schools. The results can be used to improve PE specific support for mainstream teachers and to enhance both pre-service and in-service PE teacher education opportunities. The large response rate from teachers covering all regions of Ireland is another strength of this study.

The primary stratified random sampling method was changed to inviting all teachers to complete the questionnaire, which introduced a risk of bias as teachers with a greater interest in PE may have been more likely to complete the survey compared to teachers with no interest in teaching PE. However, post-stratification was conducted to ensure a representative sample of teachers from all regions of Ireland and from schools across each disadvantaged status were included. Furthermore, teachers in special schools were not included, which limits the generalisability of the results to those who work with children with special needs and/or moderate to severe learning difficulties.

5.7 Conclusion and summary

Irish schoolteachers have generally positive attitudes towards teaching PE and perceive it to be an important subject, however, they report that pre-service teacher training does not adequately prepare them to teach all strand areas equally. The majority of teachers would welcome assistance from a PE specialist on a part-time or occasional consultative basis. Considering 65% completed at least one form of in-service training, but only 5% felt happy to cover the full PE curriculum without any external assistance, suggests that further support is needed to improve teacher confidence. Teachers possess different strengths, weakness and abilities to teach PE, thus various CPD opportunities should be provided to cater for diverse training needs. For example, male teachers may require more support in teaching dance whereas female teachers may require extra support in the games strand.

As part of pre-service training, increasing the number of compulsory PE specific modules with greater emphasis on the theoretical concepts of motor learning and skill acquisition may be beneficial (Rudd et al., 2020). Additional opportunities for teachers to avail of in-service PE teacher training that offers practical assistance on a needs-specific basis may also contribute to improvements in pedagogical knowledge and teacher enthusiasm and confidence to teach PE. Based on the positive findings regarding FMS-based in-service training, continued roll out of the Move Well Move Often initiative should be considered. The current study provided a glimpse into the potential positive implications of this initiative; however, more strategic monitoring of such programmes is needed to provide a more solid evidence-base for effective teacher training in PE. Further investigations are required to determine firstly, if these ideas can increase teacher confidence to teach PE, and secondly, if improving teacher confidence to teach PE can advance the quality of PE lessons which may be determined by also examining changes in children's perceptions of PE and their FMS proficiency levels throughout the primary school years.

Chapter 6: Thesis Summary, Conclusion and Future Recommendations

6.1 Introduction

Children who are proficient in many FMS are more likely to have the confidence and competence to engage in regular PA (Whitehead, 2010), but need support to ensure adequate levels are acquired (Gallahue et al., 2012). Modern society has seen a shift towards more sedentary lifestyle behaviours (Kohl et al., 2013), thus children are less active than ever and opportunities to practice and learn FMS are limited. As children get older, their perceptions of skill competence may determine how motivated they are to engage in PA and sport (Stodden et al., 2008). Thus, failure to maximise opportunities for FMS development when children are young, may contribute to drop out from PA and sport, rising obesity levels and avoidable healthcare costs in later years. As primary school PE is compulsory for all children in Ireland, it provides an ideal opportunity to support their FMS development. However, primary PE lessons are typically taught by generalist teachers, many of whom feel inadequately prepared to teach all strand areas of the curriculum equally. Therefore, PE as it is currently being delivered, may be a missed opportunity to maximise children's FMS development. This thesis proposes that specialist FMS instruction and practice opportunities should be incorporated into PE lessons, but also recognises that teachers need better PE specific training opportunities and support to ensure they feel confident to teach all strand areas of the PE curriculum equally.

6.2 Thesis summary

Study 1 (**Chapter 3**) confirmed that the majority of Irish school children are not mastering FMS, with less than 40% achieving mastery across 15 skills. Consistent with recent national literature (Bolger et al., 2018; Behan et al., 2019), males were significantly better than females in the performance of ball skills and overall FMS scores, whilst no significant sex differences were found for locomotor subtest scores. Additionally, overweight and obese children displayed significantly lower locomotor, ball skills and total FMS scores than non-overweight children. This highlighted that girls and overweight children require particular attention when aiming to improve FMS, as both groups are at greater risk of disengaging from PE as they transition to second level education. It was expected that older children would perform significantly better than younger children, however, locomotor subtest scores were similar for all class groups. In addition, a plateau was observed after Year 5 (9-years-old) for ball skill subtest scores and changes in total FMS scores did not significantly change from one year to the next after Year 3 (7-years-old). Based on these findings, it is evident that Irish school children are performing below their developmental potential across a range of FMS. Therefore, an intervention aimed at improving FMS in children in Year 3 and Year 4 (7- to 8-years-old) was identified as the next phase of this research.

A short-duration intervention programme focusing on specialist FMS instruction was designed for study 2 (**Chapter 4**). A crossover design was used to ensure all children were given the opportunity to take part in the intervention programme. This crossover design, combined with the inclusion of a 13-month follow-up, provided a unique longitudinal analysis of changes in FMS proficiency over five time points. Despite the absence of a true control group, there were some indications to suggest that specialist FMS instruction can facilitate significant improvements in FMS proficiency, both immediately following the intervention and after 13 months. In addition, the intervention programme was effective for males and females and for overweight/obese and non-overweight children. This was an important finding, as although males remained significantly better than females, and non-overweight children significantly better than overweight/obese children at all time points, the gap did not increase. This would suggest that all children were engaged in the programme and it was suitable to implement with both males and females and with groups of children with varying levels of ability. The intervention was delivered using the TARGET principles to facilitate a mastery-motivational climate. Children were encouraged to focus on self-improvement rather than competition and winning, which may have enhanced their motivation to engage with the lessons. Anecdotally, Irish primary school teachers often feel inadequately prepared to teach PE following their pre-service teacher training (Fletcher and Mandigo, 2012) and therefore, may not have the skills and knowledge to provide adequate instruction and feedback to help children learn FMS during primary school PE lessons. Without appropriate instruction and feedback, children are less likely to master FMS (Gallahue et al., 2012), which may have detrimental consequences for future PA engagement (Stodden et al., 2008; Robinson et al., 2015). To the authors knowledge, no studies have yet been conducted to understand generalist teachers' perceptions, attitudes and perceived confidence to teach PE in the Irish primary school setting. This information is vital to ensure targeted support structures can be implemented for teachers to improve the overall quality of PE lessons for children.

Study 3 (**Chapter 5**) discussed the results from a comprehensive questionnaire which evaluated teachers' perceptions, attitudes and perceived confidence to teach PE in Irish primary schools. The results suggest that teachers have positive attitudes towards PE but do not feel confident to teach all aspects of the PE curriculum. Consistent with international reports (Morgan and Bourke, 2008; Harris et al., 2011), teachers feel most confident to teach games but would welcome assistance with mostly gymnastic aquatics and dance. In addition, male teachers had better attitudes towards teaching PE than female teachers. Male teachers were more likely to enjoy teaching PE, felt more confident to teach PE and were more likely to feel like they had adequate knowledge to teach PE. However, overall, only 20% of teachers felt adequately prepared to teach PE following their pre-service teacher training, which highlights the need for improved PE specific training during initial teacher education. Sixty five percent of teachers completed some form of in-service training for PE of which over 90% felt it at least somewhat improved their ability to teach PE. Differences were reported based on the type of in-service training completed as teachers who completed FMS-based in-service training, such as the Move Well Move Often seminars for example, were more likely to feel that the in-service training improved their ability to teach PE compared to teachers who completed non-FMS based in-service training. Teachers with some FMS-based training were also more likely to feel that students came away from PE having experienced a sense of achievement, which could potentially enhance children's enjoyment of and motivation to engage in PE lessons (Ntoumanis and Biddle, 1999; Standage and Treasure, 2002; Standage et al., 2005).

Demands to teach other subjects, time, inadequate pre-service training and large class sizes were reported as the main barriers to adequate delivery of PE. Combined with the fact that over 70% of teachers felt that PE should be taught by a specialist either full time, part-time or occasionally, stakeholders may wish to consider who is best positioned to be regarded as a "PE specialist" at primary level and subsequently if PE specialists can be made available to all schools on a needs-specific basis. Doing so may provide an ideal opportunity to upskill less confident teachers in their own school context, improve their attitudes and perceptions of PE, and consequently provide better PE experiences for children in primary school. Further research is needed to determine the feasibility and efficacy of these options.

6.3 Thesis conclusion

The primary school years are regarded as a critical time for FMS development (Gallahue et al., 2012). Thus every child, regardless of sex, weight status or natural ability should be afforded the best opportunity to gain proficiency in as many skills as possible so that they can leave primary school feeling well equipped to engage in any sport or PA opportunity that may arise throughout the lifetime. This research highlights that FMS proficiency levels of Irish school children need to be improved, with particular attention needed to support females and overweight children. Considering a specialist-led FMS intervention programme of just 8 weeks duration, facilitated improvements in children's FMS proficiency levels regardless of sex or weight-status, children who are exposed to eight years of PE lessons delivered by teachers with specialist knowledge in PE, may have a significantly higher chance of mastering many FMS before entering second level education.

Although Irish primary school teachers reported positive attitudes towards teaching PE, most feel inadequately prepared to teach the full PE curriculum to a high standard. Whilst male teachers were more confident than female teachers, and teachers who completed FMS-based in-service training more confident than teachers who completed non-FMS based in-service training, there remains a need to support and upskill Irish primary school teachers to confidently teach a broad and balanced PE curriculum. Potential options include, 1) increasing the number of core modules for PE teaching during initial teacher training, 2) continued provision of professional development opportunities like the Move Well Move Often initiative which emphasises FMS development, 3) the appointment of a PE expert to every primary school who can advocate for quality PE lessons and provide support to teachers on a needs-specific basis and/or 4) outsourcing specialist PE teachers to collaborate with less confident mainstream teachers on a needs-specific basis. Future research should aim to determine the feasibility and efficacy of these options.

6.4 Potential translation of research findings

The current research presents meaningful findings from both the perspective of children's FMS proficiency levels and Irish primary school teachers' perceptions, attitudes and perceived confidence to teach PE.

Of particular concern is the low levels of FMS proficiency reported in study 1 (**Chapter 3**) and study 2 (**Chapter 4**). These results align with recent national reports among similarly aged children (Bolger et al., 2018; Behan et al., 2019) and represent a worrying trend in terms of Irish school children's FMS proficiency levels. Although many avenues could be explored to try and enhance children's FMS development, the school setting is accessible to all children which reduces the participation bias that may occur in community- or home-based environments. Furthermore, in Ireland children typically attend primary school over a period of eight years, which represents a significant time frame within which the things they learn and their experiences of different subjects can influence their attitudes and behaviours and subsequent lifestyle choices they make as they get older. Of particular importance, now more than ever before, is the learning environment and experiences created during PE lessons. PE should help children to "lead full, active and healthy lives" (NCCA, 1999, p.2). The PE curriculum document also states that children should be provided with opportunities to engage in diverse, varied and developmentally appropriate movement activities through the six strand areas. However, it is unfair to expect teachers to automatically have the necessary skills and knowledge to meet such high expectations, especially among teachers who have received inadequate training to teach all aspects of the PE curriculum, in addition to teachers who are not confident in their personal ability around PA and sport and for those who have had negative personal experiences of PE in school.

The current research points towards the need for specialist FMS knowledge to be incorporated into the primary PE setting. The most appropriate means of incorporating such specialist knowledge must be examined. It is important to acknowledge, however, that most teachers want to maintain their role as the PE teacher, but would welcome assistance from a specialist. Positive steps are being made within the Irish context, where PE is now offered as a subject specialism during pre-service training, but it is not clear how many teachers qualify with this specialism; how confident they are to teach PE; how they teach PE (i.e. do they use principles of mastery-motivation or other teaching styles); or how effective their lessons are in terms of children's enjoyment, FMS development and long-term motivation for PA and sport. Furthermore, it is also unclear if teachers with specialist PE training support and upskill their teacher colleagues and take the lead in implementing a quality whole school PE policy.

It would be hoped that teachers with the PE specialism would have a positive influence on the quality of PE throughout the whole school and not just for the children they teach themselves. However, the number of schools with access to such staff is unclear and given that the option for pre-service teachers specialise in PE has only been available since 2013, it is likely to be relatively low. Therefore, in-service training opportunities for practicing teachers must also be considered.

Again, some positive efforts are ongoing within the Irish context, particularly regarding the Move Well Move Often initiative which was introduced in 2017. Interestingly, this initiative focuses on equipping teachers with specialist FMS knowledge and an understanding of how to differentiate tasks based on the child's ability so as to maximise inclusion and participation for all children in PE. These components align closely with the concepts of mastery motivation which also guided the delivery of the intervention in study 2 (**Chapter 4**). PE is accessible and suitable for all children regardless of their natural ability and should not just be taught in a manner that only supports or caters for the more athletic children in the class. All children can be given the opportunity to experience a sense of achievement in PE, and this is largely possible when a teacher creates a mastery-motivational climate when teaching PE. Teachers who understand FMS, and who can identify the different ability levels, may be better equipped to create this mastery climate when teaching the different strand areas in PE. So while the intervention in study 2 provides insight into the potential benefits associated with combining specialist FMS knowledge with mastery-motivation when teaching FMS based lessons, the intervention was not aligned with a specific strand area and therefore warrants further investigation to establish how it can be incorporated into the overall PE curriculum, particularly when teaching the strand areas that teachers feel less confident to teach, i.e. gymnastics, aquatics and dance. As the Move Well Move Often initiative seems to align with these recommendations, formal assessment of the efficacy of this type of in-service training should be conducted. It may also be worth considering expanding the potential professionalisation of such programmes by providing opportunities for teachers to gain PE expert status after completing a certain number of seminars and workshops and where they can demonstrate a minimum level of competency in teaching PE. These teachers may then be in a position to support and upskill their teaching colleagues also.

Although the current research may have raised a number of questions, what is imperative is that it is not only the children in Irish primary schools that need support to improve their FMS proficiency levels. If improvements are to happen through the medium of primary PE lessons, support must also be provided to teachers to ensure they have the confidence to deliver diverse, varied and developmentally appropriate PE lessons for all children throughout the primary school years. Various steps will be taken to maximise the impact of the findings from study 3 (**Chapter 5**). Firstly, the study will be published in a peer reviewed academic journal. Once published, efforts will be made to publicise the study and to engage with key stakeholders including PE teacher educators across the five primary teacher training colleges in Ireland and in-service providers such as the Irish Primary PE Association and the Professional Development Service for Teachers. Finally, efforts will be made to liaise with the Department of Education to advocate for greater PE teacher training opportunities for teachers with a long-term goal of ensuring all primary schools in Ireland have access to a teacher with specialist training in PE.

6.5 Thesis limitations

The findings from this research must be viewed in light of the following limitations:

- In study 1 (**Chapter 3**), the use of convenience sampling where only children from three Midlands based primary schools were included, limits the generalisability of the findings. The sample is not representative of the population of primary school children in Ireland. Despite that, the findings are similar to previous national studies investigating primary school children's FMS proficiency levels (Behan et al., 2019; Bolger et al., 2018).

- BMI was the only method used to categorise children as overweight/obese or non-overweight in both study 1 (**Chapter 3**) and study 2 (**Chapter 4**). One explanation given for why overweight children were poorer in locomotor skills was due to the possibility of having more adipose tissue around joints which may limit the range of motion required to attain mastery (Bryant et al., 2016; Riddiford-Harland et al., 2006). Although highly correlated with more accurate measures of fat mass, it must be acknowledged that BMI does not distinguish between lean mass and fat mass. Time constraints, financial constraints and expertise limited the use of more accurate assessments of body composition such as dual energy X-ray absorptiometry (DEXA), waist-hip circumference and skin-fold measurements.

- Some limitations regarding the use of the TGMD-3 to assess FMS must be noted. Firstly, the TGMD-3 does not specifically assess balance skills which are identified as a separate category of FMS alongside locomotor and object-control skills. Although the author of the TGMD assessments states that balance is a pre-requisite skill needed for many locomotor skills (Ulrich 1985; 2000; 2019), assessing balance specifically would provide a more comprehensive analysis of overall FMS proficiency levels. Secondly, there is a risk of a ceiling effect when using the TGMD-3, however, no child in the current research achieved the maximum TGMD-3 score of 100, and this ceiling effect was therefore not a significant concern. Thirdly, the TGMD-3 is a process-oriented assessment with scores assigned based on the presence or absence of pre-determined performance criteria. This scoring method does not allow for variation in technique and may inaccurately categorise higher skilled children as having poorer proficiency than they do. The inclusion of product-oriented assessments with process-oriented assessment may more accurately determine changes in FMS proficiency levels over time (Hulteen et al., In press; Lander et al., 2017; Logan et al., 2017). Finally, due to time constraints, children were assessed in groups which meant that children may have been distracted or potentially influenced each other's skill performances. Attempts were made to minimise this disruption by keeping the group sizes as small as possible, asking each child if they understood what was being asked of them and repeating the instructions for the skill to each child before they performed the skill.

- ❖ There may have been a risk of bias when scoring the skills in study 2 (**Chapter 4**), as scoring was completed by the principal investigator who was not blinded to participant allocation. Blinding was not possible in the current research, but efforts were made to reduce the bias by completing inter- and intra-rater reliability testing and by strictly adhering to the scoring guidelines outlined in the common errors video on TGMD-3 website.

- ❖ The interpretability of the findings from study 2 (**Chapter 4**) are limited by the absence of a true control group. However, the opportunity for all children to receive the intervention was essential for the recruitment process and to attain ethical approval for the study.

- ❖ In study 2 (**Chapter 4**) the lack of information about what was taught in typical PE lessons and how PE was taught can also be seen as a limitation. The inclusion of this type of information would have allowed a more accurate comparison of the differences between typical PE lessons and the strategies used in the intervention programme.

- ❖ The intervention in study 2 (**Chapter 4**) was delivered in ideal circumstances by an instructor with specialist FMS knowledge and an understanding of mastery-motivational theory. Thus, another limitation is the feasibility and fidelity of the intervention to be delivered in the primary school setting by generalist primary school teachers. Furthermore, the intervention was not delivered in line with any particular strand area of the PE curriculum. Consideration must therefore be given to how the programme could be integrated into the six strand areas outlined in the PE curriculum. The fidelity of future intervention programmes could be examined by observing teachers deliver the lessons, asking teachers to complete a checklist after each lesson to outline the extent to which they felt critical components of the programme were implemented and/or by conducting semi-structured interviews with teachers, both during and after the intervention (Haynes et al., 2016).

- In study 3 (**Chapter 5**), there was likely a risk of bias whereby the questionnaire may have been completed mostly by teachers who have positive attitudes towards and a vested interest in teaching PE, rather than by teachers with more negative attitudes and less interest in PE. Therefore, the responses may not accurately represent the views of the overall population of primary teachers in Ireland. The initial sampling design aimed to reduce this bias by using a stratified random sample. However, after four weeks of recruitment, budget and time constraints influenced the decision to invite all mainstream primary teachers in Ireland to complete the survey. Post-stratification was conducted to ensure a representative sample of teachers from the eight regions in Ireland and from schools across four levels of disadvantaged status completed the survey.

- Finally, the results of the questionnaire in study 3 (**Chapter 5**) cannot be generalised to teachers who primarily work with children with special needs or moderate to severe learning difficulties as only mainstream teachers were included in the study.

6.6 Recommendations for future work

The results of this research have addressed important research questions regarding 1) FMS proficiency levels of Irish primary school children, 2) the efficacy of a short-duration FMS intervention programme on FMS proficiency levels and 3) generalist teachers' perceptions, attitudes and perceived confidence to teach PE in the Irish primary school setting. In addition, a number of recommendations for future work have been identified from this research and are outlined below:

- As mentioned previously, FMS were assessed using a process-oriented assessment tool which focus on the quality of movement rather than the movement outcome. Sometimes improvements in skill performance are difficult to detect due to how the scores are assigned and the potential for a ceiling effect to occur. Future research should consider incorporating a combination of process- and product-oriented assessments which would provide a more comprehensive overview of FMS proficiency levels (Hulteen et al. 2020). Furthermore, balance skills should also be included when assessing children's FMS proficiency levels.

- Findings from study 1 (**Chapter 3**) suggest that a plateau in object-control skill development occurs in 3rd class (Year 5), whilst locomotor skill proficiency does not improve significantly throughout the primary school years. However, this interpretation is speculative due to the cross-sectional nature of the study and factors which influence this potential stagnation are unclear. Future investigations should consider a longitudinal analysis of primary school children's FMS development and include information on potential correlates that may impact this development, for example, socio-economic status, ethnicity, sports participation, PA levels, sedentary behaviour, perceived motor competence, PE participation etc. The data generated could then be used to inform the development of targeted interventions to support the most at-risk groups and consequently maximise their efficacy and cost-effectiveness.

- In study 2 (**Chapter 4**), the intervention was delivered in ideal circumstances by a specialist with comprehensive knowledge of FMS and an understanding of mastery-motivational theory. Future studies should investigate if this type of intervention can be adapted to fit in with the overall school PE curriculum and if mainstream teachers can be upskilled to deliver the intervention either alone or with the assistance of a PE specialist.

- Primary schools are under pressure in many areas and the time devoted to teaching PE may often be reduced to facilitate learning in other subjects. However, it must be acknowledged that integrated learning is a possibility in PE and could provide unique learning opportunities for children who struggle to concentrate and sit still in the classroom environment. For example, maths, languages and geography are potential areas that could be integrated into PE lessons. However, it is unclear if integrated teaching provides adequate learning outcomes for both PE and the integrated subject, or if overall learning suffers as a result of trying to focus on too many things at once. The effectiveness of integrated learning in PE on FMS development and knowledge acquisition of the integrated subject should be investigated in future studies.

❖ A recommendation from this research is that teachers are supported to improve their content and pedagogical knowledge for teaching PE. Further investigations are required to determine the most effective ways to do this through pre-service and in-service training, and perhaps the additional support of PE specialists to assist teachers on a needs-specific basis. The feasibility and efficacy of different approaches need to be investigated to determine if they can: 1) help to upskill teachers, 2) facilitate improvements in children's FMS development and 3) improve PE experiences for children.

Bibliography

Adams, J., 1987. Historical review and appraisal of research on the learning, retention and transfer of human motor skills, *Psychological Bulletin*, 10(1), 41-74.

Adams, J.A. 1971. A closed-loop theory of motor learning. *Journal of Motor Behaviour,* 3(2), 111-149.

Adams, J.A. 1986. Use of the model's knowledge of results to increase the observer's performance. *Journal of Human Movement Studies*, 12, 89-98.

Ames, C. 1992. Classroom: Goals, structures and student motivation. *Journal of Educational Psychology,* 84(3), 261-271.

Anastasi, A., and Urbina, S. 1997. *Psychological testing* (7th ed.). Prentice Hall/Pearson Education.

Anderson, J.R. 1982. Acquisition of cognitive skill. *Psychological Review*, 89(4), 369-406.

Arnold, P. 1988. *Education, movement and the curriculum.* London: Falmer Press.

Babic, M.J., Morgan, P.J., Plotnikoff, R.C., Lonsdale, C., White, R.L. and Lubans, D.R. 2014. Physical activity and physical self-concept in youth: Systematic review and meta-analysis. *Sports Medicine,* 44(11), 1589-1601.

Baddeley, A.D. and Longman, D.J.A. 1978. The influence of length and frequency of training session on the rate of learning to type. *Ergonomics,* 21(8), 627-635.

Bailey, R. 2006. Physical education and sport in schools: A review of benefits and outcomes. *Journal of School Health*, 76(8), 397-401.

Bailey, R., Armour, K. M., Kirk, D., Jess, M., Pickup, I., Sandford, R. and BERA Physical Education and Sport Pedagogy Special Interest Group. 2009. The educational benefits claimed for physical education and school sport: an academic review. *Research Papers in Education,* 24(1), 1-27.

Bandeira, P.F.R., De Souza, M.S., Zanella, L.W. and Valentini, N.C. 2017. Impact of motor interventions oriented by mastery motivational climate in fundamental motor skills of children: A systematic review. *Motricidade,* 13(S1), 50-61.

Bandura, A. 1977. Self-efficacy: toward a unifying theory of behavioural change. *Psychological Review*, 84(2), 191–215.

Bandura, A. 1986. *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bardid, F. Vannozzi, G., Logan, S.W., Hardy, L.L. and Barnett, L.M. 2019. A hitchhiker's guide to assessing young people's motor competence: Deciding what method to use. *Journal of Science and Medicine in Sport,* 22(3), 311-318.

Bardid, F., Huyben, F., Lenoir, M., Seghers, J., De Martelaer, K., Goodway, J and Deconinck. 2016. Assessing fundamental motor skills in Belgian children aged 3-8 years highlights difference to US reference sample. *Acta Paediatrica*, 105(6), 281-290.

Bardid, F., Lenoir, M., Huyben, F., De Martelaer, K., Seghers, J., Goodway, J. and Deconinck, F. 2017. The effectiveness of a community-based fundamental motor skill intervention in children aged 3-8 years: Results of the "Multimove for Kids" project. *Journal of Science and Medicine in Sport*, 20(2), 184-189.

Barnett, L., Cliff, K., Morgan, P. and Van Beurden, E. 2013. Adolescents' perception of the relationship between movement skills, physical activity and sport. *European Physical Education Review*, 19(2), 271–285.

Barnett, L., Ridgers, N and Salmon J. 2015. Associations between young children's perceived and actual ball skill competence and physical activity. *Journal of Science and Medicine in Sport,* 18(2), 167-171.

Barnett, L., Stodden, D., Cohen, K., Smith, J., Lubans, R., Lenoir, M., Iivonen, S., Miller, A., Laukkanen, A., Dudley, D., Lander, N., Brown, H and Morgan, P. 2016. Fundamental movement skills: An important focus. *Journal of Teaching in Physical Education,* 35(3), 219-225.

Barnett, L., van Beurden, E., Morgan, P.J., Lincoln, D., Zask, A. and Beard, J. 2009. Interrater objectivity for field-based fundamental motor skill assessment. *Research Quarterly for Exercise and Sport*, 80(2), 363-368.

Barnett, L.M, van Beurden, E., Morgan, P.J, Brooks, L.O, Zask, A. and Beard, J.R. 2009. Six year follow-up of students who participated in a school-based physical activity intervention: a longitudinal cohort study. *International Journal of Behaviour Nutrition and Physical Activity,* 6(48), article no: 48 (2009) [no pagination], doi:10.1186/1479-5868-6-48.

Barnett, L.M., Minto, C., Lander, N. and Hardy, L.L. 2014. Interrater reliability assessment using the test of gross motor development-2. *Journal of Science and Medicine in Sport,* 17(6), 667-670.

Barnett, L.M., Morgan, P.J., van Beurden, E., Ball, K., and Lubans, D.R. 2011. A reverse pathway? Actual and perceived skill proficiency and physical activity. *Medicine and Science in Sports and Exercise*, 43(5), 898-904.

Barnett, L.M., Van Beurden, E., Morgan, P., Brooks, L. and Beard, J.R. 2008. Does childhood motor skill proficiency predict adolescent fitness? *Medicine and Science in Sports and Exercise*, 40(12), 2137-2144.

Baron, L.J. and Downey, P.J. 2007. Perceived success and enjoyment in elementary physical education. *Journal of Applied Research on Learning*, 1(2), 1-24.

Barroso, C.S., McCullum-Gomez, C., Hoelscher, D.M., Kelder, S.H. and Murray, N.G. 2005. Self-reported barriers to quality physical education by physical education specialists in Texas. *Journal of School Health*, 75(8), 313-319.

Bel-Serrat, S, Heinen, M.M., Murrin, C.M., Daly, L., Mehegan, J., Concannon, M., Flood, C., Farrell, D., O'Brien, S., Eldin, N. and Kelleher, C.C. 2017. The Childhood Obesity Surveillance Initiative (COSI) in the Republic of Ireland: Findings from 2008, 2010, 2012 and 2015. Dublin: Health Service Executive.

Benhamou, M., Baron, G., Dalichampt, M., Boutron, I., Alami, S., Rannou, F., Ravaud, P. and Poiraudeau, S. 2013 Development and Validation of a Questionnaire Assessing Fears and Beliefs of Patients with Knee Osteoarthritis: The Knee Osteoarthritis Fears and Beliefs Questionnaire (KOFBeQ). *PLoS One,* 8(1): article no: e53886. [no pagination], doi:10.1371/journal.pone.0053886.

Beni, S., Fletcher, T. and Ní Chróinín, D. 2017. Meaningful Experiences in Physical Education and Youth Sport: A Review of the Literature, *Quest,* 69(3), 291-312.

Berg, M. 2013. Sampling Methods for the NZCER Primary National Survey. NZARE Conference. 26-28 November 2013: Dunedin, New Zealand.

Bernstein, B. 1996. *Pedagogy, Symbolic Control, and Identity*. London: Taylor and Francis.

Bernstein, N. 1967. *The coordination and regulation of movement*. New York: Pergamon Press.

British Heart Foundation National Centre. 2012. *Sedentary behaviour: Evidence briefing.* British Heart Foundation National Centre: Physical Activity and Health, Loughborough University.

British Heart Foundation. 2017. *Physical Inactivity and Sedentary Behaviour Report 2017*. Available at: file:///C:/Users/Lisa/Downloads/physical-inactivity-report---mymarathon-final.pdf.

Biddle, S, J. and Mutrie, N. 2008. *Psychology of physical activity: Determinants, well-being and interventions (2nd Ed)*, London: Routledge.

Blakemore, J.E.O. and Centers, R.E. 2005. Characteristics of Boys' and Girls' Toys. *Sex Roles*, 53(9-10), 619-633.

Blandin, Y., Lhuisset, L. and Proteau, L. 1999. Cognitive processes underlying observational learning of motor skills. *The Quarterly Journal of Experimental Psychology*, 52A(4), 957-979.

Boiche, J.C.S. and Sarrazin, P.G. 2009. Proximal and distal factors associated with dropout versus maintained participation in organised sport. *Journal of Sports Science and Medicine,* 8(1), 9-16.

Bolger L, Bolger L, O'Neill C, Coughlan E, O'Brien W, Lacey S and Burns C. 2018. Age and sex differences in fundamental movement skills among a cohort of Irish school children. *Journal of Motor Learning and Development*, 6(1), 81-100.

Bolger, L.E., Bolger, L.A., O' Neill, C., Coughlan, E., O'Brien, W., Lucey, S. and Burns, C. 2019. The effectiveness of two interventions on fundamental movement skill proficiency among a cohort of Irish primary school children. *Journal of Motor Learning and Development*, 7(2), 153-179.

Booth, F.W., Roberts, C.K. and Laye, M.J. 2012. Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology*, 2(2), 1143-1211.

Booth, M.L., Denney-Wilson, E., Okely, A.D. and Hardy, L. 2005. Methods of the NSW Schools Physical Activity and Nutrition Survey (SPANS). *Journal of Science and Medicine in Sport*, 8(3), 284-293.

Booth, M.L., Okely, T., McLellan, L., Phongsavan, P., Macaskill, P., Patterson, J., Wright, J. and Holland, B. 1999. Mastery of fundamental motor skills among New South Wales School Students: Prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, 2(2), 93-105.

Bowles, R. and O'Sullivan, M. 2020. Opportunity knocks: the intersection between schools, their teachers and external providers of physical education and school sport, *Discourse: Studies in the Cultural Politics of Education*, 41(2), 251-267.

Braithwaite, R., Spray, C.M. and Warburton, V.E. 2011. Motivational climate interventions in physical education: A meta-analysis. *Psychology of Sport and Exercise*, 12(6), 628–638.

Branch, K., Hooper, D.A., Thompson, J. and Creighton. J. 1984. *Guide to social assessment*. Boulder: Westview Press.

Branta, C., Haubenstricker, J. and Seefeldt, V. 1984. Age changes in motor skills during childhood and adolescence. *Exercise and Sport Sciences Reviews*, 12, 467-520.

Bremer, E. and Cairney, J. 2018. Fundamental movement skills and health-related outcomes: A narrative review of longitudinal and intervention studies targeting typically developing children. *American Journal of Lifestyle Medicine*, 12(2), 148-159.

Breslin, G., Hanna, D., Lowry, R., McKee, D., McMullan, K., Haughey, T.J. and Moore, N. 2012. An exploratory study of specialist and generalist teachers: predicting self-efficacy in delivering primary physical education. Predicting self-efficacy in physical education. *Working Papers in Health Science,* 1(1), 1-9.

Breslin, G., Murphy, M., McKee, D., Delaney, B. and Dempster, M. 2012. The effect of teachers trained in a fundamental movement skills programme on children's self-perceptions and motor competence. *European Physical Education Review*, 18(1), 114-126.

Brian, A., Goodway, J.D., Logan, J.A. and Sutherland, S. 2017. SKIPing with teachers: an early year's motor skill intervention. *Physical Education and Sport Pedagogy*, 22(3), 270-282.

British Heart Foundation National Centre (BHFNC). 2013. *Making the case for physical activity. Evidence briefing.* British Heart Foundation National Centre for Physical Activity and Health: Loughborough University.

Broderick, D., and G. Shiel. 2000. *Diet and activity patterns of children in primary schools in Ireland.* Dublin: St. Patrick's College Dublin.

Bruininks, R. 1978. Bruininks-Oseretsky *Test of Motor Proficiency: Examiner's Manual.* Circle Pines, MN: American Guidance Service.

Bruininks, R. and Bruininks-Oteretsky, B. 2005. *Bruininks-Oseretsky Test of Motor Proficiency (2nd ed).* Minneapolis, MN: NCS Pearson.

Bryan, C.L. and Solmon, M.A. 2012. Student motivation in physical education and engagement in physical activity. *Journal of Sport Behaviour,* 35(3), 267-285.

Bryant, E., Duncan, M. and Birch, S. 2014. Fundamental movement skills and weight status in British primary school children. *European Journal of Sports Science*. 14(7), 730-736.

Bryant, E.S., Duncan, M.J., Birch, S.L. and James, R.S. 2016. Can fundamental movement skill mastery be increased via a six-week physical activity intervention to have positive effects on physical activity and physical self-perception? *Sports,* 4(1), article no: 10 [no pagination] doi:10.3390/sports4010010.

Burgess, R. and Goulding, M. 2009. I'm a primary non-specialist PE teacher, get me out of here. Conference Paper. Presented at: *British Educational Research Association Annual Conference*, University of Manchester, 2-5 September 2009.

Bürgi, F., Meyer, U., Granacher, U., Schindler, C., Marques-Vidal, P., Kriemler, S. and Puder, J.J. 2011. Relationship of physical activity with motor skills, aerobic fitness and body fat in preschool children: a cross-sectional and longitudinal study (Ballabeina). *International Journal of Obesity*, 35(7), 937-944.

Butterfield, S.A., Angell, R.M. and Mason, C.A. 2012. Age and sex differences in object-control skills by children ages 5 to 14. *Perceptual and Motor Skills*, 114(1), 261-274.

Cairney, J., Kwan, M. Y., Velduizen, S., Hay, J., Bray, S. R., and Faught, B. E. 2012. Gender, perceived competence and the enjoyment of physical education in children: a longitudinal examination. *The International Journal of Behavioral Nutrition and Physical Activity*, 9(26), doi:10.1186/1479-5868-9-26.

Callcott, D., Miller, J. and Wilson-Gahan, S. 2012. *Health and Physical Education: Preparing Educators for the Future.* Melbourne: Cambridge University Press.

Capelle, A.V., Broderick, C.R., van Doorn, N., Ward, R.E. and Parmenter, B.J. 2017. Interventions to improve fundamental motor skills in pre-school aged children: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport,* 20(7), 658-666.

Capio, C.M., Poolton, J.M., Sit, C.H.P., Holmstrom, M. and Masters, R.S.W. 2011. Reducing errors benefits the field-based learning of a fundamental movement skill in children. *Scandinavian Journal of Medicine and Science in Sport*, 23(2), 181-188.

Carlson, T.B. 1995. We hate gym: Student alienation from physical education. *Journal of Teaching in Physical Education*, 14(4), 467-477.

Catuzzo, M., dos Santos Henrique, R., Nicolai Ré, A., De Oliveira, I., Melo, B., de Sousa Moura, M., de Araújo, R. and Stodden, D. 2016. Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport*, 19(2), 123-129.

Chan, C., Ha, A. and Ng, J.Y.Y. 2016. Improving fundamental movement skills in Hong Kong students through an assessment for learning intervention that emphasizes fun, mastery, and support: the A + FMS randomized controlled trial study protocol. *Springerplus, 5(1),* article no: 724 [no pagination], doi:10.1186/s40064-016-2517-6.

Chatzisarantis, N.L.D., Hagger, M.S. and Brickell, T. 2008. Using the construct of perceived autonomy support to understand social influence within the theory of planned behavior. *Psychology of Sport and Exercise*, 9(1), 27-44.

Chen, W., Hammond-Bennett, A. and Hypnar, A. 2017. Examination of motor skill competency in students: evidence-based physical education curriculum. *BMC Public Health*, 17, article no: 222 (2017) [no pagination], doi:10.1186/s12889-017-4105-2.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., and Araújo, D. 2007. The role of nonlinear pedagogy in physical education. *Review of Educational Research,* 77(3), 251-278.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., and Araújo, D. 2006. Nonlinear pedagogy: a constraints-led framework to understand emergence of game play and skills. Nonlinear Dynamics. *Psychology and Life Sciences*, 10(1), 74-104.

Chow, J.J., Davids, K., Hristovski, R., Araújo, D. and Passos, P. 2011. Nonlinear pedagogy: Learning design for self-organising neurobiological systems. *New Ideas in Psychology*, 29(2), 189-200.

Chow, J.Y. 2013. Nonlinear learning underpinning pedagogy: evidence, challenges, and implications. *Quest*, 65(4), 469-484.

Clark, C.C.T. 2019. Profiling movement and gait quality using accelerometery in children's physical activity: Consider quality, not just quantity. *British Journal of Sports Medicine,* 53(8) 493-494.

Clark, J. E. 2005. From the Beginning: A Developmental Perspective on Movement and Mobility. *Quest,* 57(1), 37-45.

Clark, J. E. and Metcalfe, J. M. 2002. The mountain of motor development: A metaphor. In: Clark, J.E. and Humphrey, J.H. eds. *Motor development: Research and reviews (volume 2*). Reston, VA: National Association for Sport and Physical Education, 163-190.

Clark, J.E. 2007. On the Problem of Motor Skill Development. *Journal of Physical Education, Recreation and Dance*. 78(5), 39-44.

Clark, J.E., and Whitall, J. 1989. What is motor development? The lessons of history. *Quest,* 41, 183-202.

Cliff, D. P., Okely, A. D., Morgan, P. J., Jones, R. A., Steele, J. R. and Baur, L. A. 2012. Proficiency deficiency: Mastery of fundamental movement skills and skill components in overweight and obese children. *Pediatric Obesity*, 20(5), 1024-1033.

Cliff, D.P., Okely, A.D. Smith, L. and Mckeen, K. 2009. Relationship between fundamental movement skills and objectively measured physical activity in pre-school children. *Pediatric Exercise Science,* 21(4), 436-449.

Cliff, D.P., Okely, A.D., Morgan, P.J., Steele, J.R., Jones, R.A., Colyvas, K. and Baur, L.A. 2011. Movement skills and physical activity in obese children: Randomised controlled trial. *Medicine in Sport and Exercise Science,* 43(1), 90-100.

Coelho, J. 2010. Gymnastics and Movement Instruction. *Journal of Physical Education, Recreation and Dance,* 81(1), 14-18.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioural Sciences*. (2nd Ed.) Hillsdale, NJ: Lawrence Erlbaum.

Cohen, K.E., Morgan, P.J., Plotnikoff, R.C., Callister, R. and Lubans, D.R. 2015. Physical activity and skills intervention: SCORES cluster randomised controlled trial. *Medicine and Science in Sports and Exercise*. 47(4), 765-774.

Cole, T.J. and Lobstein 2012. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Paediatric Obesity*, 7(4), 284-294.

Cole, T.J., Bellizzi, M.C., Flegal, K.M. and Dietz, W.H. 2000. Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal*, 320(7244), 1240-1243.

Coles, E.S. 1995. A comparative study of the experiences of specialist and nonspecialist teachers of physical education in elementary schools. Unpublished master's thesis, Memorial University, St. John's, NL.

Cools, W., De Martelaer, K., Samaey, C. and Andries, C. 2009. Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of Sports Science and Medicine*, 8(2), 154-168.

Coppens, E., Bardid, F., Deconinck, F.J.A., Haerens, L., Stodden, D., D'Hondt, E.D. and Lenoir, M. 2019. Developmental change in motor competence: A latent growth curve analysis. *Frontiers in Physiology*, 10(1273), [no pagination], doi:10.3389/fphys.2019.01273.

Coulter, M. 2012. *Teaching outdoor and adventure activities: Describing analysing and understanding a primary school physical education professional development programme.* PhD Thesis. School of Health and Human Performance, Dublin City University. Available at: http://doras.dcu.ie/17522/1/Maura_Coulter_PhD_Sept_2012.pdf.

Coulter, M. and Woods, C.B. 2012. Primary teachers' experience of a physical education professional development programme. *Irish Educational Studies*, 31(3), 329-343.

Coulter, M., and Woods, C.B. 2011. An exploration of children's perceptions and enjoyment of school-based physical activity and physical education. *Journal of Physical Activity and Health*, 8(5), 645-654.

Craig, L.C., Love, J., Ratcliffe, B. and McNeill G. 2008. Overweight and cardiovascular risk factors in 4- to 18-year-olds. *Obesity Facts,* 1(5), 237–242.

Crane, J. and Temple, V. 2015. A systematic review of dropout from organised sport among children and youth. *European Physical Education Review*, 21(1), 114-131.

Crane, J. Foley, J., Naylor, P-J. and Temple, V.A. 2017. Longitudinal change in the relationship between fundamental motor skills and perceived competence: Kindergarten to grade 2. *Sports*, 5(3), article no: 59, [no pagination], doi:10.3390/sports5030059.

Crane, J.R., Naylor, P.J., Cook, R. and Temple, V.A. 2015. Do perceptions of competence mediate the relationship between fundamental motor skill proficiency and physical activity levels of children in kindergarten? *Journal of Physical Activity and Health,* 12(7), 954-961.

Craven, R.G. and Marsh, H.W. 2008. The centrality of the self-concept construct for psychological wellbeing and unlocking human potential: implications for child and educational psychologists. *Education and Child Psychology*, 25(2), 104-118.

Crawford, D., Cleland, V., Timperio, A., Salmon, J., Andrianopoulos, N. Roberts, R., Giles-Corti, B., Baur, L. and Ball, K. 2010. The longitudinal influence of home and neighbourhood environments on children's body mass index and physical activity over 5 years: the CLAN study. *International Journal of Obesity,* 34(7), 1177-1187.

Crawford, S., McKee, D., Wallace, S. and Marron, S. 2016. Examining fundamental movement skills training in initial teacher education in the Republic of Ireland and Northern Ireland. The Standing Conference on Teacher Education, North and South.

May 18 2016 [online] Available at: http://scotens.org/site/wp-content/uploads/LMML-Final-Narrative-Report.pdf.

D'Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuij, I., Vaeyens, R., Philippaerts, R., and Lenoir, M. 2013. A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity,* 37(1), 61-67.

Dagkas, S. and Stathi, A. 2007. Exploring social and environmental factors affecting adolescents' participation in physical activity. *European Physical Education Review*, 13(3), 369–384.

Davids, K., Button, K., and Bennett, C. 2008. *Dynamics of skill acquisition: A constraints-led approach*. Champaign, IL: Human Kinetics.

Davis, K.S., Burgeson, N.D., McManus, B.T. and Wechsler, H. 2005. The relationship between qualified personnel and self-reported implementation of recommended physical education practices and programs in U.S. schools. *Research Quarterly for Exercise and Sport,* 76(2), 202-211.

De Meester, A.D., Stodden, D., Goodway, J., True, L., Brian, A., Ferkel, R. and Haerens, L. 2018. Identifying a motor proficiency barrier for meeting physical activity guidelines in children. *Journal of Science and Medicine in Sport*, 21(1), 58-62.

Decorby, K., Halas, J., Dixon, S., Wintrup, L. and Janzen, H. 2005. Classroom teachers and the challenges of delivering quality physical education. *The Journal of Educational Research,* 98(4), 208-220.

Deci, E.L. and Ryan, R.M. 2008. Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology*, 49(1), 14-23.

Deci, E.L., and Ryan, R.M. 2000. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.

Deci, E.L. and Ryan, R.M. 1985. *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

Deenihan, J. 2005. Physical education provision in primary schools (Unpublished survey). Dublin: Fine Gael.

Deitz, J.C. Kartin, D. and Kopp, K. 2007. Review of the Bruininks-Oteretsky test of gross motor proficiency (2nd ed., BOT-2), *Physical and Occupational Therapy in Paediatrics*, 27(4), 87-102.

Department of Education and Skills 2016. *Action Plan for Education 2016-2019*. Department of Education and Skills Strategy Statement.

Department of Education Victoria. 1996. *Fundamental motor skills: A manual for classroom teachers.* Melbourne, Australia: Department of Education.

Department of Health. 2018. Healthy Ireland. *National Physical Activity Plan Implementation Summary 2018*. Department of Transport, Tourism and Sport: Dublin.

Di Tore, P.A., Schiavo, R. and D'Isanto, T. 2016. Physical education, motor control and motor learning: theoretical paradigms and teaching practices from kindergarten to high school. *Journal of Physical Education and Sport,* 16(4), 1293-1297.

Diamond, A. 2000. Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development,* 71(1), 44-56.

Dijk, H., Jannink, M.J.A. and Hermens, J. 2005. Effects of augmented feedback on motor function of the affected upper extremity in rehabilitation patients: A systematic review of randomized controlled trials. *Journal of Rehabilitative Medicine*, 37(4), 202-211.

Donovan, J.J. and Radosevich, D.J. 1999. A meta-analytic review of the distribution of practice effect: Now you see it, now you don't. *Journal of Applied Psychology*, 84(5), 795-805.

Draper, C.E., Achmat, M., Forbes, J. and Lambert, E.V. 2012. Impact of a community-based programme for motor development on gross motor skills and cognitive function in preschool children from disadvantaged settings. *Early Child Development and Care*, 182(1), 137-152.

Elliot, D.L., Atencio, M., Campbell, T. and Jess, M. 2013. From PE experiences to PE teaching practices? Insights from Scottish primary teachers' experiences of PE, teacher education, school entry and professional development. *Sport, Education and Society,* 18(6), 749-766.

Epstein, J. 1988. Effective schools or effective students? Dealing with diversity. In: Hawkins, R. and MacRae, B. eds. *Policies for America's public schools*, Norwood, NJ: Ablex, 89-126.

Ericsson, K.A., Krampe, R. and Tesch-Römer, C. 1993. The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 363-406.

ESRI, 2010. *Sample design and response in wave 1 of the nine-year cohort of growing up in Ireland.* The Economic and Social Research Institute, May 2010.

Fajan, B.R., Riley, M.A. and Turvey, M.T. 2009. Information, affordances and the control of action in sport. *International Journal of Sport Psychology*, 40(1), 79–107.

Farmer, O., Belton, S. and O'Brien, W. 2017. The relationship between actual fundamental motor skill proficiency, perceived motor skill confidence and competence, and physical activity in 8–12-year-old Irish female youth. *Sports,* 5(4), article no: 74 [no pagination], doi:10.3390/sports5040074.

Fisher-Thompson, D. 1993. Adult toy purchases for children: Factors affecting sex-typed toy selection. *Journal of Applied Developmental Psychology*, 14(3), 385-406.

Fisher-Thompson, D., Sausa, A.D. and Wright, T.F. 1995. Toy selection for children: Personality and toy request influences. *Sex Roles,* 33(3-4), 239–255.

Fitts, P. and Posner, M. 1967. *Human Performance*. Belmont, CA: Brooks/Cole.

Flanagan, D. 2014. Fun games and health: evaluating physical education related CPD provision in primary schools: the case of the Buntus programme. PhD thesis. National University of Ireland Galway.

Fletcher, T. and Mandigo, J. 2012. The primary schoolteacher and physical education: a review of research and implications for Irish physical education. *Irish Educational Studies*. 31(3), 363-376.

Flintoff, A. and Scraton, S. 2006. Girls and physical education. In: Kirk, D., Macdonald, D and O'Sullivan, M. eds. *The handbook of physical education,* London: SAGE, 767-783.

Folio, M.R. and Fewell, R.R. 2000. *Peabody Developmental Motor Scales -2*. Austin, TX: PRO-ED.

Foulkes, J.D., Knowles, Z., Fairclough, S.J., Stratton, G., O'Dwyer, M., Ridgers, N.D. and Foweather, L. 2015. Fundamental movement skills of preschool children in Northwest England. *Perceptual and Motor Skills: Physical Development and Measurement*. 12(1), 260-283.

Foulkes, J.D., Knowles, Z., Fairclough, S.J., Stratton, G., O'Dwyer, M., Ridgers, N.D. and Foweather, L. 2017. Effect of a 6-week active play intervention on fundamental movement skill competence of preschool children: A cluster randomized controlled trial. *Perceptual and Motor Skills,* 124(2), 393-412.

Foweather, L., McWhannel, N., Henaghan, J., Lees, A. and Stratton, G. 2008. Effect of a 9-week after-school multiskills club on fundamental movement skill proficiency in 8- to 9-yr-old children: An exploratory trial. *Perceptual and Motor Skills*, 106(3), 745-754.

Freedman, D.S., Khan, L.K., Dietz, W.H., Srinivasan, S.R. and Berenson, G.S. 2001. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: The Bogalusa Heart Study. *Pediatrics,* 108(3), 712-718.

Frick, A. and Möhring, W. 2016. A matter of balance: Motor control is related to children's spatial and proportional reasoning skills. *Frontiers in Psychology*, 6, article no: 2049 [no pagination], doi:10.3389/FPSYG.2015.02049.

Fullan, M. 2006. *Change theory: A force for school improvement*. Centre for Strategic Education, Seminar Series Paper No. 157.

Gallahue, D.I., Ozmun, J.C. and Goodway, J.D. 2012. *Understanding motor development: Infants, children, adolescents and adults* (7th ed). Boston: McGraw-Hill.

Gallahue, D.L. and Ozmun, J.C. 2006. *Understanding Motor Development: Infants, children, adolescents, adults* (6th ed). New York: McGraw-Hill.

Garcia, C. 1994. Gender differences in young children's interactions when learning fundamental motor skills. *Research Quarterly in Exercise and Sport,* 65(3), 213-225.

García-González, L., Sevil-Serrano, J., Abós, A., Aelterman, N. and Haerens, L. 2019. The role of task and ego-oriented climate in explaining students' bright and dark motivational experiences in physical education. *Physical Education and Sport Pedagogy,* 24(4), 344-358.

Getchell, N. and Roberton, M.A. 1989. Whole body stiffness as a function of developmental level in children's hopping. Developmental Psychology, 25(6), 920-928.

Gibbons, S. 2008. Female student perceptions of grade 5 physical education. *Physical and Health Education Journal,* 74(3), 14-20.

Gibson. J.J. 1979. *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.

Gill, T.P. 1997. Key issues in the prevention of obesity. *British Medical Bulletin*, 53(1), 359-388.

Goodway, J., Brian, A. and Chang, S.H. 2014. Methodological approaches to evaluate motor-skill development, physical activity, health-related fitness, and perceived motor competence in young children. In: Saracho, O. ed. *Handbook of Research Methods in Early Childhood Education (volume 2),* Charlotte, NC: Information Age Publishing, 349-391.

Goodway, J., Robinson, L. and Crowe, H. 2010. Gender differences in fundamental motor skill development in disadvantaged preschoolers from two geographical regions. *Research Quarterly for Exercise and Sport.* 81(1), 17-24.

Goodway, J.D. and Branta, C.F. 2003. Influence of motor skill intervention on fundamental motor skill development of disadvantaged preschool children. *Research Quarterly for Exercise and Sport,* 74(1), 36-47.

Goodway, J.D. and Rudisill, M.E. 1997. Perceived physical competence and actual motor skill competence of African American preschool children. *Adapted Physical Activity Quarterly*, 14(4), 314-326.

Goodwin, L.D. 2001. Interrater agreement and reliability. *Measurement in Physical Education and Exercise Science,* 5(1), 13-34.

Gordon, B. and Inder, T. 2000. The competency levels of third year pre-service primary teachers in performing and learning fundamental motor skills. *New Zealand Physical Educator,* 33(3), 53-66.

Goudas, M. and Biddle, 1994. Perceived motivational climate and intrinsic motivation in school physical education classes. *European Journal of Psychology of Education,* 9(3), 241-250.

Green, B., Jones, M., Hughes, D, and Willimas, A. 1999. Applying the Delphi technique in a study of GP's information requirements. *Health and Social Care in the Community*, 7(3), 198-205.

Greendorfer, S.L. 1983. Shaping the female athlete: The impact of the family. In: Boutilier, M.A. and Sangiovanni, L. eds. *The sporting woman.* Champaign, IL: Human Kinetics, 135-155.

Griggs, G. 2007. Physical Education: Primary matters, secondary importance. *Education*, 35(1), 59-69.

Growing Up in Ireland Study Team. 2018. Key findings: Cohort '08 at 9 years old, Health and physical development (No. 3). Dublin: ESRI/TCD/DCYA.

Growing Up in Ireland Study Team. 2019. Key findings: Cohort '98 at 20 years old in 2018/19, Physical health and development (No.2). Dublin: ESRI/TCD/DCYA.

Guadagnoli, M.A. and Lee, T.D. 2004. Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning, *Journal of Motor Behaviour*, 36(2), 212-224.

Haapala, E.A. 2013. Cardiorespiratory fitness and motor skills in relation to cognition and academic performance in children - A review. *Journal of Human Kinetics*, 36(1), 55-68.

Haga, M. 2008. The relationship between physical fitness and motor competence in children. *Child: Care, Health and Development*, 34(3), 329-334.

Haga, M. 2009. Physical fitness in children with high motor competence is different from that in children with low motor competence. *Physical Therapy,* 89(10), 1089-1097.

Handford, C., Davids, K., Bennet, S. and Button, C. 1997. Skill acquisition in sport: some applications of an evolving practice ecology. *Journal of Sports Sciences,* 15(6), 621-640.

Handford, C., Davids, K., Bennett, S., and Button, C. 1997. Skill acquisition in sport: Some applications of an evolving practice ecology. *Journal of Sports Sciences*, 15(6), 621-640.

Handford, C.H. 2006. Serving up variability and stability. In: Davids, K., Button, C. and Newell, K. eds. *Movement system variability*. Champaign, IL: Human Kinetics, 73-83.

Hands, B. P. 2012. How fundamental are fundamental movement skills?. *Active and Healthy Magazine,* 19(1), 14-17.

Hands, B.P. 2002. How can we best measure fundamental movement skills? *23rd Biennial National/International Conference,* Health Sciences Conference Papers; University of Notre Dame Australia.

Hardman, K. 2007. *Current situation and prospects for physical education in the European Union.* Policy Department Structural and Cohesion Policies. Brussels: European Parliament. Available at: http://www.europarl.europa.eu [Accessed: August 10, 2017]

Hardman, K. 2008. Physical education in schools: A global perspective. *Kinesiology, 40*(1), 5-28.

Hardy, L.L., Barnett, L., Espinel, P. and Okely, A.D. 2013. Thirteen-year trends in child and adolescent fundamental movement skills: 1997-2010. *Official Journal of the American College of Sports Medicine,* 1965-1970.

Hardy, L.L., King, L., Farrell, L., Macniven, R. and Howlett, S. 2010. Fundamental movement skills among Australian preschool children. *Journal of Science and Medicine in Sport*, 13(5), 503–508.

Hardy, L.L., Reinton-Reynolds, T., Espinel, P., Zask, A. and Okely, A.D. 2012. Prevalence and correlates of low fundamental movement skill competency in children. *Pediatrics*, 130(2), e390-e398.

Hardy, LL., Mihrshahi, S., Drayton, B.A. and Bauman, A. 2016. *NSW Schools Physical Activity and Nutrition Survey (SPANS) 2015: Full Report.* Sydney: New South Wales Department of Health.

Hargreaves, J. 1994. *Sporting Females: Critical Issues in the History and Sociology of Women's Sports,* London, UK: Routledge.

Harris , J., Cale, L. and Musson, H. 2011. The effects of a professional development programme on primary school teachers' perceptions of physical education*, Professional Development in Education,* 37(2), 291-305.

Harris , J., Cale, L. and Musson, H. 2012. The predicament of primary physical education: a consequence of 'insufficient' ITT and 'ineffective' CPD*? Physical Education and Sport Pedagogy,* 17(4), 367-381.

Hart, M.A. 2005. Influence of a physical education methods course on elementary education majors' knowledge of fundamental movement skills. *Physical Educator,* 62(4), 198-204 .

Harter, S. 1978. Effectance motivation reconsidered: towards a developmental model. *Human Development,* 21(1), 34-64

Harter, S. 1985. *Manual for the Self-perception Profile for Children*. Denver, CO: University of Denver.

Harter, S. 1999. *The construction of the self: A developmental perspective*. New York: Guilford Press.

Harter, S. and Pike, R. 1984. The pictorial scale of perceived competence and social acceptance for young children. *Child Development*, 55(6), 1969-1982.

Hasson, F., Keeney, S. and McKenna, H. 2000. Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing,* 32(4), 1008-1015.

Hastie, P. A., Rudisill, M. E., and Wadsworth, D. D. 2013. Providing students with voice and choice: lessons from intervention research on autonomy-supportive climates in physical education. *Sport, Education and Society*, 18(1), 38-56.

Haynes, A., Brennan, S., Redman, S., Williamson, A., Gallego, G., Butow, P. and The CIPHER team. 2016. Figuring out fidelity: a worked example of the methods used to identify, critique and revise the essential elements of a contextualised intervention in health policy agencies. *Implementation Science*, 11(23). [Open access]. doi: 10.1186/s13012-016-0378-6.

Haywood K, Roberton M, Getchell N. 2012. *Advanced analysis of motor development*. Human Kinetics; Champaign, IL.

Haywood, K. and Getchell, N. 2009. *Life span motor development. 5th ed*. Champaign: Human Kinetics Publishers.

Healthy Active Living and Obesity Research Group. 2013. *Canadian assessment of physical literacy testing manual.* Ottawa, ON: Healthy Active Living and Obesity Research Group.

Hills, A.P., Andersen, L.B. and Byrne, N.M. 2011. Physical activity and obesity in children. *British Journal of Sports Medicine*, 45(11), 866-870.

Hjorth, M.F., Chaput, F-P., Ritz, C., Dalskov, S-M., Anderson, R. and Astrup, A., Tetens, I., Michaelsen, K.F. and Sjodin, A. 2013. Fatness predicts decreased physical activity and increased sedentary time, but not vice versa: support from a longitudinal study in 8- to 11-year-old children. *International Journal of Obesity,* 38(7), 959-965.

Hodges, N.J. and Franks, I.M. 2002. Modelling coaching practice: the role of instruction and demonstration. *Journal of Sports Sciences*, 20(10), 793-811.

Holfelder, B. and Schott, N. 2014. Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. *Psychology of Sport and Exercise*, 15(4), 382–391.

Hraste, M., De Giorgio, A., Jelaska, P.M., Padulo, J. and Granić, I. 2018. When mathematics meets physical activity in the school-aged child: The effect of an integrated motor and cognitive approach to learning geometry. *PLOS ONE,* 13(8): article no: e0196024, [no pagination], doi:10.1371/journal. pone.0196024.

Hulteen, R.M., Barnett, L.M., True, L., Lander, N.J., del Pozo Cruz, B. and Losdale, C. In press. Validity and reliability evidence for motor competence assessments in children and adolescents: A systematic review. *Journal of Sports Sciences,* Online [ahead of print], doi: 10.1080/02640414.2020.1756674.

Hulteen, R.M., True, L. and Pfeiffer, K.A. 2020. Differences in associations of product- and process-oriented motor competence assessments with physical activity in children, *Journal of Sports Sciences*, 38(4), 375-382.

Hume, C., Okely, A., Bagley, S., Telford, A., Booth, M., Crawford, D. and Salmon, J. 2008. Does weight status influence associations between children's fundamental movement skills and physical activity? *Research Quarterly for Exercise and Sport*, 79(2), 158-165.

Humphries, C. and Ashy, M. 2006. "The confidence I needed": Elementary education majors' perceptions of teaching physical education. *Teacher Development,* 10(2) 179-196.

IPPEA, 2010. Quality Physical Education in Ireland, Irish Primary PE Association. Online. Available at: http://www.irishprimarype.com/policy-documents/, [accessed 21 May 2018].

IPPEA. 2017. Position Statement on NCCA consultation in relation to redeveloped primary curriculum. Irish Primary Physical Education Association. IPPEA Executive Committee May 2017. Online. Available at: https://www.irishprimarype.com/wp-content/uploads/2014/12/Irish-Primary-PE-Association-Position-Statement-on-NCCA-consultation-in-relation-to-redeveloped-curriculum.pdf, [accessed 23 May 2018].

Irish National Teachers' Organisation (INTO). 2007. *Physical education in the primary school: Proceedings of consultative conference on education.* Irish National Teachers' Organisation, Dublin, Ireland.

Irish National Teachers Organisation. 2015. *Curriculum: A discussion paper.* Paper presented at: INTO Education Conference, Athlone, Ireland.

Jaakkola, T., Hillman, C., Kalaja, S. and Liukkonen, J. 2015. The associations among fundamental movement skills, self-reported physical activity, and academic performance during junior high school in Finland. *Journal of Sports Sciences*, 33(16), 1719-1729.

Jennings, P., O'Brien, S. and O'Shea, D. 2018. *Tackling Childhood Obesity: A written submission from the Health Service Executive to the Joint Committee on Children and Youth Affairs.* Health Service Executive, 16th May 2018.

Johnson, J.E., Christie, J.F., and Wardle, F. 2005. *Play, Development, and Early Education.* Boston: Pearson Education, Inc.

Johnson, J.L., Rudisill, M.E., Hastie, P., Wadsworth, D., Strunk, K., Sassi, J., Morris, M. and Merritt, M. 2019. Changes in Fundamental Motor-Skill Performance Following a Nine-Month Mastery Motivational Climate Intervention. *Research Quarterly in Exercise and Sport,* 90(4), 517-526.

Johnson, T.M., Ridgers, N.D., Hulteen, R.M., Mellecker, R.R. and Barnett, L.M. 2016. Does playing a sports active video game improve young children's ball skill competence? *Journal of Science and Medicine in Sport*, 19(5), 432-436.

Jones, L. and Green, K. 2015. Who teaches primary physical education? Change and transformation through the eyes of subject leaders. *Sport, Education and Society*, 22(6), 759-771.

Kalaja, S.P., Jaakkola, T.T., Liukkonen, J.O. and Digelidis, N. 2012. Development of junior high school students' fundamental movement skills and physical activity in a naturalistic physical education setting. *Physical Education and Sport Pedagogy*, 17(4), 411-428.

Karabourniotis, D., Evaggelinou, C., Tzetzis, G. and Kourtessis, T. 2002. Curriculum enrichment with self-testing activities in development of fundamental movement skills of first-grade children in Greece. *Perceptual Motor Skills*, 94(3 Pt 2), 1259-1270.

Karni, A., Meyer, G., Rey-Hiolito, C., Adams, M.M., Turner, R. and Ungerleider, L.G. 1998. *The acquisition of skilled motor performance: Fast and slow experience-driven changes in primary motor cortex.* Colloquium paper. Presented at: the National Academy of Sciences, Arnold and Mabel Beckman Centre, Irvine, California. February 1998, 95, 861-868.

Kelly L, O'Connor S, Harrison A.J and Ní Chéilleachair N.J. 2019. Does fundamental movement skill proficiency vary by sex, class group or weight status? Evidence from an Irish primary school setting. *Journal of Sports Sciences*, 37(9), 1055-1063.

Kelso, J. 1995. *Dynamic patterns: The self-organisation of brain and behaviour.* Cambridge, MA: MIT Press.

Kelso, J.A.S. and Ding, M. 1993. Fluctuations, intermittency and controllable chaos in biological coordination. In: Newell, K.M. and Carcos D.M. eds. *Variability and motor control.* Champaign IL: Human Kinetics Publishers, 291-316.

Kernodle, M.W. and Carlton, L.G. 1992. Information feedback and the learning of multiple-degree-of-freedom activities. *Journal of Motor Behaviour*, 24(2), 187-196.

Kim, J.W., Ritter, F.E. and Koubek, R.J. 2013. An integrated theory for improved skill acquisition and retention in three stages of learning. *Theoretical issues in ergonomic science*, 14(1), 22-37.

Kinchin, G., MacPhail, A. and Ní Chróinín, D. 2012. Irish primary school teachers' experiences with Sport Education, *Irish Education Studies,* 31(2), 207–222.

Kiphard, E.J. and Schilling, F. 1974. Körperkoordinationstest für Kinder KTK: Manual. Weinhein: Beltz Test.

Kirk, D. and MacPhail, A. 2002. Teaching games for understanding and situated learning: Rethinking the Bunker and Thorpe model. *Journal of Teaching Physical Education*, 21(2), 177-192.

Knudson, D.V. and Morrison, C.S. 1997. *Qualitative Analysis of Human Movement.* Champaign, IL: Human Kinetics.

Kockstejn, J. and Musalek, M. 2019. The relationship between fundamental motor skills and game specific skills in elite young soccer players. *Journal of Physical Education and Sport,* 19(1), 249-254.

Koo, T.K. and Li, M.Y. 2015. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, 15(2), 155-163.

Krejcie, R.V. and Morgan, D.W. 1970. Determining sample size for research activities. Educational and Psychological Measurement, 30, 607-610.

Kugler, P.N. and Turvey, M.T. 1987. *Information, natural law and self-assembly of rhythmic movement: Theoretical and experimental investigations*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Lai, S.K., Costigan, S.A., Morgan, P.J., Lubans, D.R., Stodden, D.F., Salmon, J. and Barnett, L.M. 2014. Do school-based interventions focusing on physical activity, fitness or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents? A systematic review of follow-up studies. *Sports Medicine*, 44(1), 67-79.

Lander, N., Barnett, L.M., Brown, H. and Telford, A. 2015. Physical education teacher training in fundamental movement skills makes a difference to instruction and assessment practices. *Journal of Teaching in Physical Education*, 34(3), 548-556.

Lander, N., Eather, N., Morgan, P.J. Salmon, J and Barnett, L.M. 2016. Characteristics of teacher training in school-based physical education interventions to improve fundamental movement skills and/or physical activity: A systematic review. *Sports Medicine,* 47(1), 135-161.

Lander, N.J., Hanna, L., Brown, H., Telford, A., Morgan, P.J., Salmon, J. and Barnett, L.M. 2017. Physical education teachers' perspectives and experiences when teaching FMS to early adolescent girls. *Journal of Teaching in Physical Education,* 36(1), 113-118.

Lander, N., Nahavandi, D., Mohamed, S., Essiet, I. and Barnett, L.M. 2020. Bringing objectivity to motor skill assessment in children, *Journal of Sports Sciences*, Online, doi: 10.1080/02640414.2020.1747743 [accessed May 25 2020].

Larson, A. 2006. Student perception of caring teaching in physical education, *Sport, Education and Society*, 11(4), 337-352.

Bernstein, 1996. Levels of construction of movements. In: Latash, M. and Turvey, M.T. *Dexterity and its Development,* Mahwah, NJ: Lawrence Erlbaum Associations, 115-170.

Laukkanen, A., Pesola, A., Havu, M., Sääkslahti, A. and Finni, T. 2014. Relationship between habitual physical activity and gross motor skills is multifaceted in 5 to 8 year-old children. *Scandinavian Journal of Medicine and Science in Sports,* 24(2), e102–e110 .

Lester, D., McGrane, B., Belton, S., Duncan, M. J., Chambers, F. C. and O'Brien, W. 2017. The Age-Related Association of Movement in Irish Adolescent Youth. *Sports,* 5(4), 77(16pp), doi:10.3390/sports5040077.

Lever, J. 1978. Sex differences in the complexity of children's play and games. *American Sociology Review,* 43(4), 471–83.

Lewis, K. 2014. Pupils' and teachers' experiences of school-based physical education: a qualitative study. *British Medical Journal,* 4(9), article no: e005277, [no pagination], doi:10.1136/bmjopen-2014005277.

Light, R. 2008. Complex learning theory – Its epistemology and its assumptions about learning: Implications for physical education. *Journal of Teaching in Physical Education*. 27(1), 21-37.

Lima, A. R., Bugge, A., Ersbøll, A. K., Stodden, D. F., and Andersen, L. B. 2018. The longitudinal relationship between motor competence and measures of fatness and fitness from childhood into adolescence. *Journal of Pediatrics,* 95(4) 482–488.

Logan, S. W., Robinson, L.E., Wilson, A.E. and Lucas, W.A. 2012. Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. *Child Care Health Development.* 38(3), 305–315.

Logan, S., Robinson, L., Webster, E.K. and Barber, L. 2013. Exploring preschoolers' engagement and perceived physical competence in an autonomy-based object control skill intervention: A preliminary study. *European Physical Education Review*, 9(3), 302-314.

Logan, S.W., Ross, S.M., Chee, K., Stodden, D.F. and Robinson, L.E. 2018. Fundamental motor skills: A systematic review of terminology. *Journal of Sports Sciences*, 36(7), 781-796.

Logan, S.W., Webster, E.K., Getchell, N., Pfeiffer, K.A. and Robinson, L.E. 2015. Relationship between fundamental motor skill competence and physical activity during childhood and adolescence: A systematic review. *Kinesiology Review*, 4(4), 416-426.

Lonsdale, C., Rosenkranz, R.R., Peralta, L.R., Bennie, A., Fahey, P. and Lubans, D.R. 2013. A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. *Preventative Medicine*, 56(2), 152-161.

Lopes, L., Santos, R., Pereira, B., and Lopes, V.P. 2013. Associations between gross motor coordination and academic achievement in elementary school children. *Human Movement Science*, 32(1), 9-20.

Lopes, V.P., Rodrigues, L.P., Maia, A.R. and Malina, R.M. 2011. Motor coordination as a predictor of physical activity in childhood. S*candinavian Journal of Medicine and Science in Sports*, 21(5), 663-669.

Loprinzi, P.D., Davis, R.E. and Fu, Y-C. 2015. Early motor skill competence as a mediator of child and adult physical activity. *Preventative Medicine Reports,* 2(2015), 833-838.

Lubans, D., Morgan, P., Cliff, D., Barnett, L. and Okely, A. 2010. Fundamental movement skills in children and adolescents: Review of associated health benefits. *Sports medicine*, 40(12), 1019-1035.

Lunn, P., Kelly, E. and Fitzpatrick, N. 2013. *Keeping them in the game: Taking up and dropping out of sport and exercise in Ireland.* Research Series 33. The Economic and Social Research Institute, Dublin, Ireland.

Lynch, T and Soukup G.J. Sr. 2017. Primary physical education (PE): School leader perceptions about classroom teacher quality implementation, Cogent Education, 4(1), article no: 1348925 [no pagination], doi: 10.1080/2331186X.2017.1348925.

Macdonald, K., Milne, N., Orr, R. and Pope, R. 2018. Relationships between motor proficiency and academic performance in mathematics and reading in school-aged children and adolescents: A systematic review. *International Journal of Environmental Research and Public Health,* 15(8), article no: 1603, [no pagination] doi:10.3390/ijerph15081603.

MacPhail, A. and Halbert, J. 2005. The implementation of a revised physical education syllabus in Ireland: circumstances, rewards and costs. *European Physical Education Review,* 11(3), 287-308.

MacPhail, A., Tannehill, D. and Avsar, Z. 2019. *European physical education teacher training practices: Initial induction and professional development*. Maidenhead, UK: Meyer and Meyer Sport.

Maeng, H.J., Webster, K.E. and Ulrich, D.A. 2016. Reliability of the test of gross motor development – Third Edition (TGMD-3). *Research Quarterly for Exercise and Sport, supplement.* 87(S2), A38, doi:10.1080/02701367.2016.1217725.

Magill, R.A. 2007. *Motor learning and control: Concepts and applications (8th ed)*, New York: McGraw-Hill.

Marron, S., Murphy, F. and Coulter, M. 2018. *Specialising in primary physical education: Primary teachers 'fit' to enhance well-being of children*. In: Irelands yearbook of education 2018-2019, 166-170, Available at: https://issuu.com/educationmattersie/docs/irelands_yearbook_of_education_2018_fd142f04af68b3 [accessed 25 May 2020].

Martens R., Burwitz L., and Zuckerman J. 1976. Modelling effects on motor-performance. *Research Quarterly. American Alliance for Health, Physical Education and Recreation*. 47(2), 277–291.

Martin, E. H., Rudisill, M. E., and Hastie, P. A. 2009. Motivational climate and fundamental motor skills performance in a naturalistic physical education setting. *Physical Education and Sport Pedagogy*, 14(3), 227-240.

Masters, R. S. W. 1992. Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology*, 83(3), 343–358.

Masters, R. Sw., Poolton, J.M., Maxwell, J.P., and Raab, M. 2008. Implicit motor learning and complex decision making in time-constrained environments. *Journal of Motor Behaviour,* 40(1), 71-79.

Maxwell, J. P., Masters, R. S. W. and Eves, F. F. 2003. The role of working memory in motor learning and performance. *Consciousness and Cognition*, 12(3), 376-402.

Maxwell, J.P., Capio, C.M. and Masters, R.S.W. 2017. Interaction between motor ability and skill learning in children: Application of implicit and explicit approaches, *European Journal of Sport Science*, 17(4), 407-416.

Maxwell, J.P., Masters, R.S.W., Kerr, E. and Weedon, E. 2001. The implicit benefit of learning without errors. *The Quarterly Journal of Experimental Psychology*, 54(4), 1049-1068.

McAuley, B.E. and Gill, D. 1983. Reliability and validity of the physical self-efficacy scale in a competitive sport setting. *Journal of Sport and Exercise Psychology,* 5(4), 410-418.

McCoy, E.C. 2017. Understanding the intention-to-treat principle in randomised controlled trials. *Western Journal of Emergency Medicine*, 18(6), 1075-1078.

McCoy, S., Quail, A. and Smyth, E. 2012. *Influences on 9-year olds' learning: Home, school and community. Growing Up in Ireland, National Longitudinal Study of Children*. Department of Children and Youth Affairs. Government Publications: Dublin.

McCoy, S., Smyth, E. and Banks, J. 2012. *The primary classroom: insights from the growing up in Ireland study.* NCCA, Economic and Social Research Institute: Dublin.

McGrane, B., Belton, S., Fairclough, S.J., Powell, D. and Issartel, J. 2018. Outcomes of the Y-PATH randomised controlled trial: Can a school based intervention improve fundamental movement skill proficiency in adolescent youth? *Journal of Physical Activity and Health,* 15(2), 89-98.

McGrane, B., Belton, S., Powell, D. and Issartel, J. 2017. The relationship between fundamental movement skill proficiency and physical self-confidence among adolescents. *Journal of Sports Sciences,* 35(17), 1709-1714.

McGrane, B., Belton, S., Powell, D., Woods, C.B. and Issartel, J. 2015. Physical self-confidence levels of adolescents: Scale reliability and validity. *Journal of Science and Medicine in Sport,* 19(7), 563-567.

McGuinness, S. and Shelly, B. 1995. *An evaluation of the implementation of the physical education curriculum in Irish primary schools*. Dublin: School of Education, Trinity College.

McKenzie, T. and Kahan, D. 2008 Physical activity, public health, and elementary schools. *The Elementary School Journal,* 108(3), 171-180.

McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader, P. R., Berry, C. C., and Brennan, J. J. 2002. Childhood movement skills: Predictors of physical activity in Anglo American and Mexican American adolescents. *Research Quarterly for Exercise and Sport,* 73(3), 238-244.

McKenzie, T. L., Stone, E. J., Feldman, H. A., Epping, J. N., Yang, M., Strikmiller, P. K., Lytle, L. A. and Parcel, G. S. 2001. Effects of the CATCH physical education intervention: Teacher type and lesson location. *American Journal of Preventive Medicine,* 21(2), 101-109.

McKenzie, T.L. 2007. The preparation of physical educators: A public health perspective. *Quest*, 59(4), 346–357.

McKenzie, T.L., Nader, P.R., Strikmiller, P.K., Yang, M., Stone, E.J., Perry, C.L., Taylor, W.C., Epping, J.N., Feldman, H.A., Luepker, R.V. and Kelder, S.H. 1996. School physical education: Effect of the child and adolescent trial for cardiovascular health. *Preventative Medicine*, 25(4), 423-431.

McKenzie, T.L., Stone, E.J., Feldman, H.A., Epping, J.N., Yang, M., Strikmiller, P.K., Lytle, L.A. and Parcel, G.S. 2001. Effects of the catch physical education intervention: Teacher type and lesson location. *American Journal of Preventive Medicine*, 21(2), 101-109.

McLennan, N. and Thompson, J. 2015. Quality Physical Education: Guidelines for Policy-Makers, Paris: United Nations Educational, Scientific and Cultural Organization (UNESCO).

McMorris, 2004. *Acquisition and performance of sports skills*. West Sussex, England: John Wiley and Sons Ltd.

Miller, A., Christensen, E.M., Eather, N., Sproule, J., Annis-Brown, L. and Lubans, D.R. 2015. The PLUNGE randomized controlled trial: Evaluation of a games-based physical activity professional learning program in primary school physical education. *Preventative Medicine,* 74(May 2015), 1-8, doi:10.1016/j.ypmed.2015.02.002.

Mitchell, B., McLennan, S., Latimer, K., Graham, D., Gilmore, J. and Rush, E. 2013. Improvement of fundamental movement skills through support and mentorship of class room teachers. *Obesity Research and Clinical Practice*, 7(3), e230-e234.

Mitchell, F., Gray, S. and Inchley, J. 2015. 'This choice thing really works … ' Changes in experiences and engagement of adolescent girls in physical education classes, during a school-based physical activity programme. *Physical Education and Sport Pedagogy,* 20(6), 593-611.

Möhring, W., Newcombe, N.S., Levine, S.C. and Frick, A. 2015. Spatial proportional reasoning is associated with formal knowledge about fractions. *Journal of Cognition and Development,* 17(1), 67-84.

Morano, M., Colella, D. and Caroli, M. 2011. Gross motor skill performance in a sample of overweight and non-overweight preschool children. *International Journal of Pediatric Obesity,* 6(S2), 42-46.

Morano, M., Colella, D., Rutigliano, I. Fiore, P., Pettoello-Mantovani, M, and Camponozzi, A, 2014. A multi-modal training programme to improve physical activity, physical fitness and perceived physical ability in obese children. *Journal of Sports Science,* 32(4), 345-353.

Morgan, P. and Hansen, V. 2008. The relationship between PE biographies and PE teaching practices of classroom teachers. *Sport, Education and Society* 13(4), 373-391.

Morgan, P. J. and Bourke, S. F. 2005. An investigation of preservice and primary school teachers' perspectives of PE teaching confidence and PE teacher education. *ACHPER Healthy Lifestyles Journal*, 52(1), 7-13.

Morgan, P., Barnett, L., Cliff, D., Okely, A., Scott, H., Cohen, K. and Lubans, D. 2013. Fundamental movement skill interventions in youth: a systematic review and meta-analysis. *Pediatrics*, 132(5), 1361–1383.

Morgan, P.J. 2003. *Personal school experiences, attitudes and efficacy beliefs: A causal analysis focusing on the primary school physical education teacher*. (PhD Thesis), University of Newcastle.

Morgan, P.J. 2008. Teacher perceptions of physical education in the primary school: Attitudes, values and curriculum preferences. *The Physical Educator*, 65(1), 46-56.

Morgan, P.J. and Hansen, V. 2008. Classroom teacher's perceptions of the impact of barriers to teaching physical education on the quality of physical education programs. *Research Quarterly for Exercise and Sport,* 79(4), 506-516.

Morley, D., Ogilvie, P., McKenna, J., Daly-Smith, A. and Till, K. 2016. Bupa Start to Move Executive Summary, Commissioned by the Youth Sport Trust: www.youthsporttrust.org. Liverpool John Moores University, February 2016.

Moss, S. 2012. *Natural Childhood.* UK: National Trust, [online] Available at: https://nt.global.ssl.fastly.net/documents/read-our-natural-childhood-report.pdf, [accessed 15 April 2020].

Moy, B., Renshaw, I. and Davids, K. 2016. The impact of nonlinear pedagogy on physical education teacher education students' intrinsic motivation. *Physical Education and Sport Pedagogy,* 21(5), 517-538.

Mukherjee, S., Jamie, L.C.T. and Hin Fong, L. 2017. Fundamental motor skill proficiency of 6- to 9-year-old Singaporean children. *Perceptual and Motor Skills,* 124(3), 584-600.

Murphy, F. and O'Leary, M. 2012. *Supporting primary teachers to teach physical education: continuing the journey.* St. Patrick's College, Dublin City University, Dublin, Available at: http://doras.dcu.ie/21573/1/136_SCAN.pdf, [accessed 10 April 2020].

Murphy, F. 2007. *Capacity building for primary physical education: Enhancing teacher expertise for quality teaching and learning.* Unpublished Thesis, PhD, St Patrick's College, A college of Dublin City University.

NASPE. 2004. *Physical activity for children: A statement of guidelines for children ages 5-12*. Reston, VA: AAHPERD.

NASPE. 2012. *Instructional framework for fitness education in physical education. Guidance document*. Reston, VA: AAHPERD

Nathan, N., Sutherland, R., Beauchamp, M.R., Cohen, K., Hulteen, R.M., Babic, M., Wolfenden, L. and Lubans, D.R. 2017. Feasibility and efficacy of the Great Leaders Active StudentS (GLASS) program on children's physical activity and object control skill competency: A non-randomised trial. *Journal of Science and Medicine in Sport,* 20(12), 1081-1086

National Council for Curriculum and Assessment 1999. *Physical Education, Primary School Curriculum*. Department of Education and Science. Stationary Office: Dublin.

Navarro-Patón, R., Lago-Ballesteros, J., Basanta-Camiño, S., and Arufe-Giraldez, V. 2019. Relation between motivation and enjoyment in physical education classes in children from 10 to 12 years old. *Journal of Human Sport and Exercise,* 14(3), 527-537.

New South Wales Department of Education and Training. 2000. *Get skilled: Get active: Fundamental movement skills resource for primary schools.* Sydney: NSW Department of Education and Training.

New South Wales Department of Health 2003. *Move It, Groove It—Physical Activity in Primary Schools Summary Report.* Northern NSW Health Promotion: Lismore, NSW, Australia.

Newell, 2003. Schema theory 1975: Retrospectives and perspectives. *Research Quarterly for Exercise and Sport*, 74(4), 383-388.

Newell, A. and Rosenbloom, P.S. 1981. Mechanisms of skill acquisition and the law of practice. In: J.R. Anderson, ed. *Cognitive skills and their acquisition.* Hillsdale, NJ: Lawrence Erlbaum, 1–55.

Newell, K.M. 1985. Coordination, control and skill. In: Goodman, D., Wilberg, R.B. and Franks, I.M. eds. *Differing perspectives in motor learning, memory and control*. North-Holland: Elsevier Science Publishers. 295-317.

Newell, K.M. 1986. Constraints on the development of coordination. In: Wade, M.G. and Whiting, H.T.A. eds. *Motor development in children: Aspects of coordination and control.* Boston: MA: Martinus Nijhoff, 341-360.

Ní Chróinín, D. and Cosgrave, C. 2013. Implementing formative assessment in primary physical education: teacher perspectives and experiences, *Physical Education and Sport Pedagogy,* 18(2), 219-233.

Ní Chróinín, D. and O'Brien, N. 2019. Primary school teachers' experiences of external providers in Ireland: learning lessons from physical education, *Irish Educational Studies,* 38(3), 327-341.

Nicholls, J. G. 1984. Conceptions of ability and achievement motivation. In: R. Ames and C. Ames. eds. *Research on motivation in education: Student motivation*. New York: Academic Press, 39-68.

Nicholls, J.G. 1989. *The competitive ethos and democratic education*. Cambridge, UK: Harvard University Press.

Nobre, F.S.S., Valentini, N.C. and Rusidill, M.E. 2020. Applying the bioecological theory to the study of fundamental motor skills, *Physical Education and Sport Pedagogy*, 25(1), 29-48

Ntoumanis, N. and Biddle, S. 1999. A review of motivational climate in physical activity. *Journal of Sports Sciences,* 17(8), 643-665.

Ntoumanis, N. 2001. A self-determination approach to the understanding of motivation in Physical Education. *British Journal of Educational Psychology,* 71(2), 225-242.

Ntoumanis, N. and Biddle, S.J.H. 1999. Affect and achievement goals in physical activity: A meta-analysis. *Scandinavian Journal of Medicine and Science in Sports*, 9(6), 315-332.

O'Brien, W., Belton, S. and Issartel, J. 2016a. The relationship between adolescents' physical activity, fundamental movement skills and weight status. *Journal of Sports Sciences*, 34(12), 1159-1167.

O'Brien, W., Belton, S. and Issartel, J. 2016b. Fundamental movement skill proficiency amongst adolescent youth. *Physical Education and Sport Pedagogy*, 21(6), 557-571.

O'keeffe, S.L., Harrison, A.J. and Smyth, P.J. 2007. Transfer or specificity? An applied investigation into the relationship between fundamental overarm throwing and related sport skills. *Physical Education and Sport Pedagogy*, 12(2), 89-102.

Okely, A.D. and Booth, M.L. 2004. Mastery of fundamental movement skills among children in New South Wales: prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport,* 7(3), 358-372.

Okely, A.D., Booth, M.L. and Patterson, J.W. 2001. Relationship of physical activity to fundamental movement skills among adolescents. *Medicine and Science in Sport and Exercise*, 33(11), 1899-1904.

Ommundsen, Y. and Kvalø, S.E. 2007. Autonomy–mastery, supportive or performance focused. Different teacher behaviours and pupils' outcome in physical education. *Scandinavian Journal of Educational Research*, 51(4), 385-413.

Palmer, K.K., Chinn, K.M. and Robinson, L.E. 2017. Using achievement goal theory in motor skill instruction: A systematic review. *Sports Medicine,* 47(12), 2569-2583.

Pan, Y. 2014. Relationships among teachers' self-efficacy and students' motivation, atmosphere, and satisfaction in physical education*, Journal of Teaching in Physical Education*, 33(1), 68-92.

Pang, A. and Fong, D. 2009. Fundamental motor skill proficiency of Hong Kong children aged 6-9 years. *Research in Sports Medicine*, 17(3), 125-144.

Parish, L.E., and Treasure, D.C. 2003. Physical activity and situational motivation in physical education: Influence of the motivational climate and perceived ability. *Research Quarterly for Exercise and Sport,* 74(2), 173-182.

Parker, M., MacPhail, A., O'Sullivan, M., Ní Chróinín, D. and McEvoy, E. 2018. 'Drawing' conclusions: Irish primary school children's understanding of physical education and physical activity opportunities outside of school. *European Physical Education Review*, 25(4), 449-466.

Pate, R.R., O'Neill, J.R. and Lobelo, F. 2008. The evolving definition of "sedentary". *Exercise and Sport Science Reviews*, 36(4), 173-178.

Patton, K., and Griffin, L.L. 2008. Experiences and patterns of change in a physical education teacher development project. *Journal of Teaching in Physical Education* 27(3), 272-291.

Payne, V.G. and Isaacs, L.D. 2011. *Human Motor Development: A Lifespan Approach* (8th ed). New York: McGraw-Hill.

PDST. 2017. *Move Well Move Often: Developing the physically literate child through the lens of fundamental movement skills. Teacher Guide*, PE Curriculum, Dublin.

Perlman, D. and Webster, C.A. 2011. Supporting student autonomy in physical education. *Journal of Physical Education, Recreation and Dance*, 82(5), 46-49.

Perry, I.J, Millar, S.R. Balanda, K.P., Dee, A., Bergin, D., Carter, L., Doherty, E., Fahy, L., Hamilton, D., Jaccard, A., Knuchel-Takano, A., McCarthy, L., McCune, A., O'Malley, G., Pimpin, L., Queally, M. and Webber, L. 2017. What are the estimated costs of childhood overweight and obesity on the island of Ireland? Safefood. Cork: Ireland.

Perry, D.G., Pauletti, R.E., and Cooper, P.J. 2019. Gender identity in childhood: A review of the literature. *International Journal of Behavioural Development*, 43(4), 289-304.

Poldrack, R.A., Sabb, F.W., Foerde, K., Tom, S.M., Asarnow, R.F., Bookheimer, S.Y. and Knowlton, B.J. 2005. The neural correlates of motor skill automaticity. *Journal of Neuroscience,* 25(2), 5356-5364.

Porter, J.M., Wu, W.F.W. and Partridge, J.A. 2010. Focus of attention and verbal instructions: Strategies of elite track and field coaches and athletes. *Sports Science Review*, 19(3-4), 199-211.

Rainer, P. and Jarvis, S. 2020. Fundamental movement skills and their relationship with measures of health-related physical fitness of primary school children prior to secondary school transition: A Welsh perspective, *Education*, 48(1), 54-65.

Renshaw, I., Chow, J.Y., Davids, K. and Hammond, J. 2010. A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis?. *Physical Education and Sport Pedagogy,* 15(2), 117-137.

Renshaw, I., Davids, K.W., Shuttleworth, R. and Chow, J. 2009. Insights from ecological psychology and dynamical systems theory can underpin a philosophy of coaching. *International Journal of Sport Psychology*, 40(4), 540-602.

Riddiford-Harland, D.L., Steele, J.R. and Baur, L.A. 2006. Upper and lower limb functionality: Are these compromised in obese children? *International Journal of Pediatric Obesity,* 1(1), 42-49.

Riethmuller, A.M., Jones, R.A. and Okely, A.D. 2009. Efficacy of interventions to improve motor development in young children: A systematic review. *Pediatrics*, 124(4), e782–e792.

Rintala, P.O., Sääkslahti, A.K. and Iivonen, S. 2017. Reliability assessment of scores from video-recorded TGMD-3 performances. *Journal of Motor Learning and Development,* 5(1), 59-68.

Roberts, G.C. 2012. Motivation in sport and exercise from an achievement goal theory perspective: After 30 years, where are we? In: G.C. Robert and D.C. Treasure, eds. *Advances in motivation in sport and exercise (3rd ed),* Champaign, IL: Human Kinetics, 5-58.

Robinson, L., Palmer, K., and Meehan, S. 2017. Dose-response relationship: The effect of motor skill intervention duration on motor performance. *Journal of Motor Learning and Development*, 5(2), 280-290.

Robinson, L., Stodden, D., Barnett, L., Lopes, V., Logan, S., Rodrigues, L. and Hondt, E. 2015. Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine*, 45(9), 1273-1284.

Robinson, L.E and Goodway, J.D. 2009. Instructional climates in preschool children who are at risk part 1. *Research Quarterly for Exercise and Sport*, 80(3), 533-542.

Robinson, L.E., Webster, E.K., Logan, S.W., Lucas, W.A. and Barber, L.T. 2012. Teaching practices that promote motor skills in early childhood settings. *Early Childhood Education Journal,* 40(2), 79-86.

Rodrigues, L.P., Stodden, D.F. and Lopes, V.P. 2016. Developmental pathways of change in fitness and motor competence are related to overweight and obesity status at the end of primary school. *Journal of Science and Medicine in Sport,* 19(1) 87-92.

Rohbanfard H. and Proteau L. 2011. Learning through observation: a combination of expert and novice models favours learning. *Experimental Brain Research*. 215(3-4), 183-197.

Ross, S., Metcalf, A., Bulger, S.M. and Housner, L.D. 2014. Modified Delphi investigation of motor development and learning in physical education teacher education, *Research Quarterly for Exercise and Sport,* 85(3), 316-329.

Royal College of Paediatrics and Child Health (RCPCH) 2013. *UK-WHO Growth Charts, 0 – 18 years.* Available at: http://www.rcpch.ac.uk/growthcharts/, [accessed November 19 2016].

Rudd, J.R., O'Callaghan, L. and Williams, J. 2019. Physical education pedagogies built upon theories of movement learning: How can environmental constraints be manipulated to improve children's executive function and self-regulation skills?. *International Journal of Environmental Research and Public Health*, 16(9), article no: 1630, [no pagination], doi:10.3390/ijerph16091630.

Rudd, J.R., Crotti, M., Fitton-Davies, K., O'Callaghan, L., Bardid, F., Utesch, T., Roberts, S., Boddy, L.M., Cronin, C.J., Knowles, Z., Foulkes, J., Watson, P.M., Pesce, C., Button, C., Lubans, D.R., Buszard, T., Walsh, B. and Foweather, L. 2020. Skill acquisition methods fostering physical literacy in early-physical education (SAMPLE-PE): Rationale and study protocol for a cluster randomized controlled trial in 5–6-year-old children from deprived areas of North West England. *Frontiers in Psychology*, 11(June 2020), article no: 1228, [no pagination], doi:10.3389/fpsyg.2020.01228.

Rudisill, M. and Johnson, J. 2018. Mastery Motivational Climates in Early Childhood Physical Education: What Have We Learned over the Years? *Journal of Physical Education, Recreation and Dance,* 89(6), 26-32.

Rudolf, M. 2009. *Tackling Obesity Through the Healthy Child Programme: A Framework for Action.* University of Leeds, Leeds Community Healthcare.

Russell-Bowie, D.E. 2013. What? Me? Teach dance? Background and confidence of primary preservice teachers in dance education across five countries. *Research in Dance Education*, 14(3), 216-232.

Ryan, R.M., and Deci, E.L. 2002. Overview of self-determination theory: An organismic dialectical perspective. In: Deci, E.L. and Ryan, R.M. eds. *Handbook of self-determination research,* Rochester, NY: University of Rochester Press, 3-36.

Sääkslahti, A., Numminen, P., Niinikoski, H., Rask-Nissilä, L., Viikari, J., Tuominen, J. and Välimäki, I. 1999. Is physical activity related to body size, fundamental motor skills, and CHD risk factors in early childhood? *Pediatric Exercise Science*, 11(4), 327–340.

Sabo, D., Miller, K., Melnick, M. and Heywood, L. 2004. *Her life depends on it: Sport, physical activity and the health and well-being of American girls.* East Meadow, NY: Women's Sports Foundation.

Sahoo, K., Sahoo, B., Choudhury, A.K., Sofi, N.Y., Kumar, R. and Bhdoria, A.S. 2015. Childhood obesity: causes and consequences. *Journal of Family Medicine and Primary Care,* 4(2), 187-19.2

Sallis, J.F., Prochaska, J.J. and Taylor, W.C. 2000. A review of correlates of physical activity of children and adolescents. *Medicine and Science in Sports and Exercise,* 32(5), 963-975.

Salmon, J., Ball, K., Hume, C., Booth, M. and Crawford, D. 2008. Outcomes of a group-randomized controlled trial to prevent weight gain, reduce screen time behaviours and promote physical activity in 10-year-old children: Switch-Play. *International Journal of Obesity,* 32(4), 601-612.

Salmoni, A.W., Schmidt, R.A. and Walter, C.B. 1984. Knowledge of Results and Motor Learning: A Review and Critical Reappraisal. *Psychological Bulletin*, 95(3), 355-386.

Sandholtz, J.H. 2002. Inservice training or professional development: contrasting opportunities in a school/university partnership. *Teaching and Teacher Education*, 18(7), 815-830.

Scarpa, S. and Nart, A. 2012. Influences if perceived sport competence on physical activity enjoyment in early adolescents. *Social, Behaviour and Personality Research*, 40(2), 203-204.

Schmidt, M., Egger, F., Benzing, V., Jäger, K., Conzelmann, A., Roebers, C.M. and Pesce, C. 2017. Disentangling the relationship between children's motor ability, executive function and academic achievement. *PLoS ONE,* 12(8): article no: e0182845 [no pagination], doi:10.1371/journal.pone.0182845.

Schmidt, R. A. 1975. A schema theory of discrete motor skill learning. *Psychological Review,* 82(4), 225-260.

Schmidt, R.A. 1982. The schema concept. In: Kelso, J.A. ed. *Human motor behaviour: An introduction.* Hillsdale, NJ: Lawrence Erlbaum Associates, 219-235.

Schmidt, R.A. 1985. The 1984 C. H. McCloy research lecture: The search for invariance in skilled movement behaviour. *Research Quarterly for Exercise and Sport*, 56(2), 188-200.

Schmidt, R.A. 2003. Motor schema theory after 27 years: Reflections and implications for a new theory. *Research Quarterly for Exercise and Sport.* 74(4), 366-379.

Schmidt, R.A. and Wrisberg, C.A. 2008. *Motor learning and performance: A situation based learning approach. (4th ed).* Champaign, IL: Human Kinetics.

Schneider, W. and Shiffrin, R.M. 1977. Controlled and automatic human information processing: Detection, search, and attention. *Psychological Review*, 84(1), 1-66.

Scoilnet, 2019. *Physical Literacy, Move Well Move Often: Developing the physically literate child through the lens of fundamental movement skills.* Viewed 20 December 2019, https://www.scoilnet.ie/pdst/physlit/.

Seefeldt, V. 1979. Developmental motor patterns: implications for elementary school physical education. In: Nadeau, C., Halliwell, W., Newell, K and Roberts, C. eds. *Psychology of motor behaviour and sport.* Champaign, IL: Human Kinetics, 314-323.

Seifert, L. and Davids, K. 2015. *Ecological Dynamics: a theoretical framework for understanding sport performance, physical education and physical activity.* CS-DC'15 World e-conference, Sep 2015, Tempe, United States. CS-DC'15 World e-conference.

Sember, V., Morrison, S. A., Jurak, G., Kovač, M., Golobič, M., Pavletić Samardžija, P., Gabrijelčič, M., Primožič, M., Kotar, T., Djomba, J., and Starc, G. 2018. Results from Slovenia's 2018 Report Card on Physical Activity for Children and Youth. *Journal of Physical Activity and Health*, 15(s2), S404-S405.

Shadmehr, R. and Brushers-Krug, T. 1997. Functional stages in the formulation of human long-term motor memory. *Journal of Neuroscience*, 17(1), 409-419.

Sharma, D.A., Chevidikunnan, M.F., Khan, F.R. and Gaowgzeh. 2016. Effectiveness of knowledge of results and knowledge of performance in the learning of skilled motor activity by healthy young adults. *The Journal of Physical Therapy Science*, 28(5), 1482-1486.

Shaw, R.E. and Alley, T.R. 1985. How to draw learning curves: their use and justification, In: Johnson, T. D. and Pietrewicz, A. T. eds. *Issues in the Ecological Study of Learning.* Hillsdale: Erlbaum, 275-304.

Shaw, R., and Turvey, M. 1999. Ecological foundations of cognition: II. Degrees of freedom and conserved quantities in animal environment systems. *Journal of Consciousness Studies*, 6(11/12), 111-123.

Shea, C.H, Wright, D.L, Wulf, G. and Whitacre C. 2000. Physical and observational practice afford unique learning opportunities. *Journal of Motor Behavior,* 32(1), 27-36.

Shea, C.H., Wulf, G. and Whitacre, C.A. 1999. Enhancing training efficiency and effectiveness through the use of dyad training. *Journal of Motor Behaviour*, 31(2), 119-125.

Sigmundsson, H., Trana, L., Polman, R. and Haga, M. 2017. What is trained develops! Theoretical perspective on skill learning. *Sports,* 5(2), article no: 38, [no pagination], doi: 10.3390/sports5020038.

Simon, H.A. and Chase, W.G. 1973. Skill in chess. *American Scientist*, 61(4), 394-403.

Slotte, S., Sääkslahti, A., Kukkonen- Harjula, K. and Rintala, P. 2017. Fundamental movement skills and weight status in children: A systematic review. *Baltic Journal of Health and Physical Activity,* 9(2), 115-127.

Slotte, S., Sääkslahti, A., Metsämuuronen, J. and Rintala, P. 2015. Fundamental movement skill proficiency and body composition measured by dual energy X-ray absorptiometry in eight year old children. *Early Child Development and Care*, 185(3), 475-485.

Smith, R.E., Smoll, F.L. and Barnett, N.P. 1995. Reduction of children's sports performance anxiety through social support and stress-reduction training for coaches. *Journal of Applied Developmental Psychology,* 16(1), 125-142.

Smith, W. 2016. Fundamental movement skills and fundamental games skills are complementary pairs and should be taught in complementary ways at all stages of skill development. *Sport Education and Society,* 21(3), 431-442.

Smits-Engelsman B.C.M. 1998. *Movement Assessment Battery for Children*, Handleiding. Lisse the Netherlands: Swets and Zeitlinger.

Solmon, M.A. 1996. Impact of motivational climate on students' behaviors and perceptions in a physical education setting. *Journal of Educational Psychology*, 88(4) 731-738.

Sonstroem, R.J. Harlow, L.L and Josephs, L. 1994. Exercise and self-esteem: validity of model expansion and exercise associations. *Journal of Sports and Exercise Psychology*, 16(1), 29-42.

Southall, J., Okely, A.D. and Steele, J.R. 2004. Actual and perceived physical competence in overweight and non-overweight children. *Paediatric Exercise Science,* 16(1), 15-24.

Spencer, A. 1998. Physical educator: Role model of roll the ball out? *Journal of Physical Education, Recreation and Dance,* 69(6), 58-63.

Spessato, B.C., Gabbard, C., Valentini, N., and Rudisill, M. 2013. Gender differences in Brazilian children's fundamental movement skill performance. *Early Child Development and Care*, 183(7), 916-923.

Sproule, J., Wang, C.K.J., Morgan, K., McNeill, M. and McMorris, T. 2007. Effects of motivational climate in Singaporean physical education lessons on intrinsic motivation and physical activity intention. *Personality and Individual Differences*, 43(5), 1037-1049.

Standage, M. and Treasure, D.C. 2002. Relationship among achievement goal orientations and multidimensional situational motivation in physical education, *British Journal of Educational Psychology*, 72, 87-103.

Standage, M. Duda, J.L. and Ntoumanis, N. 2003. A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity interventions. *Journal of Educational Psychology,* 95(1) 97-110.

Standage, M., Duda, J.L. and Ntoumanis, N. 2005. A test of self-determination theory in school physical education. *British Journal of Educational Psychology*, 75(Pt 3), 411-33.

Stodden, D., Langendorfer, S., and Roberton, M.A. 2009. The association between motor skill competence and physical fitness in young adults. *Research Quarterly for Exercise and Sport*, 80(2), 223-229.

Stodden, D.F., Goodway, J.D., Langendorfer, S.J., Roberton, M.A., Rudisill, M.E., Garcia, C. and Garcia, L.E. 2008. A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest*, 60(2), 290–306.

Stodden, D.F., True, L.K., Langendorfer, S.J. and Gao, Z. 2013. Associations Among Selected Motor Skills and Health-Related Fitness: Indirect Evidence for Seefeldt's Proficiency Barrier in Young Adults? *Research Quarterly for Exercise and Sport*, 84(3), 397-403.

Stoller, R. J. 1964. A contribution to the study of gender identity. *International Journal of Psychoanalysis,* 45(2/3), 220-226.

Sullivan, K.J., Kantak, S.S., and Burtner, P.A. 2008. Motor learning in children: feedback effects on skill acquisition. *Physical Therapy*, 88(6), 720-732.

SurveyMonkey Inc, San Mateo: California, USA. www.surveymonkey.com.

Swinnen, S.P., Schmidt, R.A., Nicholson, D.E. and Shapiro, D.C. 1990. Information feedback for skill acquisition: Instantaneous knowledge of results degrades learning. *Journal of Experimental Psychology,* 16(4), 706-716.

Teaching Council. 2013. *Final report of the review panel to the Teaching Council following a review of the reconceptualised degree programme submitted for accreditation by St. Patrick's College*, Drumcondra Bachelor of Education Programme. Dublin.

Telford, R.M., Telford, R.D., Olive, L.S., Cochrane, T. and Davey, R. 2016. Why are girls less physically active than boys? Findings from the LOOK longitudinal study. *PLoS One,* 11(3), article no: e0150041, [no pagination], doi:10.1371/journal.pone.0150041.

Temple, V.A. and Foley, J.T. 2017. A peek at the developmental validity of the test of gross motor ability-3. *Journal of Motor Learning and Development,* 5(1), 5-14.

TGMD-3. 2017. *TGMD-3 Common Errors Video* [Online video]. 30 May. Available at: https://www.youtube.com/watch?v=iXs2zI9JgKs (Accessed 29 September 2017).

Thomas, J.R. and French, K.E. 1985. Gender differences across age in motor performance: A meta- analysis. *Psychology Bulletin,* 98(2), 260-82.

Thomas, J.R. and French, K.E. 1985. Gender differences across age in motor performance: A meta-analysis. *Psychology Bulletin,* 98(2), 260-82.

Tompsett, C., Sanders, R., Taylor, C. and Cobley, S. 2017. Pedagogical approaches to and effects of fundamental movement skill interventions on health outcomes: A systematic review. *Sports Medicine*, 47(9), 1795-1819.

Trost, S.G., Kerr, L., Ward, D.S. and Pate, R.R. 2001. Physical activity and determinants of physical activity in obese and non-obese children. *International Journal of Obesity Related Metabolic Disorders,* 25(6), 822-829.

Tremblay, M.S., Aubert, S., Barnes, J.D., Saunders, T.J., Carson, V., Latimer-Cheung, A.E., Chastin, S.F., Altenburg, T.M. and Chinapaw, M.J., 2017. Sedentary behavior research network (SBRN)–terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 75, doi: 10.1186/s12966-017-0525-8.

Trudeau, F. and Shephard, R.J. 2005. Contribution of school programmes to physical activity levels and attitudes in children and adults. *Sports Medicine*, 35(2), 89-105.

Truelove, S., Johnson, A.M., Burke, S.M. and Tucker, P. 2019. Comparing Canadian generalist and specialist elementary school teachers' self-efficacy and barriers related to physical education instruction. *Journal of Teaching in Physical Education*, (ahead of print), 1-11. doi:10.1123-jtpe.2019-0091.

Tzetzis, G., Votsis, E. and Kouressis, T. 2008. The effect of different corrective feedback methods on the outcome and self-confidence of young athletes. *Journal of Sports Science and Medicine,* 7(3), 371-378.

Ulrich, D.A., 1985. *Test of gross motor development*. Austin, TX: PRO-ED.

Ulrich, D.A., 2000. *Test of gross motor development 2: examiner's manual*, 2nd ed. Austin, TX: PRO-ED.

Ulrich, D.A., 2019. *Test of gross motor development 3: examiner's manual*, 3rd ed. Austin, TX: PRO-ED.

Ulrich, D.A. and Webster, E.K. 2015. Revisions for the Third Edition of the Test of Gross Motor Development. *Journal of Sport and Exercise Psychology*, 37(1), S16. June 2015. North American Society for Physical Activity and Sport Psychology in Portland, OR.

UNESCO, 2014. *World-wide Survey of School Physical Education – Final Report 2013*. United Nations Educational, Scientific and Cultural Organization: France.

Valentini, N. C., and Rudisill, M. E. 2004. Motivational climate, motor-skill development, and perceived competence: Two studies of developmentally delayed kindergarten children. *Journal of Teaching in Physical Education*, 23(3), 216–234.

Valentini, N.C., Zanell, L.W. and Webster, E.K. 2016. Test of gross motor development – Third edition: Establishing content and construct validity for Brazilian children. *Journal of Motor Learning and Development*, 5(1), 15–28.

Vallerand, R. J., Deci, E. L. and Ryan, R. M. 1987. Intrinsic motivation in sport. *Exercise and Sport Science Reviews*, 15(1), 389-426.

van Beurden, E., Barnett, L.M., Zask, A., Dietrich, U.C., Brooks, L.O. and Beard, J. 2003. Can we skill and activate children through primary school physical education lessons? 'Move it Groove it' - a collaborative health promotion intervention. *Preventative Medicine,* 36(4), 493-501.

Van Beurden, E., Zask, A., Barnett, L.M. and Dietrich, U.C. 2002. Fundamental Movement Skills: How do Primary School Children Perform the 'Move it Groove it' Program in Rural Australia. *Journal of Science and Medicine in Sport*, 5(3), 244–252.

van der Fels, I.M.J., te Wierike, S.C.M., Hartman, E., Elferink-Gemser, M.T., Smith, J. and VanLehn, K. 1996. Cognitive skill acquisition. *Annual Review of Psychology,* 47(Feb 1996), 513-539.

Vasconcellos, D., Parker, P. D., Hilland, T., Cinelli, R., Owen, K. B., Kapsal, N., Lee, J., Antczak, D., Ntoumanis, N., Ryan, R. M. and Lonsdale, C. 2019. Self-determination theory applied to physical education: A systematic review and meta-analysis. *Journal of Educational Psychology,* Advance online publication: doi:10.1037/edu0000420.

Veldman, S., Jones, R and Okely, A. 2016. Efficacy of gross motor skill interventions in young children: an updated systematic review. *BMJ Open Sport and Exercise Medicine,* 2(1), article no: e000067 [no pagination], doi:10.1136/bmjsem-2015-000067.

Veldman, S., Palmer, K., Okely, A. and Robinson, L. 2017. Promoting ball skills in preschool-age girls. *Journal of Science and Medicine in Sport*, 20(1), 50-54.

Vereijken, B. Vab Emmerik, R.E.A., Whiting, H.T.A., and Newell, K.M. 1992. Free(z)ing degrees of freedom in skill acquisition. *Journal of Motor Behaviour*, 24(1), 133-142.

Vereijken, B., Whiting, H.T.A. and Beek, W.J. 1992. A dynamical approach to skill acquisition. *The Quarterly Journal of Experimental Psychology,* 45a(2), 323-344.

Walsh, T. 2016. 100 years of primary curriculum development and implementation in Ireland: a tale of a swinging pendulum. *Irish Educational Studies*, 35(1), 1-16.

Ward, J., Wilkinson, C., Graser, S. and Prusak, K. 2008. Effects of choice on student motivation and physical activity behavior in physical education. *Journal of Teaching in Physical Education,* 27(3), 385-398.

Warren, W. 2006. The dynamics of perception and action. *Psychological Review*, 113(2), 358-389.

Webster, E.K. and Ulrich, D.A. 2017. Evaluation of the psychometric properties of the test of gross motor development – third edition. *Journal of Motor Learning and Development*, 5(1), 45-58.

Webster, E.K., Martin, C.K. and Staiano, A.E. 2019. Fundamental motor skills, screen-time, and physical activity in preschoolers. *Journal of Sport and Health Science,* 8(2), 114-121.

Weiller, K.H. and Richardson, P.A. 1993. A program for kids: success-oriented physical education. *Childhood Education*, 69(3), 133-137.

Weiss, M. and Amorose, A. 2008. Motivational orientations and sport behaviour. In: Horn, T. ed. *Advances in sport psychology (3 ed),* Champaign, IL: Human kinetics, 116-155.

Westendorp, M., Hartman, E., Houwen, S., Smith, J. and Visscher, C. 2011. The relationship between gross motor skills and academic achievement in children with learning disabilities. *Research in Developmental Disabilities*, 32(6), 2773-2779.

Whitall, J. and Getchell, N. 1995. From walking to running: applying a dynamical systems approach to the development of locomotor skills. *Child Development,* 66(5), 1541-1553.

Whitehead, M. 2010. *Physical literacy: Throughout the life course*. Oxon: Routledge, 11-12.

Whittle, R. J., Telford, A., and Benson, A.C. 2018. Teacher's Perceptions of how they Influence Student Academic Performance in VCE Physical Education. *Australian Journal of Teacher Education*, 43(2), doi: http://dx.doi.org/10.14221/ajte.2018v43n2.1.

Wick, K., Leeger-Aschmann,C.S., Monn, N.D., Radtke, T., Ott, L.V., Rebholz, C.E., Cruz, S., Gerber, N., Schmutz, E.A., Puder, J.J., Munsch, S., Kakebeeke, T.H., Jenni, O.G., Granacher, U. and Kriemler, S. 2017. Interventions to promote fundamental movement skills in childcare and kindergarten: A systematic review and meta-analysis. *Sports Medicine*, 47(10), 2045-2068.

Wilhelmsen, T., Sørensen, M., and Seippel, Ø. N. 2019. Motivational Pathways to Social and Pedagogical Inclusion in Physical Education, *Adapted Physical Activity Quarterly*, 36(1), 19-41.

Williams, A.M. and Hodges, N.J. 2005. Practice, instruction and skill acquisition in soccer: Challenge tradition. *Journal of Sports Sciences,* 23(6), 637-650.

Winstein, C.J. and Schmidt, R.A. 1990. Reduced frequency of knowledge of results enhances motor skill learning. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 16(4), 677- 691.

Witt, P.A. and Dangi, T.P. 2018. Why children/youth drop out of sports. *Journal of Park and Recreation Administration,* 36, 191-199.

Women in Sport. 2012. *Changing the game for girls: Policy report*. London: Women's Sport and Fitness Foundation.

Woodard, R.L. and Surburg, P.R. 2001. The performance of fundamental movement skills by elementary school children with learning disabilities. *The Physical Educator*, 58(4), 198-206.

Woods, C.B., Powell, C., Saunders, J.A., O'Brien, W., Murphy, M.H., Duff, C., Farmer, O., Johnston, A., Connolly, S. and Belton S. 2018. *The Children's Sport Participation and Physical Activity Study 2018 (CSPPA 2018).* Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland, Sport Ireland, and Healthy Ireland, Dublin, Ireland and Sport Northern Ireland, Belfast, Northern Ireland.

Woods, C.B., Tannehill, D., Quinlan, A., Moyna, N. and Walsh, J. 2010. *The Children's Sport Participation and Physical Activity Study (CSPPA). Research Report No 1*. School of Health and Human Performance, Dublin City University and The Irish Sports Council, Dublin, Ireland.

Wulf, G. 2013. Attentional focus and motor learning: a review of 15 years. *International Review of Sport and Exercise Psychology,* 6(1), 77-104.

Wulf, G. and Shea, C. and Lewthwaite, R. 2010. Motor skill learning and performance: a review of influential factors. *Medical Education*, 44(1), 75-84.

Wulf, G. and Shea, C.H. 2002. Principles derived from the study of simple skills do not generalize to complex skill learning. *Psychonomic Bulletin and Review,* 9(2), 185-211.

Wulf, G. and Shea, C.H. 2004. Understanding the role of augmented feedback. In: Williams, A.M and Hodges, N.J. eds. *Skill acquisition in sport: Research, theory and practice.* New York: Routledge, 121-144.

Wulf, G., and Lewthwaite, R. 2010. Effortless motor learning?: An external focus of attention enhances movement effectiveness and efficiency. In: Bruya, B. ed. *Effortless Attention: A new perspective in the cognitive science of attention and action.* London: A Bradford Book, 75-102.

Xiang, P., McBride, R.E. and Solmon, M.A. 2003. Motivational climates in ten teachers' elementary physical education classes: An achievement goal theory approach. *The Elementary School Journal,* 104(1), 71-91.

Xu, L., Rogers, C.R., Halliday, T.M., Wu, Q. and Wilmouth, L. 2020. Correlates of physical activity, psychosocial factors, and home environment exposure among U.S. adolescents: insights for cancer risk reduction from the FLASHE study. *International Journal Environment Research Public Health*, 17, 5753. doi: 10.3390/ijerph17165753.

Zimmer R. and Volkamer M. 1987. *Motoriktest für vier- bis sechsjärige Kinder (manual).* Betltztest, Weinheim.

Zwicker, J. and Harris, S.R. 2009. A reflection on motor learning theory in paediatric occupational therapy practice. *Canadian Journal of Occupational Therapy*, 76(1), 29-37.

Appendices

Appendix A: Study 1 Recruitment email

Institiúid Teicneolaíochta Bhaile Átha Luain
Athlone Institute of Technology

Dear Principal,

We would like to invite your school to take part in a research project run by the Department of Life and Physical Science at Athlone Institute of Technology. The project will involve establishing fundamental movement skill (FMS) proficiency in children from senior infants to 5th class. The skills we will test are run, gallop, hop, skip, horizontal jump, vertical jump, slide, two hand strike, one hand forehand strike, one hand stationary dribble, two hand catch, kick, overhand throw, underhand throw, static balance and dynamic balance. These skills are the primary movements required for many sports specific skills and are a critical link to lifelong physical activity levels. It is first necessary to establish current levels of proficiency so that future intervention programmes can be developed in order maximise the benefits associated with FMS proficiency.

We would welcome the opportunity to discuss the project with you further and the benefits of taking part in the project for your school. I will contact the school in the coming week to further explain this research, answer any questions you may have and discuss if this would be feasible to implement in your school. Please feel free to contact any of the following should you have any questions before then.

<u>We can be contacted at the following address:</u>

Ms Lisa Kelly (master's research student) email: l.kelly@research.ait.ie

Dr. Siobhán O Connor: (supervisor) email: soconnor@ait.ie

Dr. Niamh Ní Cheilleachair: (supervisor) email: nnicheilleachair@ait.ie

We look forward to hearing from you with the possibility of working with you in the near future.

Yours Sincerely,

Lisa Kelly
Department of Life and Physical Science,
Athlone Institute of Technology
Athlone

Phone: 0831698067

Appendix B: Study 1 Plain language statement and informed consent form

Plain language statement

Supervisors: Dr. Niamh Ní Chéilleachair, Dr. Siobhán O Connor **Principal Investigator:** Ms. Lisa Kelly

Purpose:

The aim of this study is to identify fundamental movement skill (FMS) proficiency levels among primary school children. FMS are divided into three categories including locomotor, object-control or ball skills and stability skills. They are an essential component of motor development. Unfortunately, it is widely accepted that these skills are acquired naturally. This is not the case, as was found when only 11% of Irish first year students (13 years old) achieved mastery in 9 FMS that children have the potential to master by the age of 6. FMS need to be taught and practised in order to become proficient. The critical age period for learning FMS is between 3 and 8 years and so it is essential that proficiency levels are investigated while children are in primary school. FMS are a critical component of lifelong motor development as they are the basic building blocks for more sports specific skills. This study will form the foundation for much needed investigation in the area of motor development and physical activity in children.

What is required of your child?

Each child will be asked to complete 16 fundamental movement skills. These skills are divided into three categories.

Locomotor Skills	Run	Gallop	Skip	Hop	Horizontal jump	Vertical jump	Slide
Ball Skills	2 hand strike	1 hand forehand strike	Stationary dribble	2 hand catch	Kick	Overhead throw	Underhand throw
Stability Skills	Single leg stance	Y balance test					

All of these are the under pinning skills in sporting activities. These FMS are no more strenuous than what is usually carried out as part of a normal Physical Education lesson.

Your child will be given a personal ID number and all information will be recorded under this ID number. Your child's height and weight will be measured on an individual basis behind a screen. Measurements will be recorded on the participant information sheet and will not be verbally announced to ensure all information is kept confidential. Your child will take part in a warm up activity before performing the skills. A demonstration and explanation of each skill will be given before asking the child to perform a practice trial. Once we are sure the child understands the task, he/she will then perform two trials of each skill which will be video recorded in order to ensure results can be measured as accurately as possible. Your child's face will be pixelated to remove identity upon first viewing by the principal investigator. Only the principal investigator and supervisors will have access to the tapes.

We would ask that your child wears normal PE clothes such as knee length shorts or tracksuit bottoms, a t-shirt and suitable rubber soled running shoes.

Location and Supervision

These skills will be tested in the school hall during a typical PE class. The principal supervisor will be assisted by the class teacher and up to six students from 3rd and 4th year BSc (Hons) Sports Science with Exercise Physiology and BSc (Hons) Athletic and Rehabilitation Therapy undergraduate degree courses in Athlone Institute of Technology. Each student has completed Garda vetting and has experience working with the public from previous placements. They will help to organise the testing stations, record particpants weight and height, supervise the warm up and record results. The Principal Investigator has completed a 'Safegaurding 1: Child Welfare and Protection' workshop and will ensure fair treatment of all participants is maintained throughout the study.

Potential Risks

All the procedures used are safe, will be conducted by trained personnel and do not require anything extra in the daily routine. The risks involved are no more than what may occur in a normal PE class.

Benefits

Your child's FMS proficiency level will be measured in 16 skills. You will receive information as to what skills need improvement. This information will be useful for the development of future interventions that will aim to improve overall FMS proficiency levels. Improving FMS proficiency levels has the potential to increase adherence to physical activity and consequently help with maintaining a healthy lifestyle.

Confidentiality

The results and information received from this study are regarded as confidential and will be used by the investigating team only. All video-recordings will be stored on a password protected memory stick. The memory stick will be stored in a locked filing cabinet and will not leave AIT. This will only be accessible to the principal investigator doing this study. Your child's data will be kept anonymous through a personal ID number and through pixelating faces on all videotapes. Data will be destroyed 5 years after publication of this study.

Freedom of withdrawal

Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time.

We hope you will be interested in allowing your child to participate in this project once more and should you have any queries please do not hesitate to get in touch.

Contact details: **Name:** Lisa Kelly (Principal Investigator)

Email: l.kelly@research.ait.ie **Phone:** 083 1698067

Informed Consent Form

To investigate fundamental movement skill proficiency levels amongst primary school children

- I have read and understand all the information in the **plain language statement**.
- I understand what the project is about and what the results will be used for.
- I am fully aware of all testing procedures and they have been verbally explained to me in detail.
- I am aware of the potential **risks and benefits** associated with this study.
- I understand that any information about my child will be kept confidential and will be coded with a subject ID.
- I understand that the results of the research study may be published but that my child's identity will not be revealed.
- I know that participation in this study is voluntary and that my child can withdraw/I can withdraw my child from the study at any time without giving a reason.
- I understand that if I/my child have any questions regarding any aspect of this research study I/my child can contact any of the investigators involved with this study.

Child's name: ______________ **Parent/Guardian Signature:** _________________

Child's signature: ____________ **Date:** ________________________

Investigator's signature: ______________ **Date:**_____________________

Appendix C: Assessment and scoring protocol for 15 FMS

Appendix C.1: Performance criteria and instructions for assessing the run and two-hand strike as outlined in the TGMD-3 protocol (Ulrich 2019)

Skill	Instructions	Performance Criteria	Equipment
Run	*'Run fast from cone 1 to cone 2'* (50 feet apart) Video: Side view	(1) Arms move in opposition to legs with elbows bent (2) Brief period where both feet are off the surface (3) Narrow foot placement landing on heel or toe (not flat footed) (4) Non-support leg bent about 90 degrees, so foot is close to buttocks	Measuring tape 2 cones
Gallop	*'Gallop from cone 1 to cone 2 and stop'* (25 feet apart) Video: Side view	(1) Arms flexed and swinging forward (2) A step forward with lead foot followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot) (3) Brief period where both feet come off the surface (4) Maintains a rhythmic pattern for four consecutive gallops	Measuring tape 2 cones
Hop	*'Hop 4 times on your preferred foot' (cones placed 15 feet apart)* Video: Side view	(1) Non-hopping leg swings forward in pendular fashion to produce force (2) Foot of non-hopping leg remains behind hopping leg (does not cross in front of) (3) Arms flex and swing forward to produce force (4) Hops 4 consecutive times on preferred foot before stopping	Measuring tape 2 cones

Skip	*'Skip from cone 1 to cone 2'* (30 feet apart) Video: Side view	(1) A step forward followed by a hop on the same foot (2) Arms are flexed and move in opposition to legs to produce force (3) Completes 4 continuous rhythmical alternating skips	Measuring tape 2 cones
Slide	*'Slide form cone 1 to cone 2, stop and slide from cone 2 to cone 1'* (25 feet apart) Video: Face view	(1) Body is turned sideways so shoulders remain aligned with the line on the floor (score on preferred side only) (2) A step sideways with the lead foot, followed by a slide with trailing foot where both feet come off the surface briefly (score preferred side only) (3) Four continuous slides to preferred side (4) Four continuous slides to non-preferred side	Measuring tape 2 cones
Horizontal Jump	'*Stand behind the line and jump as far as you can'* Video: Side view	(1) Prior to take-off, both knees are flexed and arms are extended behind back (2) Arms extend forcefully forward and upward, reaching above the head. (3) Both feet come off the floor together and land together (4) Both arms are forced downwards during landing	White tape

Appendix C.2 Performance criteria and instructions for assessing ball skills in TGMD-3 protocol (Ulrich 2019)

Skill	**Instructions**	**Performance Criteria**	**Equipment**
Two-hand strike of a stationary ball	(place ball on batting tee at child's waist level) *'Hit the ball hard with this bat, straight ahead towards the wall'* Video: Side view	(1) Childs preferred hand grips bat above non-preferred hand (2) Child's non-preferred hip-shoulder faces straight ahead (3) Hip and shoulders rotate and derotate during swing (4) Steps with non-preferred foot (5) Hits ball, sending it straight ahead	Batting tee Plastic bat 4-inch plastic ball
One-hand forehand strike of a self-bounced ball	(Hand plastic paddle and ball to the child) '*Hold the ball up and drop it (so that it bounces to waist height), once it bounces, hit it with the paddle towards the wall straight ahead'* Video: Side view	(1) Child takes back swing with paddle once the ball is bounced (2) Steps with non-preferred foot (3) Strikes the ball towards the wall (4) Paddle follows through toward non-preferred shoulder	Tennis ball Light plastic paddle
One-hand stationary dribble	'*Bounce the ball at four times without moving your feet, using one hand and then catch the ball to stop'* Video: Side view (to side that's closest to the side the ball is being bounced)	(1) Contacts the ball with one hand at about waist level (2) Pushes the ball with fingertips (not slapping the ball) (3) Maintains control of the ball for at least 4 consecutive bounces without moving the feet to retrieve the ball	Basketball

Two-hand catch	*'Stand at that line and catch the ball with two hands when I throw it to you'* (thrower is standing 15 feet away and throws the ball using the underhand technique to the child at chest height) Video: Side view	(1) Childs hands are positioned in front of the body with elbows flexed (2) Arms extend, reaching for the ball as it arrives (3) Ball is caught by hands only	Tennis ball Wall White tape
Kick a stationary ball	Starting at line 1 (28 feet from wall) *'run up to the ball (20 feet from wall) and kick it hard against the wall'* Video: Side view	(1) Rapid, continuous approach to the ball (2) Child takes an elongated stride or leap just prior to ball contact (3) Non-kicking foot placed close to the ball (4) Kicks ball with in-step or inside of preferred foot (not with toes)	Soccer ball White tape Wall
Overhand throw	*'Stand behind the tape (20 feet from the wall) and throw the ball hard at the wall'* Video: Side view	(1) Wind-up is initiated with a downward movement of hand and arm (2) Rotates hip and shoulder to a point where the non-throwing side faces the wall (3) Steps with the foot opposite the throwing hand towards the wall (4) Throwing hand follows through after the ball release, across the body towards the hip of the non-throwing side	Tennis ball
Underhand throw	*'Stand behind the tape and throw the ball underhand to hit the wall'* Video: Side view	(1) Preferred hand reaches down and back reaching behind the trunk (2) Step forward with the foot opposite the throwing hand (3) Ball is tossed forward hitting the wall without a bounce (4) Hand follows through after the ball release to at least chest level	Tennis ball

Appendix C.3: Additional FMS (NSW Department of Education and Training 2000; Department of Education Victoria, 1996).

Protocol	Skill	Instructions	Performance Criteria	Equipment
Victorian Fundamental Movement Skills Manual **(NSW Department of Education and Training, 2000)**	Vertical Jump	*'Jump vertically as high as possible'* Video: Side view	(1) Eyes focused forward or upward throughout (2) Crouch with knees bent. Arms behind the body (3) Forceful forward and upward swing of arms (4) Legs straighten in air (5) Land on balls of feet. Bend knees to absorb land (6) Controlled landing with ≤1 step any direction	White tape
Get Skilled; Get Active **(Department of Education Victoria, 1996)**	Static Balance	*'Stand on one leg with your arms held out to the side'* Video: Face view	(1) Support leg still, foot flat on the ground. (2) Non-support leg bent, not touching the support leg. (3) Head stable, eyes focused forward. (4) Trunk stable and upright. (5) No excessive arm movements	White tape

Appendix D: Plain language statement and informed consent for study 2

Institiúid Teicneolaíochta Bhaile Átha Luain
Athlone Institute of Technology

Plain Language Statement

Supervisors: Dr. Niamh Ní Chéilleachair, **Principal Investigator:** Ms. Lisa Kelly

Dr. Siobhán O Connor

Purpose:

After the establishment of fundamental movement skill (FMS) proficiency it is now essential that participants are given the opportunity to improve on their current levels. It is important the intervention is targeted towards the skills and skill components that are most problematic based on the baseline proficiency results. The intervention programme will be targeted towards improving these areas with an overall aim of giving participants the skills and the confidence to participate in lifelong physical activity be it for competitive or recreational purposes or for activities of daily living.

What is required of your child?

This phase of the project will consist of three stages (pre-test, intervention and post-test)

Pre-test and Post-test

Each participant will have their FMS proficiency assessed before and after the intervention. This will include testing the following 13 skills.

Run, gallop, hop, skip, slide, horizontal jump, two hand strike, one-hand forehand strike, kick a stationary ball, overhand throw, underhand throw, two-hand catch and stationary dribble.

Your child will be given a personal ID number and all information will be recorded under this ID number. Your child's height and weight will be measured and recorded on the participant information sheet and will not be verbally announced to ensure all information is kept confidential. Your child will take part in a warm up activity before performing the skills. A demonstration and explanation of each skill will be given before asking the child to perform a practice trial. Once we are sure the child understands the task, he/she will then perform two trials of each skill which will be video recorded in order to ensure results can be measured as accurately as possible. Your child's face will be pixelated to remove identity upon first viewing by the principal investigator. Only the principal investigator and supervisors will have access to the tapes. We would ask that your child wears normal PE clothes such as knee length shorts or tracksuit bottoms, a t-shirt and suitable rubber soled running shoes.

Location and Supervision

These skills will be tested in the school hall. The principal investigator will be assisted by the class teacher and up to six students from 3rd and 4th year BSc (Hons) Sports Science with Exercise Physiology and BSc (Hons) Athletic and Rehabilitation Therapy undergraduate degree courses in Athlone Institute of Technology. Each student has completed Garda vetting and has experience working with the public from previous placements. They will help to organise the testing stations, record participants weight and height, supervise the warm up and record results. The Principal Investigator has completed a 'Safeguarding 1: Child Welfare and Protection' workshop, and will ensure fair treatment of all participants is maintained throughout the study.

Intervention:

After the pre-test an intervention programme will be implemented in place of regular PE class (after Christmas). It will be run for two x 1 hour sessions each week for a period of 8 weeks. The intervention will be guided by the principal investigator but the class teacher will also be in attendance. The intervention will consist of a dynamic warm up, a skill introduction and practice session, a non-competitive game and a cool down/conclusion. The primary focus will be on developing and improving current FMS proficiency and the intervention will be tailored to suit the needs of individual participants.

The requirements of your child are the same for any other PE class. Participants are asked to wear suitable PE clothes and rubber soled footwear. The location will be as per normal PE class such as the school hall, playground or playing field.

Potential Risks

All the procedures used are safe, will be conducted by trained personnel and do not require anything extra in the daily routine. The risks involved are no more than what may occur in a normal PE class.

Benefits

Your child will take part in a targeted intervention programme that will aim to improve both confidence and competence in performing basic fundamental movement skills. While many of the skills sound relatively simple, many children and even adults have never been correctly taught how to perform the skills. Your child will receive professional instruction on how to correctly perform the skills that are proving most difficult. Such skills can be utilised for future participation in physical activity both recreationally and competitively.

Confidentiality

The results and information received from this study are regarded as confidential and will be used by the investigating team only. All video-recordings will be stored on a password protected memory stick. The memory stick will be stored in a locked filing cabinet and will not leave AIT. This will only be accessible to the principal investigator doing this study. Your child's data will be kept anonymous through a personal ID number and through pixelating faces on all videotapes. Data will be destroyed 5 years after publication of this study.

Freedom of withdrawal

Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time.

We hope you will be interested in allowing your child to participate in this project once more and should you have any queries please do not hesitate to get in touch.

Informed Consent Form

To investigate the effects of an 8-week intervention programme on fundamental movement skill proficiency levels in Irish primary school children

- I have read and understand all the information in the **plain language statement**.
- I understand what the project is about and what the results will be used for.
- I am fully aware of all testing procedures and they have been verbally explained to me in detail.
- I am aware of the potential **risks and benefits** associated with this study.
- I understand that any information about my child will be kept confidential and will be coded with a subject ID.
- I understand that the results of the research study may be published but that my child's identity will not be revealed.
- I know that participation in this study is voluntary and that my child can withdraw/I can withdraw my child from the study at any time without giving a reason.
- I understand that if I/my child have any questions regarding any aspect of this research study I/my child can contact any of the investigators involved with this study.

Child's name: ________________________ **Parent/Guardian Signature:** ______________

Investigator's signature: _______________________ **Date:** ______________________

Contact details:

Name: Lisa Kelly (Principal Investigator)

Email: l.kelly@research.ait.ie **Phone:** 083 1698067

Appendix E: Plain language and informed consent for follow-up study

Plain Language Statement

Supervisors: Dr. Niamh Ní Chéilleachair, Dr. Siobhán O Connor

Principal Investigator: Ms. Lisa Kelly

Purpose:

The aim of this follow-up study is to identify if your child has retained any improvement in skill performance following the 8-week fundamental movement skills intervention programme undertaken last year. Previously, each child underwent testing to identify their level of proficiency in 13 skills. We now want to determine if our 8-week programme provided long-term retention of skills or if any improvements immediately following the intervention are lost after one-year of finishing the programme.

What is required of your child?

Each participant will have their FMS proficiency re-assessed, as conducted previously. This will include testing the following 13 skills.

Run, gallop, hop, skip, slide, horizontal jump, two hand strike, one-hand forehand strike, kick a stationary ball, overhand throw, underhand throw, two-hand catch and stationary dribble.

Your child will be given a personal ID number and all information will be recorded under this ID number. Your child's height and weight will be measured and recorded on the participant information sheet and will not be verbally announced to ensure all information is kept confidential. Your child will take part in a warm up activity before performing the skills. A demonstration and explanation of each skill will be given before asking the child to perform a practice trial. Once we are sure the child understands the task, he/she will then perform two trials of each skill which will be video recorded in order to ensure results can be measured as accurately as possible. Your child's face will be pixelated to remove identity upon first viewing by the principal investigator. Only the principal investigator and supervisors will have access to the tapes. We would ask that your child wears normal PE clothes such as knee length shorts or tracksuit bottoms, a t-shirt and suitable rubber soled running shoes.

Location and Supervision

These skills will be tested in the school hall. The principal investigator will be assisted by the class teacher and up to six students from 3rd and 4th year BSc (Hons) Sports Science with Exercise Physiology and BSc (Hons) Athletic and Rehabilitation Therapy undergraduate degree courses in Athlone Institute of Technology. Each student has completed Garda vetting and has experience working with the public from previous placements. They will help to organise the testing stations, record participants weight and height, supervise the warm up and record results. The Principal Investigator has completed a 'Safeguarding 1: Child Welfare and Protection' workshop and will ensure fair treatment of all participants is maintained throughout the study.

Potential Risks

All the procedures used are safe, will be conducted by trained personnel and do not require anything extra in the daily routine. The risks involved are no more than what may occur in a normal PE class.

Benefits

Information regarding your child's FMS proficiency will be provided. This will include how your child performed before and immediately after the intervention programme in addition to his/her ability to retain any improvements one-year post-intervention. While many intervention programmes have successfully led to improvements immediately following a targeted intervention programme, the long-term consequences are less clear. If we want children to maintain a physically active lifestyle, it is essential that they are proficient in a wide range of basic skills. There is a need to identify if skills can be retained in the long-term in order to provide children with the motivation and confidence to partake in sport and/or physical activity for life.

Confidentiality

The results and information received from this study are regarded as confidential and will be used by the investigating team only. All video-recordings will be stored on a password protected memory stick. The memory stick will be stored in a locked filing cabinet and will not leave AIT. This will only be accessible to the principal investigator doing this study. Your child's data will be kept anonymous through a personal ID number and through pixelating faces on all videotapes. Data will be destroyed 5 years after publication of this study.

What results will be used for

Results of this study will be used to create a thesis document as part of a postgraduate research project. While results may be used for various publications and oral presentations, your child's identity will not be revealed in any case.

Freedom of withdrawal

Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time.

We hope you will be interested in allowing your child to participate in this project once more and should you have any queries please do not hesitate to get in touch.

Institiúid Teicneolaíochta Bhaile Átha Luain
Athlone Institute of Technology

Informed Consent Form

A one–year follow-up investigation of the effects of an 8-week intervention programme on fundamental movement skill proficiency levels in Irish primary school children

- I have read and understand all the information in the **plain language statement**.
- I understand what the project is about and what the results will be used for.
- I am fully aware of all testing procedures
- I am aware of the potential **risks and benefits** associated with this study.
- I understand that any information about my child will be kept confidential and will be coded with a subject ID.
- I understand that the results of the research study may be published but that my child's identity will not be revealed.
- I know that participation in this study is voluntary and that my child can withdraw/I can withdraw my child from the study at any time without giving a reason.
- I understand that if I/my child have any questions regarding any aspect of this research study I/my child can contact any of the investigators involved with this study.

Child's name: ________________________ **Parent/Guardian Signature:** _____________

Investigator's signature: ______________________ **Date:** _____________________

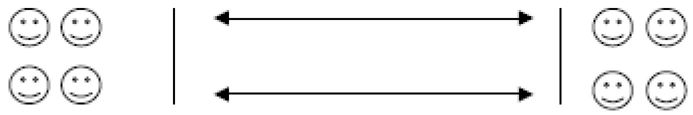
<u>Contact details</u>:

Name: Lisa Kelly (Principal Investigator)

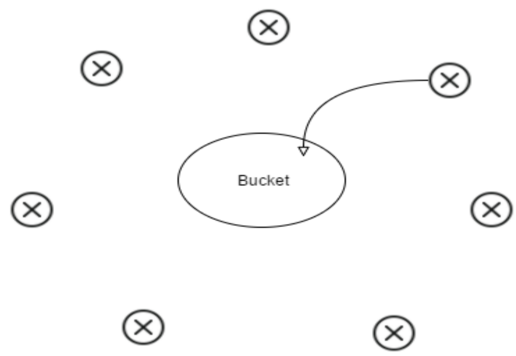
Email: l.kelly@research.ait.ie **Office Phone:** 090 646 8059

Appendix F: Lesson plans for intervention

Session 1: Throw, catch, gallop

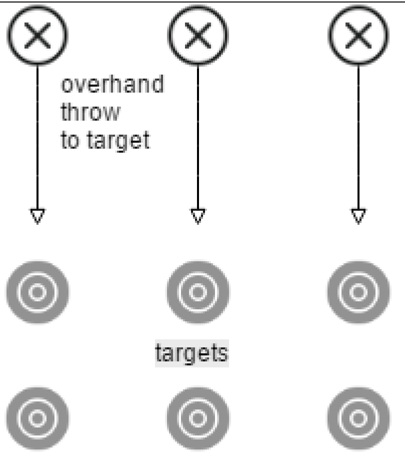
<table>
<tr>
<td>Warm up
10 minutes</td>
<td>Catch relay
Divide the class into groups of four, two on each side of the lines. Students run from one side to the other and when the runner with the bean bag reaches the other side they throw the beanbag to the next runner and so on. Students extend the space in between the group after each full rotation. (Give teams an animal to imitate for each go including a horse to identify who can/can't perform the gallop).

Quick dynamic stretch before moving on to activity 1
</td>
</tr>
<tr>
<td>Activity 1
15 minutes</td>
<td>Circuits
Divide group into three. Each group spends 5 minutes at a station. After 5 minutes, groups rotate to next station.

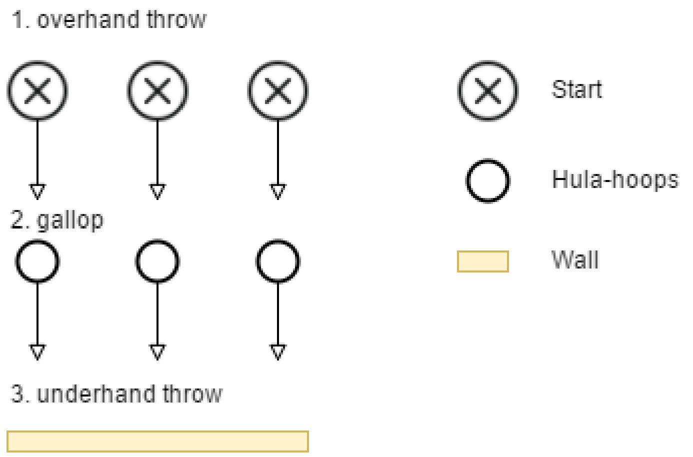
- Question on how to correctly perform the skill
- Offer encouragement and guidance to each other after each throw
- Make it easier/more difficult according to ability
Station 1: Develop Underhand Throw
Throwing different sized balls/beanbags into a bin/bucket

Place a bucket/large bag in the centre of a circle marked out by cones
Each child stands at a cone
Individually they practice underhand throwing balls/beanbags into the bucket


Station 2: Develop Overhand Throw
Throwing beanbags at targets

Divide group into 2-3 groups. Set up targets using cones or hula-hoops.
Child overhand throws beanbag towards target whilst being instructed on correct technique by station supervisor (E.g. step forward with opposite foot to throwing hand).
After throwing, each child collects their own beanbag and passes to next in line.</td>
</tr>
</table>

	 **Station 3: Develop Catching technique** Place a selection of balls inside a hoop – football, basketball, tennis ball, bouncy ball, beanbag, mini football, sliotar etc. Form a line with approx. 2 metres between each person - the person at the start picks a ball and throws it to the next person until it reaches the end of the line; the last person places the ball inside a hoop at the end. If the ball is dropped, they must start again. Variations: catch with 2-hands, catch with 1-hand, pretend the ball is an egg, pass high, pass low. **<u>Question at the end</u>** - Which ball was easiest to catch – why? - What should we do in order to correctly catch a ball?
Activity 2 15 minutes	**<u>Obstacle course</u>** *Highlight that it's not a race and that it is important to try and perform skills correctly.* Divide into 2-3 teams so that it's a relay style course. **Obstacle 1:** Overarm throw Throw beanbag into target area using overarm throw in order to start, first attempt from line 1, if they fail, move closer, and if they fail again move closer. Go after third attempt regardless. **Obstacle 2:** Gallop Gallop from start to obstacle 3. (have tennis balls placed on top of circular cones for each team) **Obstacle 3:** Underarm throw Child picks up tennis ball and throws it using the underarm technique against the wall. Encourage child to catch it without letting it bounce. If child fails to catch they must fetch the ball and return to cone before galloping back to start. Continue as relay and give pointers on how to correct technique of different skills.

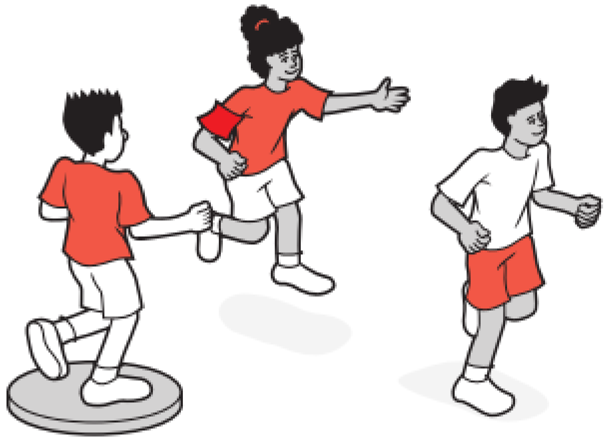
	
Cool Down 5 minutes	Gentle jog and full body stretch
Total 45 minutes	

<u>Skill components as outlined in the TGMD-3</u>

Skill	Criteria
Overhead Throw	1. Wind-up is initiated with downward movement of hand and arm 2. Rotates hip and shoulder to a point where the non-throwing side faces the wall 3. Steps with the foot opposite the throwing hand toward the wall 4. Throwing hand follows through after the ball release, across the body toward the hip of the non-throwing side
Underhand Throw	1. Windup is initiated with a downward movement of hand and arm 2. Rotates hip and shoulder to a point where the non-throwing side faces the wall 3. Steps with the foot opposite the throwing hand toward the wall 4. Throwing hand follows through after the ball release, across the body toward the hip of the non-throwing side through after ball release to at least chest level
Two-hand Catch	1. Child's hands are positioned in front of the body with the elbows flexed 2. Arms extend reaching for the ball as it arrives 3. Ball is caught by hands only
Gallop	1. Arms flexed and swinging forward 2. A step forward with lead foot followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot) 3. Brief period where both feet come off the surface 4. Maintains a rhythmic pattern for four consecutive gallops

Session 2: Jump, skip, kick

Warm up 10 minutes	**Animal moves** Students move around the allocated area as a designated animal, for example a bunny hop, seal slide, snake slither, emu run, kangaroo jump or crab crawl. Then students choose their own animal movement to move around the area. Dynamic Stretch
Activity 1 15 minutes	**<u>Game 2: 10 minutes</u>** **Skipping/jumping Tag** **Before starting the game, discuss the important components of skipping and jumping** **<u>Skipping</u>** - Use of arms - Hop followed by a step - Rhythm Explore different modes of skipping 1. Skip for length 2. Skip for height 3. Skip like a fairy 4. Skip like an elephant 5. Explore difference between using arms and not using arms **<u>Jumping</u>** 1. Start with knees bent and arms behind back 2. Use of arms to propel forward/upwards 3. Start and land on two feet 4. Soft landing, bending knees to absorb force **Movement skills/concepts** Sustained skipping/jumping, skipping/jumping for speed and to evade an opponent, balance (static and dynamic). Set-up Bands to identify the taggers, discs/spots. Grass or hard area. Groups of approximately 10, including two to three taggers (each wearing a band) per group. **Activity:** This simple tag game incorporates skipping/jumping Taggers skip/jump to tag other participants who are also skipping/ jumping within the designated area. When a person is tagged, the tagger gives their band to that person, who then becomes the tagger, while the previous tagger joins the rest of the group. You cannot be tagged if you are standing in a stork balance on one of the discs in the area.

<table>
<tr><td></td><td>
Can you see …?
• heads up to see where they are going using arms for balance
• Good technique as outlined above</td></tr>
<tr><td>Activity 2
15 minutes</td><td><u>Relay style obstacle course</u>

Form 3 teams with each team lined up behind a cone.

Station 1: Develop horizontal jump
Place 4 hoops in a line. Children jump from one hoop to the next.

1. start in a crouched position with arms behind
2. reach up to the sky
3. land softly

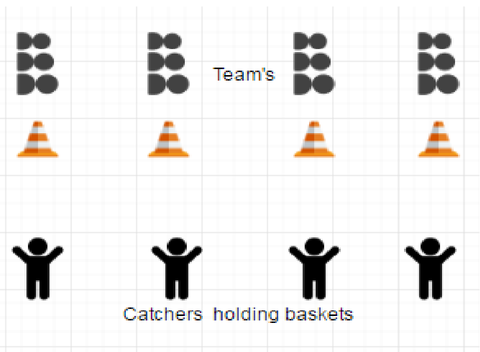
Station 2: Develop vertical jump
Set up 2 poly-spots per group and 2 mini hurdles.

Station 3: Develop kick
Place ball on top of round cones to elevate the ball. Place a target on the wall to aim for. Once a child has kicked the ball, they collect and place it on the cone for the next participant.
1. Non-kicking foot close to the ball
2. Kick with shoelace/side of foot
3. Aim for target using previous skills</td></tr>
<tr><td>Cool Down
5 minutes</td><td>Gentle jog and stretch</td></tr>
<tr><td>Total
45 minutes</td><td></td></tr>
</table>

Session 3: Jump, skip, kick

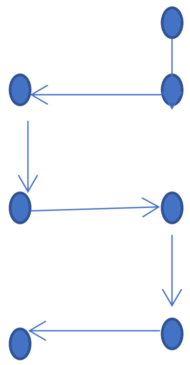
Warm up 10 minutes Bibs	**Light skipping to warm-up** Line children up and demonstrate correct skipping technique. Line up at one end of the hall and in small groups skip from one end to the hall to the other. - High skipping - Low skipping - Long skipping - Skip like a fairy/elephant/quickly/slowly **Stuck in the mud** Assign three taggers and give them a bib for identification. All children skip around the hall. If caught by a tagger, child must stand with arms and legs out wide. They can be freed when another child crawls under legs or runs under their arms. Emphasise good skipping technique. Dynamic stretch
Activity 1 15 minutes Hula-hoops Hurdles Poly-spots	**Shark attack obstacle course:** Develop jumping technique Assign three teams and line each up behind a cone Place pictures of sharks and fish around the floor to create an imaginary ocean **Set up:** Obstacle 1: 2 Hula-hoops Obstacle 2: 2 Mini hurdles Obstacle 3: 2 Poly-spots Instructions: Children must take their time performing the jumps. Tell them to stop and resume correct start position before each jump. Hula hoops emphasise horizontal jump and Mini hurdles/poly-spots emphasise vertical jump. After obstacle 3, they skip back to the back of the line and sit with their hands on their head until all team members have completed the course.
Activity 2 15 minutes Bowling pins Hula-hoops	**Bowling pins and target practice for kicking** Use the same teams from Activity 1. Set up bowling pins for each team Place ball approx. 4 metres from the pins and start line approx. 4 metres from the ball. Each team member takes a turn at running up to kick the ball to try and knock as many pins as possible. Each team adds up scores (1 point per pin knocked over) until all members have gone Repeat 3-4 times If time allows. Repeat the same activity using hula-hoops propped up against the wall.
Cool Down 5 minutes	Gentle jog and stretching
Total 45 minutes	

Session 4: Forehand strike, dribble, slide

Warm up 10 minutes	**<u>Stuck in the mud</u>** Give 3 taggers vests so children can identify who is on. Change the taggers every couple of minutes Incorporate different locomotor skills: run, skip, slide, gallop Dynamic Stretch
Activity 1 15 minutes **<u>Equipment:</u>** Soft balls/tennis balls Baskets Cones	**<u>Forehand Strike</u>** *Striker's vs Catchers:* strikers must use forehand strike technique to strike the ball using their **hands** aiming for the catcher's basket. Arrange group into equal sized teams and line up behind a cone. The first member is the catcher and picks up the basket facing their team as in the diagram. The first person on each team aims to strike the ball into the catcher's basket using correct forehand strike technique. The catcher can move to try and catch the ball in the basket. After striking, that team member swaps places with the catcher who goes to the back of the line.  **<u>Watch out for:</u>** 1. Backswing when ball is bounced 2. Step forward 3. Good strike technique 4. Follow through 5. Eyes focussing on target
Activity 2 15 minutes **<u>Equipment:</u>** Basketballs/playground balls Cones to make a square	**<u>Dribble</u>** Squares: Set up 3-4 squares with equal numbers at each station. Number the cones 1-4. Team members start at cone 1 with a ball and take it in turns going around the square, performing 5-6 dribbles at each cone as outlined below. Different dribble technique at each cone 1. Right hand 2. Left hand 3. Switch hands 4. Walk/jog and dribble and pass to next team member

	<u>Watch out for:</u> 1. Contact ball at waist level 2. Pushing ball with fingertips and not slapping the ball 3. Control **<u>Slide</u>** Keep the same set up as in the dribble. Call a number and children must slide around the cones to the number cone that is called and then return to start. Do it individually first and then in pairs with pairs facing each other. **<u>Watch out for:</u>** 1. Body turned sideways 2. Shoulders aligned in straight line (not twisted) 3. Step with leading foot and slide with trailing foot 4. Continuous rhythm
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 5: Forehand strike, dribble, slide

Warm up 10 minutes	**Animal Moves** **Side gallop challenge** Divide group into two groups. Team 1 have no bibs and team 2 have bibs. In a designated area scatter coloured cones randomly. Student's side gallop in square marked out by white lines. Coach calls out one or two colours. Participants run to the centre and pick up a cone of the colour that was called out. Only one cone allowed per person. The team who picks up the most gets a point. Repeat a few times, changing direction of side gallop each time. Dynamic stretch
Activity 1 15 minutes **<u>Equipment:</u>** Cones Playground balls/basketballs	**<u>Slide and dribble development</u>:** Run straight and slide sides Incorporate dribbling Relay style after practicing for a while  **<u>Watch out for:</u>** **Slide:** 1. Smooth rhythmical movement. 2. Brief period where both feet are off the ground. 3. Weight on the balls of the feet. 4. Hips and shoulders point to the front. 5. Head stable, eyes focused forward or in the direction of travel. **Dribble:** • Pushing ball (not slapping) • Control of ball • Bouncing at waist height
Activity 2 15 minutes **<u>Equipment:</u>** Rackets Tennis balls Hoops Cones	**<u>Forehand Strike:</u>** Strikers and catchers Divide up so people of similar ability in same groups Incorporate rackets and aim for target/hoop **Forehand strike:** • One foot in front • Drop ball with one hand and strike with the other • Timing/co-ordination between bounce and strike • Ability to gently strike the ball (controlled movement)
Cool Down	Gentle jog and stretch

5 minutes	**<u>Questions:</u>** • What do we need to remember when we are sliding? • What way should our body face? • What do we do with our arms? • What do we need to remember for dribbling? • What part of our hand do we dribble with? • Do we slap or push the ball? Why? • How high should the ball bounce when dribbling? • What do we need to remember for the forehand strike? • What foot do we step with? • When do we get ready to strike the ball?
Total 45 minutes	

Session 6: Two-hand strike, balance, hop

Warm up 10 minutes	**Animal Moves** Children run around the hall. Instructor calls out an animal to imitate. E.g. Horse, kangaroo, penguin, monkey, crab, turtle, rabbit, frog, flamingo When whistle is blown, children freeze and balance in different positions Dynamic stretch
Activity 1 15 minutes **<u>Equipment:</u>** Ladders Cones Poly-spots	**Balance and Hopping** **Set up:** 3 cones, 3 sets of straight lines, 3 ladders, 3 polyspots <u>Start:</u> Line up behind the cone <u>Obstacle 1</u>: Straight line walking to maintain balance **Variations** - Walk backwards - Place beanbag on head - Hop along the line without falling over <u>Obstacle 2:</u> Hop through ladders **Variations** - Hop right foot - Hop left foot - Hop side ways - Hopscotch - Skip a box <u>Obstacle 3:</u> Hop for distance Stand on one foot on poly-spot and hop as far as you can on one leg- try to beat your mark each time Return to your team and high five next person to go **<u>Hopping: watch out for</u>** 1. Non hopping leg swinging forward to produce force 2. Foot of non-hopping leg remains behind hopping leg 3. Use of arms 4. Rhythmic hopping
Activity 2 15 minutes **<u>Equipment:</u>** Targets Batting tee Bats Tennis balls	**Target practice using two-hand strike** Keep the 3 teams as in activity 1 Each player takes it in turns to strike at the target Instructor gives tips on how to improve technique 1. Childs preferred hands grips bat above non-preferred hand 2. Non-preferred hip/shoulder faces straight ahead 3. Hip and shoulder rotate/derotate during swing 4. Steps with non-preferred foot 5. Hits ball sending it straight ahead
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 7: Two-hand strike, balance, hop

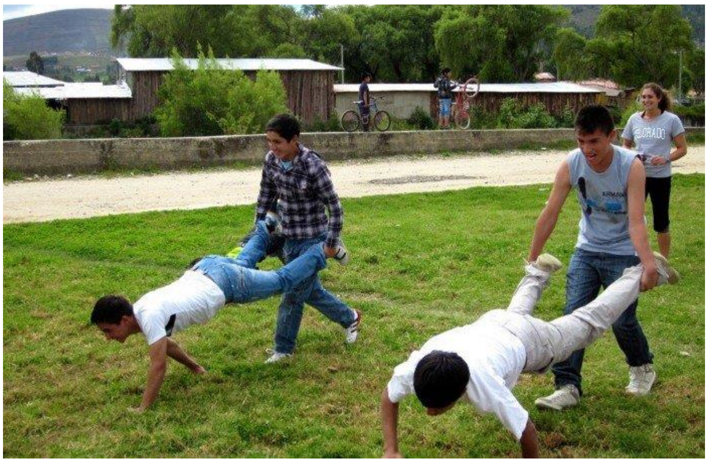
Warm up 10 minutes	**Balance tag** Four hoops placed around the hall (Standing in a hoop on one leg is the den) Two taggers hold a ball When a person is tagged, they take the ball and become the tagger. Incorporate different locomotor skills (skip, hop, jump, slide, gallop) Dynamic stretch
Activity 1 15 minutes **<u>Equipment:</u>** Cones Soft ball	**Balance Relays** **Set up:** 3 cones, 3 soft balls <u>Start:</u> Line up behind the cone **<u>1: Beanbag on head relay</u>** - Divide group into 3 teams, each team is given a beanbag. Individually, they place beanbag on head, run out to cone and back, passing the beanbag to the next team member **<u>2: Balance the ball relay</u>** - Children work in pairs to balance ball between their foreheads - Children work in pairs to balance ball between their backs - Wheel barrow race
Activity 2 15 minutes **<u>Equipment:</u>** Targets Batting tee Bats Tennis balls	**Hopping + Target practice using two-hand strike** Keep the 3 teams as in activity 1 **Obstacle 1:** Hopping through ladders **Variations** - Hop right foot - Hop left foot - Hop side ways - Hopscotch - Skip a box **<u>Hopping: watch out for</u>** 1. Non hopping leg swinging forward to produce force 2. Foot of non-hopping leg remains behind hopping leg 3. Use of arms 4. Rhythmic hopping **Obstacle 2:** Two-hand strike at target Each player takes it in turns to strike at the target Instructor gives tips on how to improve technique 6. Childs preferred hands grips bat above non-preferred hand

	7. Non-preferred hip/shoulder faces straight ahead 8. Hip and shoulder rotate/derotate during swing 9. Steps with non-preferred foot 10. Hits ball sending it straight ahead
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

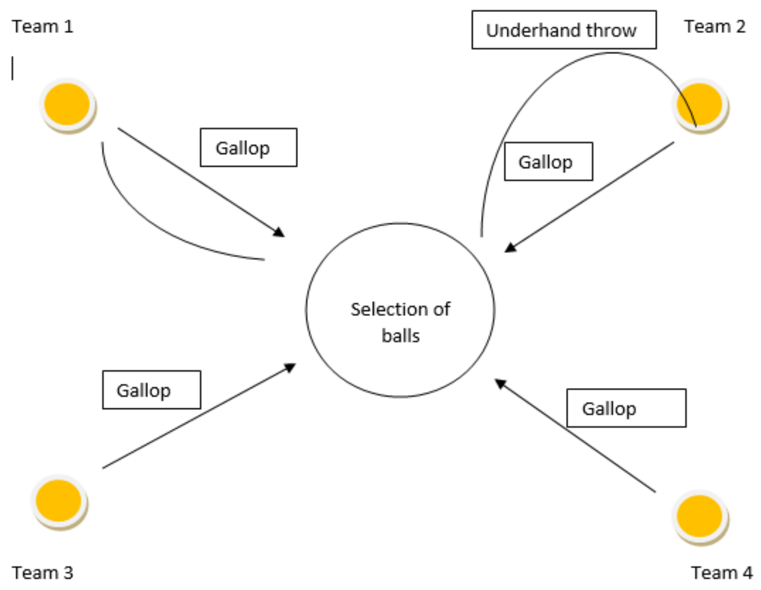
Hold the Ball

This relay game is played in pairs. Every pair stands face to face with each other and try to pinch ball between their foreheads without using their hands. Now every pair has to complete a distance without dropping the ball and is not allowed to use hands to hold it in place.

Wheel barrow race



Session 8: Throw, catch, gallop

Warm up 10 minutes	**Cups and Saucers** Randomly spread out cones with equal numbers turned upright (saucers) and upside down (cups). Make two teams calling one cups and the other saucers. Cups turn as many cones upright as possible and vice versa for saucers. Team with the most cones turned their way wins. Play 4x1minute rounds. Dynamic Stretch
Activity 1 15 minutes **<u>Equipment:</u>** Cones Variety of balls Baskets	**Underhand throw + Gallop** 4 teams - one at each corner of a square Balls in the centre of square First team member gallops to centre to collect a ball. Must underhand throw to team member who catches it and places it in basket. If it is not caught, they must return the ball to the centre. Return to end of line once the ball goes in and next player goes then. Once all balls are gone from the centre, the team with the most balls in the basket at the end wins. 
Activity 2 15 minutes **<u>Equipment:</u>** Cones Hula hoops Beanbags Tennis balls	**Overhand throw:** 3 teams line up behind a cone Place 3 hoops out in front of each team 1st hoop = 10 points, 2nd hoop = 20 points, 3rd hoop = 30 points Team members must overhand throw the tennis ball/beanbag towards the hoops and aim to score as many points as possible by the end of the game • finger grip side on throw • driving through hip, shoulder, arm, elbow, wrist, fingers following through • You could ask … How will you achieve maximum distance when throwing the ball?
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 9: Throw, catch, gallop

<table>
<tr>
<td>Warm up
10 minutes</td>
<td>Zombie Tag

Two players are given bibs and one player given a soft ball. The bibs are the taggers. If someone gets tagged, they walk around like a zombie. The player with the ball can free the zombies by touching them with the ball. Start with running, then have children gallop or skip for other rounds.

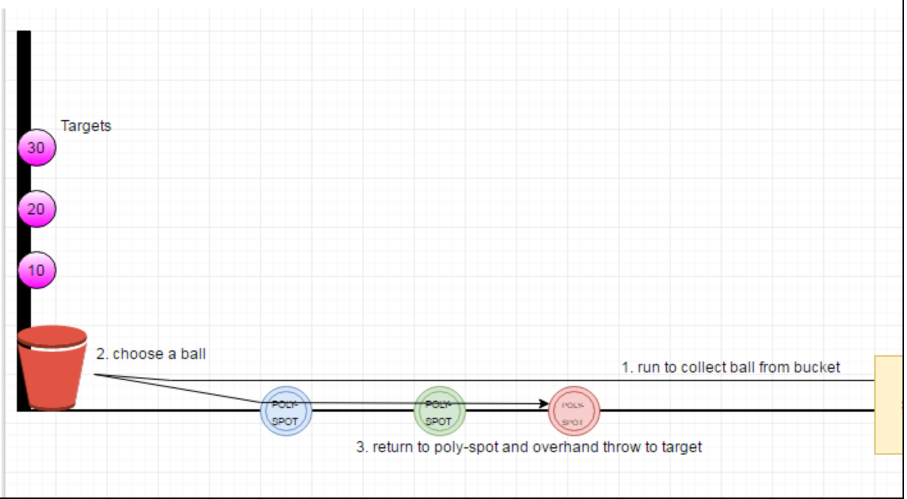
Dynamic Stretch</td>
</tr>
<tr>
<td>Activity 1
10 minutes

<u>Equipment</u>
<u>:</u>

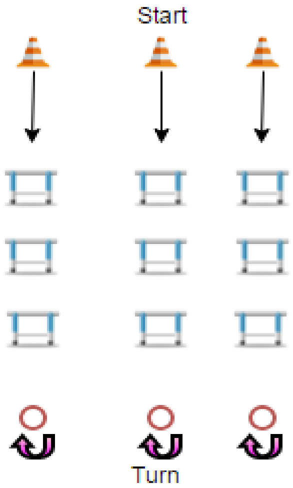
Cones
Variety of balls
Baskets</td>
<td><u>Overhand throw:</u> <u>Target throw</u>
Two teams line up
Place targets on the wall with points allocated to each target
Leave bucket of ball beside at the end of the hall
Players must run to the bucket, choose a ball of choice return to a poly-spot of their choice and aim for a target. (Change method of movement to collect ball. E.g. gallop, skip etc.
Each team adds up their score as they go along

After a player throws they must collect their ball and pass it to the next player who will then return it to the bucket and choose a different ball.

Encourage good technique for running/galloping out
Pay attention to use of arms
Encourage players to challenge themselves (don’t always choose the closest marker)
Watch for step forward with opposite foot
Side on stance
Follow through



</td>
</tr>
</table>

Activity 2 **Equipment:** Hurdles Cones Poly-spots Small balls/beanbags	**Horserace relays** **<u>Set up:</u>** 3 cones (1 for each team) 3 hurdles for each team Teams line up behind their cones The aim is to take it in turns galloping from the start cone to the end cone and jump the hurdles on the way. 
Activity 3 **Equipment:** Hurdles Cones Poly-spots Small balls/beanbags Baskets	**<u>Set up:</u>** **As above only take away the first hurdle and place a poly-spot in its place** **Place a bucket with small balls and beanbags at the end zone for each team** **Place a basket at the start line for each team** Players must gallop out, jumping hurdles along the way to their bucket. They can choose any ball/beanbag, gallop back to the poly-spot and then underhand throw to the next team member. The ball can only be put in the basket if caught cleanly. Players keep trying until the ball is caught, after which the next player goes.
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 10: Jump, kick, skip

<table>
<tr><td>Warm up
10 minutes</td><td><u>Skipping under the bridge</u>

Students skip around the designated playing area in pairs. Two students are nominated as ‘taggers’. When pairs of students are tagged, they face each other and form a bridge by joining hands and holding them above their heads. To release these students, a free pair of students must skip under the bridge.

Dynamic stretch</td></tr>
<tr><td>Activity 1
15 minutes

<u>Equipment:</u>

Cones
Footballs</td><td><u>Relays</u>
Divide into 3 teams, each team line up behind a cone

1. Skipping only
- Focus on different forms of skipping...high, low, zig-zag
- Skip from cone 1 to cone 2 emphasising good technique
- Focus mainly on correct use of arms

2. Skipping and dribbling (Place football at cone 2)
- Skip from cone 1 to cone 2
- Take football from cone 2 and dribble back to start
- Pass the ball to next player who dribbles to cone 2, this player leaves ball at cone 2 and skips back to start
- Continue for a few rounds
Remind players of good skipping technique
When dribbling, ensure they are keeping ball close and using instep/inside of foot to control the ball.</td></tr>
<tr><td>Activity 2

10 minutes

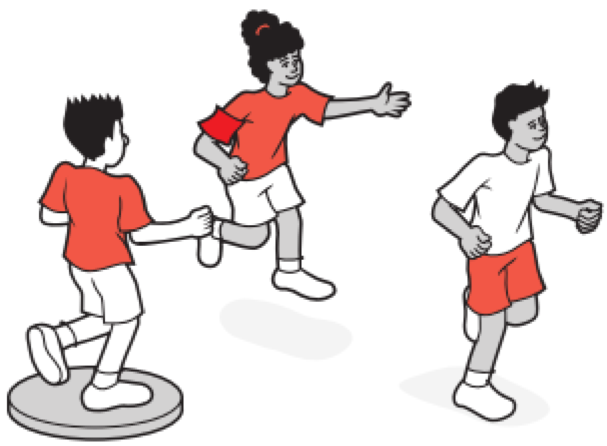
Equipment:
Hurdles
Cones
Poly-spots
Small balls/beanbags</td><td><u>Target practice to practice kicking technique</u>

<u>Use the same 3 teams from activity 1</u>

- Prop hula-hoops against the wall as a target
- Have players aim for the hula-hoop using a short run up to kick the ball
- <u>N.b.</u>
- Continuous run up
- Leap/longer final step before kicking the ball
- Kick with instep/inside of foot</td></tr>
</table>

Activity 3 **10 mins** **<u>Equipment</u>** Hurdles Poly-spots Footballs Cones	**<u>Jumping and kicking obstacle course</u>** Keep same teams as before Line up behind a cone **<u>Set up:</u>** 2 hurdles per team 2 poly-spots per team Football and hula-hoop per team - Start by jumping over hurdles starting and landing on two feet (emphasise use of arms) - Horizontal jump from poly-spots: Encourage them to jump as far as they can - Then run up and kick ball towards hula-hoops - Place ball back on cone and return to start
Cool Down 5 minutes	
Total 45 minutes	

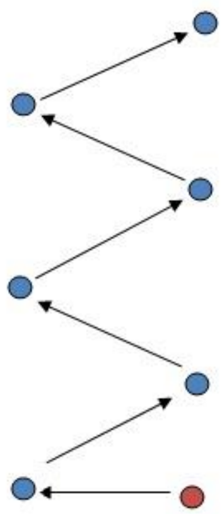
Session 11: Jump, kick, skip

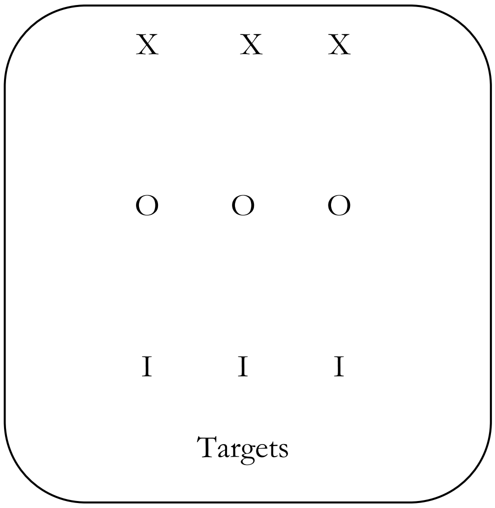
Warm up 10 minutes	<u>**Traffic Lights**</u> Children run around a circle marked out by cones Instructor stands in the middle and has a green, orange and red cone. Players must watch and react to the colour cone being held up On green: run around Orange: Slow down Red: Stop and balance Incorporate skipping/galloping/sliding **Dynamic Stretching**
Activity 1 15 minutes <u>**Equipment:**</u> Cones	**Skipping/jumping Tag** **Movement skills/concepts** Sustained skipping/jumping, skipping/jumping for speed and to evade an opponent, balance (static and dynamic). Set-up Bands to identify the taggers, discs/spots. Grass or hard area. Groups of approximately 10, including two to three taggers (each wearing a band) per group. **Activity:** This simple tag game incorporates hopping /skipping/jumping Taggers hop/skip/jump to tag other participants who are also hopping/skipping jumping within the designated area. When a person is tagged, the tagger gives their band to that person, who then becomes the tagger, while the previous tagger joins the rest of the group. You cannot be tagged if you are standing in a stork balance on one of the discs in the area. Change it up: If you're on a disc, you cannot be tagged but must be performing vertical jumps – as high as possible  **Can you see …?** • skipping only • heads up to see where they are going using arms for balance **Variations** • Skipping high, low, long etc. Vary locomotor skill: Leap, jump or skip

Activity 2 10 minutes **Equipment:** Cones Poly-spots Footballs Skittles	**<u>Game 2: Obstacle course/Relays</u>** Divide into 3 teams **<u>Relay 1: Dribble/Kicking</u>** Dribble ball from start as far as poly-spot. Place ball on poly-spot and aim to knock over skittle. 1 point for each score. After aiming for skittle, pass ball back to next team member and skip back to the start. **<u>Variation:</u>** Can add in cones that they have to dribble around if it gets too easy **<u>Main focus:</u>** Kick with instep of foot Use arms when skipping
Activity 3 **<u>Equipment</u>** Hurdles Poly-spots Footballs Cones Skittles	**<u>Practice jumping:</u>** Practice horizontal jump from one side of the hall to the next Aim is to try and get from one side to the next with as few jumps as possible Instruct the children on each jump - Ready position: (knees bent and arms behind back) - Jump (arms propel above head, two feet come off the ground together and land together) - Landing (knees bend to absorb force) **<u>Relay 2: Jumping and kicking</u>** Jump as far as they can x2, Jump over mini hurdles x2, run up and kick ball at skittle. 1 point for each skittle knocked over. Make sure ball is placed back on poly-spot after each go. **<u>Main focus:</u>** Leap before kicking ball Place non-kicking foot close to ball
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 12: Forehand strike, dribble, slide

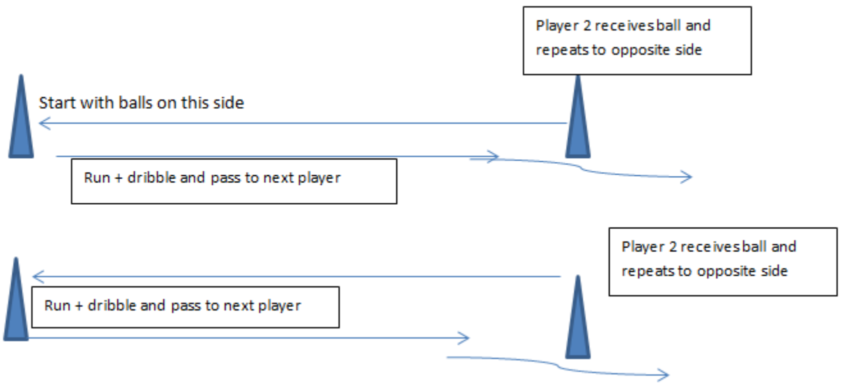
Warm up 10 minutes	• Animal moves • Traffic lights (sliding around a circle) • Dynamic Stretch
Activity 1 **<u>Equipment:</u>** Cones Rackets Tennis balls Targets Basketballs/ Playground balls	**<u>Forehand Strike</u>** *Concept:* 1 hand strike, stationary throw to bouncing, striking, ➢ Place targets on the wall at varying heights ➢ Set up a starting point 3 meters from the wall ➢ Grab the racket with one hand and the ball with the other ➢ Bounce the ball, then forehand strike the ball with the other aiming towards the target *Activity:* A striking game working on hand eye coordination, the game incorporates bouncing, striking and coordination. ➢ The child picks up the ball with one hand and picks up the racket with the other; the child will then bounce the ball in front of them and strike the ball towards the target.  *Can you see?* ➢ One hand strike ➢ Eye of the ball ➢ Bouncing the ball with the opposite hand to the striking hand

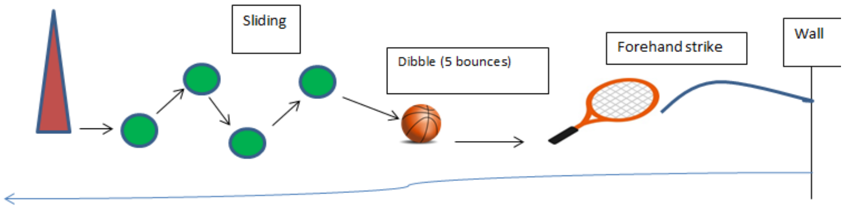
Activity 2 10 minutes **Equipment:** Cones Playground balls	**Zig-Zag Dribble** *Concept:* lateral shuffle side to side, legs and arms moving in the same directions, facing the same direction while going one way, dribbling a ball with one hand continuously. **Activity** lateral movement, 1 hand dribble, ball control, coordination ➢ A game focused on lateral movement in diagonal directions and the child will dribble the ball changing hands at every second cone.  *Can you see?* ➢ Correct lateral shuffle ➢ 1 handed dribble ➢ Use of both hands
Activity 3 **<u>Equipment</u>** Cones Playground balls Rackets Tennis balls Targets	Relay races *Concept*: A race which is involving all three new skills and combining them into one continuous event *Activity*: lateral movement, striking a ball, dribble a ball ➢ The child will start by sliding from the start cone (X) up to a ball (O), they will then pick the ball and dribble it 5 times with favourable hand, they will then slide to the next cone (I) where they will pick up a ball in one hand and the racket in the other, then striking the ball towards targets on the wall

<table>
<tr><td></td><td>

X – Start
O- Dribble the ball
I- Strike the ball</td></tr>
<tr><td>Cool Down
5 minutes</td><td>Gentle jog and stretch</td></tr>
<tr><td>Total
45 minutes</td><td></td></tr>
</table>

Session 13: Forehand strike, dribble, slide

Warm up 10 minutes	Stuck in the mud: Sliding only Dynamic stretch
Activity 1 **<u>Equipmen</u>** **<u>t:</u>** Cones Basketballs	**Dribble + slide** Set up square using cones Divide group into 4 with 1 group behind each cone Start with balls at one side First child dribbles ball and passes to the child at the opposite side and goes to the back of the line which they passed to **Add in variations** - Dribble while sliding - Dribble with other hand - Dribble in and out between cones - Dribble and stop at poly-spots bouncing 4 times on a poly-spot before moving on 
Activity 2 10 minutes **Equipmen** **t:** Rackets Tennis balls Targets	**Forehand strike** Target practice like before focussing on technique - Step forward with opposite foot - Shoulder facing direction of target - Holding racket with preferred hand - Bounce the ball correctly and timing of swing - Move further away from target each time
Activity 3 **<u>Equipmen</u>** **<u>t</u>** Basketball Cones Poly-spots Rackets Tennis balls	**Relay to incorporate dribbling, sliding and forehand strike** Slide from cone to cone swapping sides each time Bounce ball 5 times Forehand strike towards target Return to back of group line

	
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 14: Two-hand strike, hop, balance

<table>
<tr><td>Warm up
10 minutes</td><td><u>Group up</u>

Children run around the hall. Instructor blows the whistle and calls a number. Children form group of that number and stand on one leg. Go on whistle again. Incorporate hopping, skipping galloping etc.

Dynamic stretch</td></tr>
<tr><td>Activity 1
10 minutes

<u>Equipment:</u>

Cones</td><td>Sideways plank relay

Players must walk sideways with hands and feet on the ground. They must go around the cone and back to the next team member. If knees touch the ground they start again. First team with all players back wins.

Variations:
- Bear crawls
- Crab walks

<u>Main focus:</u>
Balance/body control</td></tr>
<tr><td>Activity 2

10 minutes

Equipment:
Beanbags
Tennis balls
Cones
Baskets</td><td>Hopping challenge

Divide into 3 teams
Each team lines up behind a cone
Place a basket beside each team cone
Place a bag of small balls and beanbags at the other end

<u>Aim: to gather as few balls as possible</u>
Players hop from the start to the end zone where the balls are. They must count the number of hops they take and pick out that number of balls/beanbags. Players return the balls/beanbags to their team basket. The team with the least number of balls/beanbags wins.

Main focus:
- Hop for distance
- Encourage pendular motion of leg and use of arms to gain extra distance</td></tr>
<tr><td>Activity 3
10 minutes
<u>Equipment</u>
Bats
Batting tee
Tennis balls
Targets</td><td>Hopping followed by 2-hand strike at target

Players hop from start to batting station. Two hand strike the ball towards the target on the wall. Collect ball, place it back on the batting tee and hop back to next team member. Repeat until all members of each team have completed the relay.</td></tr>
<tr><td>Cool Down
5 minutes</td><td>Gentle jog and stretch</td></tr>
<tr><td>Total
45 minutes</td><td></td></tr>
</table>

Session 15: Two-hand strike, hop, balance

<table>
<tr><td>Warm up
10 minutes</td><td>• Traffic lights going around the circle (child must stop when 'red' is shouted and stand on 1 leg until 'green' is shouted.

• Dynamic Stretch</td></tr>
<tr><td>Activity 1
10 minutes

<u>Equipment:</u>

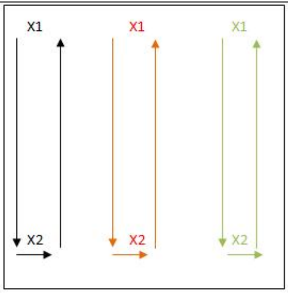
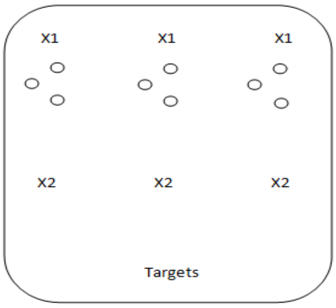
Cones
Batting tee
Bat
Tennis ball
Target</td><td>Two hand strike
Concept: 2 hand strike, ball on a stationary baseball tee, striking,
➢ Place targets on the wall at varying heights
➢ Set up a starting point 3 meters from the wall
➢ Place the tennis ball on the baseball batting tee
➢ Strike the ball with two hands on the bat, aiming towards the target
Activity: A striking game working on coordination, the game incorporates striking and coordination.
➢ The batter places the tennis ball on the batting tee, picks up the bat with two hands; the batter will then strike the ball towards the target

Can you see?
➢ Two hand strike
➢ Eye of the ball
➢ Correct body position prior to strike

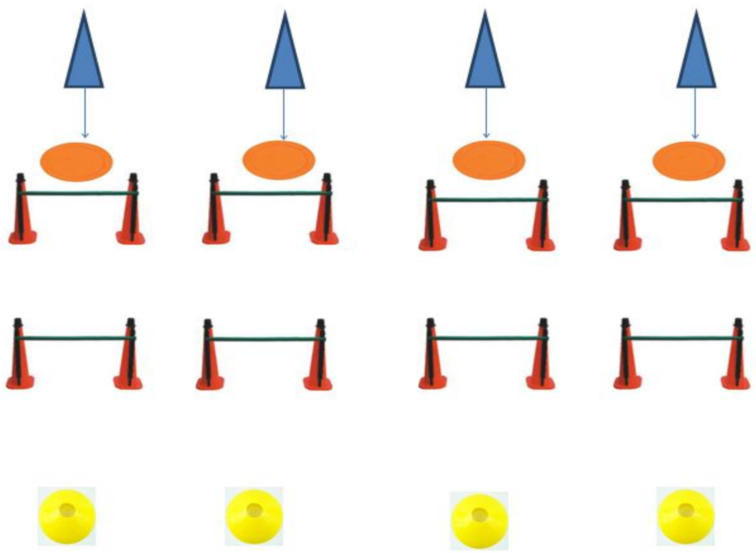
 </td></tr>
<tr><td>Activity 2

10 minutes

Equipment:
Cones
Rackets
Tennis balls
Beanbags</td><td><u>Balance relay race</u>
Concept: A series of balance games incorporated into one race involving balancing of objects
Activity Objet balancing, coordination
• The game will focus on balancing objects while moving. The children will be divided evenly into groups. The first person in the group will place a tennis ball on a tennis racket and balance the ball to the next cone. There they will place down the ball and racket and place a bean bag on their head and return to the start where the next person will take the bean bag and go towards to next cone. if the child drops the ball/bean bag they must return to nearest cone</td></tr>
</table>

	 X1- Start Point with tennis ball and racket X2- change over from racket to bean bag on head, and then return to X1.   *Can you see?* ➢ Correct balancing technique? ➢ Balancing bean bag and ball without use of hands? ➢ Enjoyment?
Activity 3 10 minutes **<u>Equipment</u>** Bats Batting tee Tennis balls Targets Ladders	Relay races (hop, balance and two hand strike) *Concept*: A race which is involving all three new skills and combining them into one continuous event *Activity*: balance, hopping and two hand strike ➢ The children will be divided evenly into groups. The first child in each group will single leg hop from the start cone(X1) to a Lilly pad/cones (O), they will then hop landing on the opposite foot to another Lilly pad/cone and so on. After the final Lilly pad they run to the next cone (X2) and will pick up the bat and strike the stationary ball towards the wall aiming for a target then return to the start for the next person to go.  X1 – Start O- Single leg hop on Lilly pad X2- Two handed strike *Can you see?* ➢ Correct execution of each skill individually ➢ Do the children understand each concept of the drill ➢ Are the children listening to instruction given earlier in the lecture? Option: Use ladders instead of poly-spots for hopping
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Session 16: Throw, catch, gallop

Warm up 10 minutes	**<u>Warm up:</u>** Cups and saucers Dynamic Stretch
Activity 1 10 minutes **<u>Equipment:</u>** Cones Hurdles Poly-spots Tennis balls Beanbags Small balls	**Galloping relays with hurdles** Divide into 4 teams Set up: start cone, 2 hurdles, end cone per team Each team lines up behind their start cone, player gallops out over hurdles and around end cone, gallops back over hurdles and high fives next player to go. 
Activity 2 10 minutes **Equipment:**	**Galloping relays + underhand throw and catch** Set up: as above with poly-spot before the first hurdle Each team has a soft ball. First player runs over hurdles around end cone and stops on poly-spot on the way back. On the poly-spot, they underhand throw the ball to the next team member who must catch it with two-hands. If they catch it, they go. If not, the ball must be thrown again until caught. **Galloping:** watch out for use of arms and good rhythm
Activity 3 10 minutes **<u>Equipment</u>**	**Overhand throw** Set up: as game 2 with hula-hoops in place of end cones Players start by standing at poly-spot and overhand throw a tennis ball towards the hula-hoop. Teams score a point for each ball that bounces inside the hoop. After the ball is thrown, that player must collect the ball and pass it to the next team member. **Underhand throw**: watch out for stepping forward with opposite foot and using appropriate force to throw to next player **Overhand throw:** step forward with opposite foot, turn hip and shoulder towards target and follow through after throwing.
Cool Down 5 minutes	Gentle jog and stretch
Total 45 minutes	

Appendix G: Final version of questionnaire

1. Perceptions and attitudes of PE among practising Irish primary school teachers

This study is being conducted as part of a PhD study at Athlone Institute of Technology. The purpose of this study is to investigate Irish primary school teachers' perceptions and attitudes of PE and their perceived efficacy to teach PE.

Benefits:

There are no direct benefits for your participation. However, the information gathered may provide general future benefits to Irish primary school teachers and pupils. The results may highlight key areas that need to be addressed to ensure teachers feel confident and competent in their ability to facilitate high-quality PE programmes. The information may guide the development of future teacher-training programmes and inform policymakers of the key components to be addressed within the Irish primary PE curriculum.

Risks:

The risks associated with participation in this study are minimal. All data will be collected anonymously meaning the risk of breach of confidentiality is minimal. No identifying information such as name, school name or date of birth will be gathered or stored. ID numbers will be assigned when storing data. All electronic copies of data provided will be stored securely with encrypted passwords and any physical copies will be stored in a locked filing cabinet accessible only to the principal investigator of the study. The security of questionnaire information that is gathered and stored in an online database cannot be guaranteed. Any information collected online from you may be intercepted, corrupted, lost or destroyed. In order to reduce any of the named risks, at the end of this study, all results will be downloaded from the online database and all responses will be permanently deleted from the online database.

Requirements for participation:

In order to participate, you must be a mainstream teacher in an Irish primary school with a minimum of one-year teaching experience.

Researcher Contact Information:

If you have any further questions about this research study, you may contact any of the following:

- Ms Lisa Kelly, Email: l.kelly@research.ait.ie, Phone: 090 646 8059 (principal investigator)
- Dr Niamh Ní Chéilleachair, nnicheilleachair@ait.ie, 090 644 2594 (supervisor)
- Dr Siobhán O'Connor, siobhan.oconnor@dcu.ie, 01 700 8579 (supervisor)

Freedom of withdrawal:

Your participation in this online questionnaire is greatly appreciated, however, participation is completely voluntary, and you are free to withdraw participation at any point throughout, by closing the questionnaire.

By clicking "I consent to participate" you are indicating that you meet the criteria for participation and that you have read the above information and are informed of the study requirements, benefits and potential risks, have been provided with contact details for the study researchers, and are freely volunteering to participate in this research study.

* 1. I consent to participate

☐ Yes ☐ No

1

2. Background Information

* 2. Gender

- [ ] Male
- [ ] Female

* 3. Age

☐ <21	☐ 36-40
☐ 21-25	☐ 41-45
☐ 26-30	☐ 46-50
☐ 31-35	☐ 51+

* 4. Years of teaching experience

Overall __________

In current school __________

5. What class group(s) are you currently teaching?

____

* 6. How many children are in your classroom?

Males __________

Females __________

7. Please answer the following in relation to your school

Where is your school located (rural, small town, large town or city)?	
In what County is your school located?	
What is your school ethos (Catholic, Church of Ireland, Multi-denominational, Inter-denominational or other)?	
How many mainstream teachers are in your school?	
Are your PE facilities adequate or inadequate?	
Please outline the PE facilities currently available in your school (e.g. indoor hall, pitches, playground, outdoor concrete area etc.)	
Is your school DEIS urban band-1, DEIS urban band-2, rural DEIS, non-DEIS rural or Non-DEIS urban?	

* 8. Please describe your current school PE context by indicating who is responsible for teaching PE to your current class

	Never	Now and then	Sometimes	Quite often	Often	Always
Myself as class teacher	○	○	○	○	○	○
Further information						
Full-time specialist PE teacher	○	○	○	○	○	○
Further information						
Part-time specialist PE teacher	○	○	○	○	○	○
Further information						
Another teacher in the school who is more interested in sport and PE	○	○	○	○	○	○
Further information						
External sports coach (please outline type of coach in box below)	○	○	○	○	○	○
Further information						
Any other external provider (please give details in box below)	○	○	○	○	○	○
Further information						

* 9. If your school utilises external providers (such as specialist PE teachers/coaches etc.) for ANY PE activities, please state how many are involved with teaching your class during a typical school year.

Other (please specify)

* 10. If your school utilises external providers (such as specialist PE teachers/coaches etc.) for ANY PE activities, please list/describe their level of involvement and specific activities taught to your class.

Activities taught

Qualifications of external provider(s) (if known)

Number of weeks spent teaching your class

4

* 11. What level of education have you completed?

- [ ] National Teacher Certificate
- [ ] BEd Primary Teaching (3 year degree)
- [ ] BEd Primary Teaching (4 year degree)
- [ ] Postgraduate Diploma in Primary Education
- [ ] Postgraduate Masters in Education Primary (PMEP)
- [ ] Certificate in Primary Physical Education
- [ ] Diploma in Primary Physical Education
- [ ] Masters in Education
- [ ] PhD (provide details in comment field)
- [ ] Training received outside Ireland (provide details in comment field)
- [ ] Other (provide details in comment field)

Comment field

3. Feelings about PE and PE teaching

Directions: Only think about <u>PE LESSONS</u> when answering each statement and not school sport or after-school sport. These questions refer to your feelings as a teacher.

* 12. As a teacher, please indicate the degree to which you AGREE or DISAGREE with the following statements concerning your feelings about PE.

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
I would like to teach PE everyday	○	○	○	○	○	○
I enjoy teaching PE	○	○	○	○	○	○
I am generally enthusiastic about teaching PE	○	○	○	○	○	○
PE is an important component of the curriculum	○	○	○	○	○	○
I am very confident in my ability to teach PE	○	○	○	○	○	○
I have limited knowledge for teaching PE	○	○	○	○	○	○
My PE teaching expertise comes from my personal interest in sport and exercise	○	○	○	○	○	○
I tend to revert back to my own experiences of PE as a child to guide my current approach to teaching PE	○	○	○	○	○	○

4. Teaching perceptions about PE

* 13. I feel confident teaching

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree	N/A
Games	○	○	○	○	○	○	○
Athletics	○	○	○	○	○	○	○
Outdoor and Adventure	○	○	○	○	○	○	○
Gymnastics	○	○	○	○	○	○	○
Aquatics	○	○	○	○	○	○	○
Dance	○	○	○	○	○	○	○

* 14. For each aspect of teaching listed in the table below, indicate how***YOU*** perceive **YOUR LEVEL OF COMPETENCE IN RELATION TO PE**

	Very incompetent	Incompetent	A little incompetent	Somewhat competent	Competent	Extremely competent
Lesson planning for PE	○	○	○	○	○	○
Long-term planning for PE (e.g. making long-term plan to ensure all strand areas are covered)	○	○	○	○	○	○
Subject content knowledge relating to PE	○	○	○	○	○	○
Implementing teaching and learning strategies in PE	○	○	○	○	○	○
Assessing student learning in PE	○	○	○	○	○	○
Reporting on student outcomes in PE	○	○	○	○	○	○
Identifying individual differences in PE	○	○	○	○	○	○
Managing the class in PE	○	○	○	○	○	○
Ability to evaluate your PE teaching	○	○	○	○	○	○

* 15. Would you prefer a PE specialist to teach your class?

- ☐ Yes - full time basis (give details of what you would do during PE time instead)
- ☐ Yes - part time basis (give details of what strand areas specifically)
- ☐ Yes - occasional consultative basis (but only to learn from the specialist and improve my confidence to teach PE)
- ☐ No - I am happy to cover all aspects of the PE curriculum with my class
- ☐ No - I am happy to teach all aspects of the PE curriculum (but welcome external providers like GAA coaches, yoga teachers etc. for extracurricular activities that do not take away from PE time specifically)

Details of your response

16. Please list any other subjects you would like a specialist to teach

* 17. To what extent do you agree/disagree with the following statements

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
A strong teacher-child relationship is essential for teaching PE	○	○	○	○	○	○
I consider each child's strengths/weaknesses when teaching PE	○	○	○	○	○	○
I consider each child's likes/dislikes when teaching PE	○	○	○	○	○	○
I consider the needs of each child when teaching PE	○	○	○	○	○	○
I consider the impact that the quality of my PE classes may have on each child's willingness to engage in healthy lifestyle behaviours within and outside of school	○	○	○	○	○	○

5. Perceptions of PE content within your pre-service and in-service teacher training

* 18. Please rate the quality of your **pre-service** teacher education as it relates to the following **PE CONTENT** areas

	Very poor	Poor	Fair	Average	Good	Excellent
Games	○	○	○	○	○	○
Athletics	○	○	○	○	○	○
Outdoor and Adenture	○	○	○	○	○	○
Gymnastics	○	○	○	○	○	○
Aquatics	○	○	○	○	○	○
Dance	○	○	○	○	○	○

* 19. "My **pre-service** teacher education prepared me to teach PE effectively"

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
○	○	○	○	○	○

* 20. Have you undertaken any **in-service** upskilling/ teacher education courses or workshops for PE?

○ Yes ○ No

21. If you answered yes to Q20 please specify the course(s) undertaken and duration of each.

Course 1 name

Duration of course 1

Course 2 name

Duration of course 2

Course 3 name

Duration of course 3

Course 4 name

Duration of course 4

If more than 4 were undertaken, list remaining in this box

* 22. "In general, the **in-service** upskilling/ teacher education courses or workshops for PE, improved my ability to teach PE"

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree	N/A
○	○	○	○	○	○	○

23. In response to Q22, please comment on how and why the course did/did not improve your ability to teach PE

* 24. What is your understanding of fundamental movement skills?

* 25. Did any **in-service** teacher education courses/workshops focus primarily on fundamental movement skills (e.g. basic skills like running, skipping, catching, throwing, striking, balancing etc.)?

- ◯ Yes
- ◯ No
- ◯ N/A

26. If you answered yes to Q25, please state the name of the course and if it was effective/ineffective

* 27. Do you use the physical literacy (Move Well, Move Often) resources on the PDST.ie website?

Never	Now and then	Sometimes	Quite often	Often	Always
◯	◯	◯	◯	◯	◯

If you use the PDST resources, to what extent and how do they help you with teaching PE?

6.

28. If you have had no input to the delivery of PE for your class in the past year, please tick the 'no input' box, otherwise, click 'continue'.

- ○ No input
- ○ Continue

7. Perceptions of your PE teaching experiences

* 29. When **YOU HAVE TAUGHT PE** lessons (in the last 12 months or so), please indicate how often your class participated in the following activities

	Never	Now and then	Sometimes	Quite often	Often	Always
Games	◯	◯	◯	◯	◯	◯
Athletics	◯	◯	◯	◯	◯	◯
Outdoor and Adventure	◯	◯	◯	◯	◯	◯
Gymnastics	◯	◯	◯	◯	◯	◯
Aquatics	◯	◯	◯	◯	◯	◯
Dance	◯	◯	◯	◯	◯	◯

* 30. How do you currently rate your level of commitment to teaching PE?

Very low	Low	Somewhat low	Somewhat high	High	Very high
◯	◯	◯	◯	◯	◯

* 31. List 3 specific activities you seem to spend most time teaching during PE lessons

* 32. How successful do you feel YOUR PE programmes have been in achieving STUDENT LEARNING OUTCOMES for the following PE strands (think about PE lessons taught in the last 12 months)?

	Very unsuccessful	Unsuccessful	Somewhat unsuccessful	Somewhat successful	Successful	Very successful
Games	◯	◯	◯	◯	◯	◯
Athletics	◯	◯	◯	◯	◯	◯
Outdoor and Adventure	◯	◯	◯	◯	◯	◯
Gymnastics	◯	◯	◯	◯	◯	◯
Aquatics	◯	◯	◯	◯	◯	◯
Dance	◯	◯	◯	◯	◯	◯

* 33. On average, how many minutes per week do you teach PE? (if below 60 minutes, give a reason why)

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* 34. During your PE lessons, how would you most accurately describe the following statements?

	Never	Now and then	Sometimes	Quite often	Often	Always
I focus mostly on competition and winning	◯	◯	◯	◯	◯	◯
I use skill practices to teach fundamental movement skills (e.g. running, skipping, kicking, catching, throwing etc.)	◯	◯	◯	◯	◯	◯
I use small sided games to teach fundamental movement skills (e.g. running, skipping, kicking, catching, throwing etc.)	◯	◯	◯	◯	◯	◯
I let children in the class choose the activities for a PE lesson	◯	◯	◯	◯	◯	◯
I use a combination of skill practices and games	◯	◯	◯	◯	◯	◯
Fundamental movement skills are an important focus of the lesson	◯	◯	◯	◯	◯	◯
All children come away from the lesson having experienced a sense of achievement	◯	◯	◯	◯	◯	◯
The focus is on self-improvement rather than competition	◯	◯	◯	◯	◯	◯

* 35. To what extent do you agree/disagree with the following statements?

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree	N/A
I am confident in my ability to differentiate/adapt PE lessons to suit both overweight and non-overweight children	○	○	○	○	○	○	○
I am confident in my ability to differentiate/adapt PE lessons according to each child's athletic ability	○	○	○	○	○	○	○
I am confident in my ability to differentiate/adapt PE lessons so that boys and girls are equally engaged with the lesson content	○	○	○	○	○	○	○
I am confident in my ability to differentiate/adapt PE lessons for children with a learning disability	○	○	○	○	○	○	○
I am confident in my ability to differentiate/adapt PE lessons for children with a physical disability	○	○	○	○	○	○	○
I am confident in my ability to differentiate/adapt PE lessons for children with diagnosed disorders such as dyspraxia, autism, asbergers, ADHD etc	○	○	○	○	○	○	○

* 36. To what extent do you reinforce the seven key considerations when planning a programme of PE

	Never	Now and then	Sometimes	Quite often	Often	Always
The importance of enjoyment and play	○	○	○	○	○	○
Maximum participation by all children	○	○	○	○	○	○
The development of skills and understanding	○	○	○	○	○	○
A balance between competitive and non-competitive activities	○	○	○	○	○	○
A balance between contact and non-contact activities	○	○	○	○	○	○
Providing opportunities for achievement for each child	○	○	○	○	○	○
Providing activities equally suitable for girls and boys	○	○	○	○	○	○

* 37. Please indicate the degree to which you **AGREE** or **DISAGREE** with the following statements with reference to **<u>PLANNING</u> YOUR PE PROGRAMME**

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
The school has a formal planning team that meets routinely to monitor and initiate programmes to promote PE in the school	◯	◯	◯	◯	◯	◯
My PE programme is developed from an overall PE policy	◯	◯	◯	◯	◯	◯
The school policy clearly outlines allocation of curriculum time to PE	◯	◯	◯	◯	◯	◯
Parents are involved in the planning process for PE	◯	◯	◯	◯	◯	◯
Students needs are considered when planning for PE	◯	◯	◯	◯	◯	◯
The school provides an overview of specific content to be covered in PE for each class which helps to guide my planning for PE lessons	◯	◯	◯	◯	◯	◯

* 38. Please indicate the degree to which you AGREE or DISAGREE with the following statements with reference to **ASSESSMENT** (i.e. monitoring the effectiveness of the PE lessons in achieving student learning outcomes) IN YOUR PE PROGRAMME

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
A range of assessment strategies are used to assess student learning in PE	○	○	○	○	○	○
The assessment process is based on the curriculum outcomes and reflect the curriculum content	○	○	○	○	○	○
I use teacher observations informed by success criteria in my PE lessons	○	○	○	○	○	○
I encourage child-led assessments in PE (e.g. self-assessment, peer assessment etc.)	○	○	○	○	○	○
I use teacher-designed tasks and tests to assess student learning in PE	○	○	○	○	○	○
I keep records of student learning in PE each week	○	○	○	○	○	○
I find it difficult to assess student learning in PE	○	○	○	○	○	○
I don't assess student learning in PE	○	○	○	○	○	○
I am comfortable with assessing student learning in PE	○	○	○	○	○	○

* 39. Please indicate the degree to which you AGREE or DISAGREE with the following statements with reference to **REPORTING** IN YOUR PE PROGRAMME

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
Students achievement of outcomes are reported and communicated to the relevant audience	○	○	○	○	○	○
Parents/caregivers are given feedback regarding what their child knows and what skills they have gained in PE	○	○	○	○	○	○

* 40. Please indicate the degree to which you AGREE or DISAGREE with the following statements with reference to **EVALUATION** IN YOUR PE PROGRAMME (i.e. judging the effectiveness of your overall PE programme)

	Strongly disagree	Disagree	Disagree slightly	Agree slightly	Agree	Strongly agree
Evaluation of PE programmes is ongoing	○	○	○	○	○	○
Evaluation of PE programmes is comprehensive	○	○	○	○	○	○
Programmes in PE are modified and improved as a result of evaluation	○	○	○	○	○	○

8. Factors influencing the delivery of PE

* 41. Please indicate the degree to which the following act as barriers to the delivery of your class PE programmes where 1 = No barrier and 6 = Major barrier

	1	2	3	4	5	6	N/A
Inadequate pre-service training in PE	◯	◯	◯	◯	◯	◯	◯
Class size too big	◯	◯	◯	◯	◯	◯	◯
Low levels of teaching confidence	◯	◯	◯	◯	◯	◯	◯
Lack of time	◯	◯	◯	◯	◯	◯	◯
Poor level of staff support provided	◯	◯	◯	◯	◯	◯	◯
Inadequate facilities	◯	◯	◯	◯	◯	◯	◯
Inadequate equipment	◯	◯	◯	◯	◯	◯	◯
Poor personal experiences in PE	◯	◯	◯	◯	◯	◯	◯
Low levels of personal interest and enthusiasm in PE	◯	◯	◯	◯	◯	◯	◯
Negative executive attitudes towards PE (i.e. board of management/ principal)	◯	◯	◯	◯	◯	◯	◯
Negative parental attitudes towards PE	◯	◯	◯	◯	◯	◯	◯
Lack of CPD (i.e. in-service courses)	◯	◯	◯	◯	◯	◯	◯
Negative student attitude towards PE	◯	◯	◯	◯	◯	◯	◯
Litigation concerns	◯	◯	◯	◯	◯	◯	◯
Demands to teach other subject areas	◯	◯	◯	◯	◯	◯	◯
No opportunity to teach due to the number of external providers in the school	◯	◯	◯	◯	◯	◯	◯
Lack of money budgeted to programmes	◯	◯	◯	◯	◯	◯	◯
Other (please specify in box below)	◯	◯	◯	◯	◯	◯	◯

Specify 'Other' here

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9. Final comments

42. Is there anything else you would like to add to help our understanding of your experiences in PE as a teacher?

Appendix H: Calculations to determine the number of schools required from each region

Calculation for stratum allocation for schools in each region

Region	Population	% of population	Required sample size
Border	484	16% [(484/3109)*100]	70 (436*0.16)
Dublin	445	14%	62
Mideast	294	9.5%	42
Midwest	400	13%	57
Southwest	474	15%	66
Midlands	241	8%	35
West	481	15.5%	68
Southeast	290	9%	40
Total	**3109**	**100%**	**440**

Border region: Target sample = 70 schools

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Border					
Cavan	65	3	0	7	75
Donegal	68	3	5	98	174
Leitrim	27	0	0	10	37
Louth	54	9	5	1	69
Monaghan	52	0	3	7	62
Sligo	51	2	2	12	67
Total	317	17	15	135	484
Percentage	65.5%	3.5%	3%	28%	100%
Target sample	70*0.655 **46**	70*0.035 **3**	70*0.03 **2**	70*0.28 **20**	**71**

Dublin Region: Target sample = 62

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Dublin	280	136	28	1	445
Total	280	136	28	1	445
Percentage	63%	31%	6%	0%	100%
Target sample	62*0.63 **39**	62*0.31 **20**	62*0.06 **4**	62*0.0 **0**	**63**

Mideast Region: Target sample = 42

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Mideast					
Kildare	90	2	5	3	100
Meath	108	0	3	2	113
Wicklow	75	2	2	2	81
Total	273	4	10	7	294
Percentage	93%	1%	3.5%	2.5%	100%
Target sample	**39**	**1**	**2**	**2**	**44**

Midwest Region: Target sample = 57

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Midwest					
Clare	98	1	4	9	112
Limerick	117	14	0	3	134
Tipperary	135	5	4	10	154
Total	350	20	8	22	400
Percentage	87.5%	5%	2%	5.5%	100%
Target sample	**50**	**3**	**2**	**3**	**58**

Southwest Region: Target sample = 66

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Southwest					
Cork	296	22	9	15	342
Kerry	110	0	5	17	132
Total	406	22	14	32	474
Percentage	85.5%	4.5%	3%	7%	100%
Target sample	**57**	**3**	**2**	**5**	**67**

Midlands Region: Target sample = 35

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Midlands					
Laois	56	5	0	2	63
Longford	26	5	0	6	37
Offaly	55	1	7	5	68
Westmeath	62	3	2	6	73
Total	199	14	9	19	241
Percentage	82%	6%	4%	8%	100%
Target sample	**29**	**2**	**2**	**3**	**36**

West Region: Target Sample = 68

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
West					
Galway	176	8	6	38	228
Mayo	87	2	1	73	163
Roscommon	73	0	2	15	90
Total	336	10	9	126	481
Percentage	70%	2%	2%	26%	100%
Target sample	**48**	**2**	**2**	**18**	**70**

Southeast Region: Target sample = 40

Region	Non-DEIS	Band-1	Band-2	Rural-DEIS	Total
Southeast					
Carlow	36	0	3	3	42
Kilkenny	66	0	2	3	71
Waterford	62	5	5	2	74
Wexford	83	4	4	12	103
Total	247	9	14	20	290
Percentage	85%	3%	5%	7%	100%
Target sample	**34**	**2**	**2**	**3**	**41**

Appendix I: Recruitment emails for questionnaire

Dear Principal,

My name is Lisa Kelly. I am a PhD student at Athlone Institute of Technology. I am emailing you with regard to my research project where I'm conducting an online questionnaire to investigate teachers perceptions, attitudes and perceived self-efficacy to teach physical education in Irish primary schools.

The hope is that this information will highlight specific areas that need to be addressed to further improve teaching and learning in physical education. I have generated a random sample of schools from all over Ireland and your school is one of the selected few. The questionnaire is to be completed by mainstream teachers in the school who have experience teaching PE for at least one year.

As it is a comprehensive questionnaire, it will take approximately **20-25 minutes** to complete. I would appreciate if you could forward this email to the relevant mainstream teachers in your school.

Any teacher who is willing to partake can email me directly at l.kelly@research.ait.ie and I will forward them the link to the questionnaire. I will also follow-up with a link to the survey to this email address. If you would prefer not to receive the link please let me know.

I would strongly encourage as many teachers as possible to complete the questionnaire in order to get a true representation of current perspectives. I am aiming to achieve an 85% response rate to limit the risk of bias on the matter and your help would be massively appreciated.

All data will be kept confidential and answers to the survey will be completely anonymous. Participation is voluntary and you may withdraw from the study at any time by closing the questionnaire.

I'm happy to answer any questions or queries you may have.

Kind Regards,

Lisa Kelly

Appendix J: Follow-up email

Dear Principal,

Thank you to those who have already completed the questionnaire on Teachers perceptions, attitudes and perceived efficacy to teach PE in Irish primary schools. However, I am looking for further responses to ensure my results are representative of the opinions of all primary school teachers in Ireland.

PE is an extremely important subject that sometimes gets pushed aside in favour of other curriculum demands or oftentimes due to lack of facilities and other issues. This questionnaire will help us to identify the supports that teachers and schools need to ensure that PE can be taught to an even higher standard than it is currently.

I understand schools are extremely busy but I would really appreciate if you could encourage as many mainstream teachers as possible to complete this questionnaire.

The link can be accessed here: https://www.surveymonkey.com/r/9YGBXXL

Kind regards,

Lisa