

Enhancing children's movement competence: Intervention implementation, evaluation, and the creation of a new, innovative assessment tool

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Authors Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, and that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

Name: Nathan Gavigan

PhD Title: Enhancing children's movement competence: Intervention implementation, evaluation, and the creation of a new, innovative assessment tool.

Movement Competence (MC) can be defined as the development of skill proficiency to ensure successful performance in a range of physical activities. Developing children's MC is important for teachers, but also for coaches, researchers, athletic therapists and physiotherapists. One key construct of overall MC are fundamental movement skills (FMS). Research has highlighted a low level of FMS proficiency in Irish children, emphasising the need to further refine, implement and evaluate the recently developed Moving Well-Being Well (MWBW) intervention among 1st and 2nd class primary school children. Findings from Phase One of this PhD study indicate that the MWBW intervention significantly improved overall FMS proficiency (22.79%), confidence, enjoyment of, and engagement in physical education among the participating children. A number of challenges to successful implementation were also identified, such as, the school calendar and teacher fidelity, with findings suggesting that teacher's fidelity had a direct impact on overall FMS improvement.

Recent literature has suggested that the definition of MC is evolving to incorporate both fundamental and functional movement skills. Despite this evolution in the way MC is being viewed, as well as the literature demonstrating the interdependent relationship between the two constructs, no practical, real-world tool has yet combined them together as one assessment. Phase Two of this research project aimed to design such a tool, using a Delphi process, including a panel of worldwide experts from numerous fields of expertise. Following the design of the tool, it's structural and convergent validity was examined. Findings suggest that the tool offers a time efficient, ecologically valid and specific alternative to current instruments such as the TGMD-3 and FMSTM, combining two essential constructs of children's motor competency.

Chapter 1: Introduction to the Thesis

Publications and Conference Proceedings

Journal Articles – Published

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Introduction to the Thesis

A Personal Journey

Throughout my life, physical activity (PA) and sport have been at the very heart of who I would define myself to be as a person. I have always had a deep, inherent love of sport, and sport has afforded me some of the greatest emotions and experiences of my life to date. Due to this, from a young age, I only ever intended on pursuing a career that allowed me to share this love and enthusiasm with others. In 2014, this resulted in a Bachelor of Science degree in Physical Education, Biology and Science in Dublin City University being the only course listed on my college application form. Thankfully, this journey began in September of that year, and quite early on a question was posed to me; why do you want to be a Physical Education (PE) teacher? Quite simply, my response was:

“Because I love sport and physical activity, I love working with young people, and I want to make a positive difference to the health and wellbeing of Irish children”.

As I began to spend more time in schools and getting involved in coaching my little brother's underage Gaelic football team in my local club, the need for this positive change became more and more apparent. I was shocked at the low level of skill, and lack of interest in PA that many children and adolescents had. One memory that has always stuck with me occurred at the beginning of my third year in university. I was on placement in a local post primary school. I wanted to teach Olympic handball through a TGfU (Teaching Games for Understanding) model, so I set up a simplified game to begin, and then intended to go out and work on some skills, then finish the class with another modified game (whole-part-whole approach). In order to get a feel for the ability level of each of the students, I put a condition on the first game. Before a team could shoot, they must pass the ball to each team member. I was confounded. Students (12-14 years old) could neither throw the ball to one another from just a couple of yards away, under no pressure, nor catch the ball with two hands. Around this time, I also noticed a lack of basic movement skills amongst many children involved in my little brother's team. Although they were much younger, they were likely to be the most

physically active children of that age. What I was seeing suggested that perhaps children did not have strong enough foundations on which to develop proficiency in these skills, which resulted in what I was seeing in post primary school children. This, I believe, may have been the tipping point that made me realise that if I really wanted to make a significant, positive difference, then I needed to do more than teach PE in a classroom. This realisation eventually culminated in the following thesis, which I hope, is the start of many more years of work in this space.

Why Physical Activity?

In Ireland, it is recommended that children and adolescents participate in at least 60 minutes of moderate to vigorous PA (MVPA) each day (Department of Health and Children, 2009). The most recent Children's Sport Participation and Physical Activity (CSPPA) study reports that only 17% of primary (13% of girls and 23% of boys) and 10% of post-primary students (7% of girls and 14% of boys) in Ireland meet these recommendations (Woods et al., 2018). Alarming, these figures represent a 2% drop in PA from the previous report published in 2010, suggesting that Irish children are becoming less physically active over time (Woods et al., 2010). This trend is cause for concern, as insufficient PA has been estimated to cause 6–10% of the major non-communicable diseases (NCD's) of coronary heart disease, type 2 diabetes, and breast and colon cancers worldwide (Lee et al., 2012). Many experts also hypothesise that the current global COVID-19 pandemic will further negatively impact the global levels of physical inactivity (Hall et al., 2021).

In light of current findings, increasing the amount of PA children and adolescents attain each day has become a global priority (World Health Organisation, 2019). Studies have found that PA participation in childhood is associated with PA participation in adolescence, and that individuals who have high PA in childhood are more likely to maintain a higher level of PA into adolescence, and then onto adulthood (Jaakkola and Washington, 2013; Lloyd et al., 2014). Therefore, the need to intervene in childhood is great, yet, to date, the majority of interventions aimed at increasing the PA levels of children and adolescents (Kriemler et al., 2011; Murillo Pardo et al., 2013; Salmon et

al., 2007) have failed to make a significant impact on a large scale (Beets et al., 2016). Such findings would indicate that in order to produce a more substantial change in behaviour, a fresh approach is needed (Metcalf, Henley, and Wilkin, 2012).

Physical Literacy – A Potential Solution

The concept of physical literacy (PL) has emerged as potentially a key determinant in engaging children in lifelong PA (Cairney et al., 2019; Edwards et al., 2017, 2018; O'Brien, Belton, and Issartel 2015; Mandigo et al., 2009; Belanger et al., 2018). The International Physical Literacy Association (IPLA) definition suggests that PL is made up of several components, namely: motivation, confidence, knowledge and understanding, and physical competence (IPLA 2017). This definition describes PL as a multi-faceted, complex construct, with each component inter-linking to contribute to the holistic development of each individual (Whitehead, 2010)

Since the adoption of this concept, several studies have explored the association between various health indicators (body mass index, waist circumference, body weight, grip strength, and cardiorespiratory fitness) and PL in children (Belanger et al., 2018; Comeau et al., 2017; Delisle Nyström et al., 2018; Holler et al., 2019; Lang et al., 2018; MacDonald et al., 2018; Saunders et al., 2018). Belanger et al. (2018) identified that children with higher PL scores were more likely to meet daily PA and sedentary behaviour recommendations suggesting that a focus on PL development may be a more effective approach.

Despite the positive association between PL and health indicators, research has demonstrated that children worldwide are below the desired level of proficiency in each component of PL (Gu, Chen, and Zhang, 2019; Tremblay et al., 2018). Recent studies have also found this to be the case in an Irish context. Behan (2020) and Peers et al. (2020) investigated the PL levels of 2,148 Irish primary school children (47% female, age range 5-12 years) using five core research measurements; fundamental movement skill, physical activity and motivation quality, perceived movement skill quality, physical self-efficacy and physical activity levels. The findings from this research showed a

dearth of proficiency across all PL components throughout Irish primary school children (Behan, 2020; Peers et al., 2020), emphasising the critical need for appropriate intervention.

Enhancing Movement Competence

Fundamental movement skills (FMS) are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018). Fundamental movement skills are typically classified into three areas: locomotor, object manipulation and stability skills (Gallahue and Ozmun, 2006; Goodway, Ozmun, and Gallahue, 2019). Locomotor skills involve moving the whole body (e.g. running, jumping, hopping etc.), object manipulation skills are those which involve manipulating an external object (e.g. kicking, catching, throwing etc.), while stability relates to balancing skills (e.g. static balance, beam balance, one foot balance etc.) (Gallahue and Ozmun, 2006). Behan et al. (2019) observed low levels of FMS proficiency in Irish youth, which is of significant concern, as research has shown that developing FMS to a sufficient proficiency at a young age has far-reaching consequences for one's health (D'Hondt et al., 2014; Lloyd et al., 2014), with some studies identifying individuals with lower competency in FMS to be at risk of low levels of PA (Barnett et al., 2009; Lloyd et al., 2014). In order to enhance the proficiency of these skills in children, the most recent CSPPA report suggests that a "FMS programme, not aligned to any one sport or activity, but whose purpose is to develop overall skills and abilities common to all sports and activities is needed in Ireland" (Woods et al., 2018 p.98).

The Moving Well-Being Well (MWBW) intervention was designed as an evidence-based approach to target the low levels of FMS proficiency observed across Ireland (Behan et al., 2019). The MWBW intervention is underpinned by both the theory of constraints (TOC) (Newell, 1986) and self-determination theory (SDT) (Deci and Ryan, 2010), and was designed using the comprehensive framework outlined by the behaviour change wheel (Michie, Stralen, and West, 2011). Initial implementation of this intervention suggests that it could be an effective resource to

improve children's FMS proficiency (16% increase from pre- to post-intervention) (Behan, 2020), however, school-based interventions are complex (van Sluijs and Kriemler, 2016), and further research is required to examine the various factors and mechanisms that positively and negatively contribute to this outcome. In addition, a recent review has shown that when scaled-up, interventions can diminish in impact (Lane et al., 2021). Hence, interventions like MWBW that show potential of developing children's FMS must be trialled with larger, more diverse samples and rigorously evaluated so that their effectiveness and feasibility can be more accurately determined (Ma et al., 2021; Moore et al., 2015).

Although developing proficiency in FMS is critical for children in order to promote and sustain positive trajectories of PA and health-related fitness (HRF) (Jaakkola et al., 2019; Robinson et al., 2015; Stodden, Goodway, et al., 2008), FMS make up only one construct of overall movement competence (MC). Another important construct of overall MC is proficiency in functional movement skills (Basman, 2019). Functional movement skill is defined as the ability to produce and maintain an adequate balance of mobility and stability along the kinetic chain while integrating functional movement patterns with accuracy and efficiency (Mills, Taunton, and Mills 2005; Bagherian et al., 2018). It has also been described as movement efficiency that minimises the risk of injury (Cook, Burton, and Hoogenboom 2006; Coker 2018; Fitton Davies et al., 2022). Developing these skills in children is also suggested to be key for health, with research linking functional movement proficiency to weight status (Duncan and Stanley, 2012; Duncan, Stanley, and Wright, 2013), sport skill acquisition (Yıldız, 2018), athletic performance (Fitton Davies, Sacko, Lyons, and Duncan, 2022), and injury risk reduction in children (Duncan and Stanley, 2012; Lloyd et al., 2015; Pfeifer et al., 2019; Wang et al., 2021).

The assessment of movement skills is an essential aspect of MC development (Chan, Ha, and Ng 2016). Although there is a plethora of existing tools available to assess FMS (Hulteen et al., 2020), the literature suggests that existing tools have significant limitations, ranging from varied amounts of empirical evidence supporting reliability and validity (Bardid et al., 2019; Eddy et al., 2020; Klingberg et al., 2019), to not measuring all components of FMS (e.g. stability) (Rudd et al.,

2015), to not being feasible to use in many “real-world” settings, such as schools (Eddy et al., 2020), or failing to consider movement patterns related to an increased risk of injury in children (Miller et al., 2018). Similarly, there are also significant concerns as to the validity and feasibility of existing tools used to assess functional movement proficiency, particularly for use with children (Mauntel et al., 2017; Moran et al., 2016). These barriers limit the ability of academics to further explore the emerging relationship between both constructs of MC, and different indicators of health and performance, as well as limiting the ability of practitioners to enhance these skills in children with maximum efficiency. Furthermore, no tools currently exist that examine all areas of MC together in one assessment. Thus, creating a tool that could examine both constructs of MC, that is practical, easy to administer, suitable for use in multiple environments and that is fun for participating children could have far-reaching benefits.

The Development of the Moving Well-Being Well Intervention

The Medical Research Council (MRC) published guidance on developing and evaluating complex interventions (Craig et al., 2000, 2006, 2008). The framework suggests that best practice when developing an intervention is systematically, using the best available evidence and appropriate theory, then to test them using a carefully phased approach, starting with a series of pilot studies, and moving on to an exploratory and then a definitive evaluation (See Figure 1.1) (Craig et al., 2000). Moreover, each phase has a common set of core elements: considering context, developing and refining programme theory, engaging stakeholders, identifying key uncertainties, refining the intervention, and economic considerations. These core elements assist researchers in conducting their research questions and are used to decide whether the research should proceed to the next phase, return to a previous phase, repeat a phase, or stop.

According to the MRC, all interventions should be based on a relevant theoretical framework (Craig et al., 2008), as those which utilise a relevant theory when developing interventions to change behaviour are more successful than those who do not (Stull, Synder, & Demark-Wahnefried, 2007).

The Moving Well-Being Well (MWBW) intervention is underpinned by a refraction framework (discussed in Chapter 2) and was designed specifically for the Irish primary school context (Behan, 2020).

Following the design of the intervention, Phase I of the intervention's implementation sought to investigate the core elements of the intervention, primarily the key outcome, which was its effectiveness at improving children's FMS (Behan, 2020). To do this, the intervention was piloted in 10 schools ($n = 417$, 52% female, mean age 7.6 ± 0.66 years). Intervention schools ($n = 5$) received the MWBW intervention with control schools ($n = 5$) continuing with their regular PE lessons. Results found that the intervention group significantly improved FMS proficiency from pre- to post-intervention (16%) and through to retention (overall increase of 23.6%) in comparison with the control group (overall increase of 5.5%). Despite this, a number of key uncertainties were highlighted that required further evaluation (i.e. will the intervention be as effective when scaled up? will different school contexts affect it? will it have different effects on genders? how feasible is it to implement? etc.).

Building on the findings of Phase I (pilot), Phase II (exploratory trial) of the intervention's implementation, which is described in Chapters 3 and 4, sought to greater understand the outcomes as well as the implementation process and feasibility of the intervention within the primary school context. These findings will be discussed further in the following thesis.

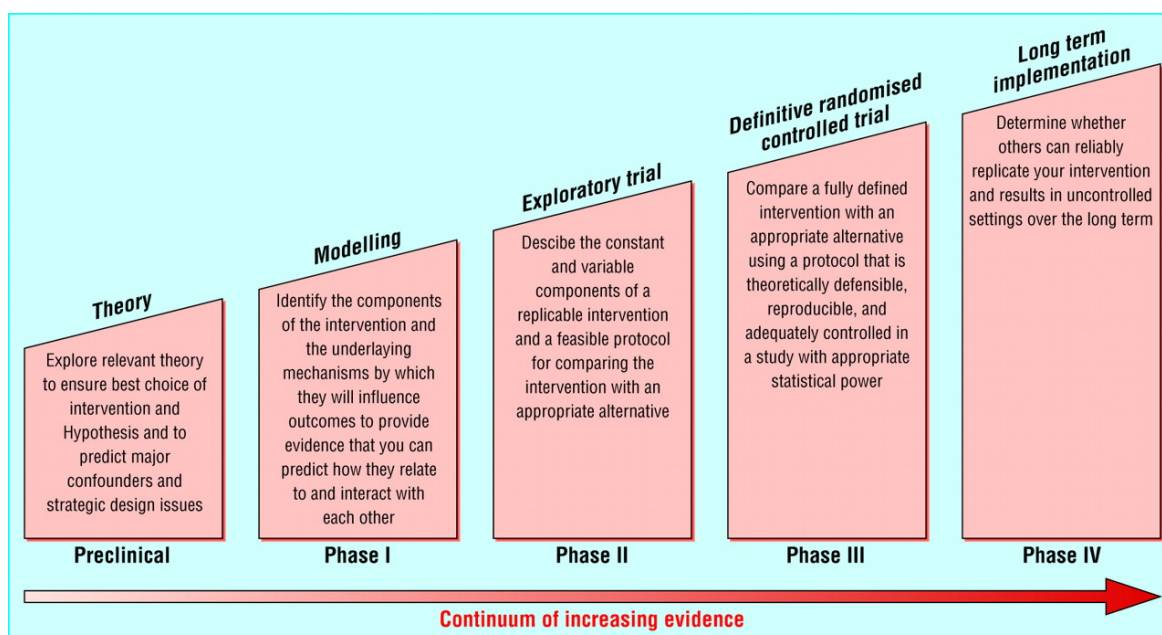


Figure 1.1: MRC Framework for complex interventions (Campbell et al., 2000)

Summary and Significance of the Thesis

It is evident that there is a lack of proficiency in key FMS among Irish children (Behan et al., 2019), highlighting the need for suitable, evidence-based programmes to develop the FMS proficiency of children (Woods et al., 2018), and enable them to develop the skills they need to participate in regular PA (Stodden et al., 2008). The MWBW intervention has emerged as potentially an effective programme to enhance the FMS of primary school children (Behan, 2020). The first aim of this thesis is to evaluate the effectiveness of the MWBW intervention at improving the FMS proficiency of a large cohort of 1st and 2nd class primary school children and evaluate whether it can elicit similar positive outcomes when implemented on a larger scale than has been seen previously.

Qualitative research is increasingly included in intervention studies to aid the development of acceptable, attractive, effective, and sustainable interventions (Cathain et al., 2013) and provide policy makers or practitioners with vital information about how interventions are delivered, issues arising or how it might be replicated (Moore et al., 2015). To date however, there is no published data related to the implementation or process evaluation of such interventions in an Irish school setting (Bolger et al., 2018). The second aim of this thesis is to examine the various factors that

contribute to the overall outcome of the MWBW intervention, which will allow the research team to assess whether the intervention is suitable for the Irish primary school environment, and to inform future mainstream implementation.

Due to the recent emergence of literature examining the interconnected relationship between fundamental and functional movement skills (Lester et al., 2017; O'Brien et al., 2021; Wu et al., 2021), the very definition of MC is evolving (Basman, 2019; Hulteen et al., 2018). As opposed to being examined in different lights, these skill constructs are now being seen as contributing to a more holistic view of overall MC (Lester et al., 2017; O'Brien et al., 2021). Consequently, methods of assessing these skills must also evolve to capture a more holistic picture. The third aim of this thesis is to design and validate a new MC assessment tool to assess the fundamental and functional movement skills of children aged 8-12, and that is suitable for use by researchers, teachers, sports coaches, athletic therapists, and physiotherapists.

The Evolution of the Research Questions

As you will read over the next few pages, there are a number of key aims, objectives and research questions which will be explored in the chapters within this thesis. As you will realise, this thesis consists of two broad, yet interconnected study areas. The first, looks to build on the existing literature around the MWBW intervention, and explore the outcomes and implementation process of this intervention within the Irish primary school environment. The second, seeks to create and validate a new tool to help researchers and practitioners assess and enhance children's MC.

For the first area of study, the research questions emerged following an analysis of the outcomes of Phase I of the intervention's implementation. This research amounted to two PhD theses which were completed in 2020. The research questions for Phase II of this project, which are investigated in this thesis, emerged following a thorough analysis of this data and key discussions with the research team involved in Phase I of this project.

The research questions for the second area of this study emerged during the data collection process of the MWBW study (chapters 3 and 4 of this thesis). As I was gathering the FMS data of the children, I began to think that there was no way a teacher could gather this kind of data on his/her students without the help of a research team. I considered the fact that if they couldn't gather this kind of data, they couldn't accurately identify the areas that their students needed to develop, they couldn't create targeted interventions to help children enhance these skills, or they couldn't provide meaningful instruction and feedback to help the children improve. Yet, it was not clear whether teachers valued this kind of data. On completion of the study, schools were given reports on the proficiency status and development of their classes. Both teachers and principals found the data informative and valuable, and wanted to use it to help their planning and evaluation going forward. In addition to this, through my reading, involvement in sport and meaningful conversations with various experts and practitioners, it became apparent that enhancing children's MC was also of importance to researchers, sports coaches, athletic therapists, and physiotherapists within their respective working environments. Following further study, I realised that functional movement skills appear to significantly contribute to children's MC and are of particular importance to practitioners working in sporting and clinical settings. These factors formed my desire to create a tool that researchers and practitioners could use to assess children's MC more holistically, facilitating a more unified approach to developing these skills. Finally, my thinking went full-circle and brought me back to the intervention element that began my research journey. It was clear from my research and that of existing literature, that when given sufficient support and guidance, practitioners with little experience or expertise can significantly develop children's MC. So, what if we could create something that could be the assessment tool, the training tool, and the intervention together? That is where the FMS² project was born, and the first steps of this project will be discussed in the following thesis.

Philosophical Position

When considering the methods and findings of the studies described in this thesis, it is important to acknowledge my own experiences and philosophical position. Stemming from ontology (what exists for people to know about) and epistemology (how knowledge is created and what is possible to know) are philosophical perspectives (generalised views of the world), which forms beliefs and drive actions (Moon and Blackman, 2014). As previously mentioned, I have spent a good deal of time teaching and coaching both primary and post-primary school aged children, with a solely positivist outlook. As I continued to develop throughout the PhD project, my knowledge of the underpinning philosophies of physical literacy (monism, existentialism and phenomenology) has continued to develop. The subsequent interpretations made throughout this PhD will have been influenced by my own experiences and understandings. As a result, it is important to recognise that I view myself as a pragmatic researcher; I believe that there are many different ways of interpreting the world and undertaking research, and that no single stance can give a complete understanding (Poucher et al., 2020). Pragmatists link the choice of approach directly to the purpose of and the nature of the research questions posed (Creswell and Creswell, 2018). To ensure the methodological coherence of a study, researchers must demonstrate the approach they have chosen is the best approach to answer their research question and that their approach aligns with the philosophical position from which they approached their work (Poucher et al., 2020). In line with this, I believe research should be practical, generate meaningful impact, and various approaches to research, dependent on the research question, can and should be adopted to achieve this.

Within the studies described in this thesis, my epistemological stance has influenced several key decisions. For example, in Chapter 3, the intervention was designed to integrate seamlessly into the Irish primary school environment. Data investigating the feasibility, suitability and implementation process of the intervention was gathered using a range of practical, time-efficient, and digital means (i.e. online questionnaires, text messages, voice notes etc.). In Chapter 4, self-reported teacher fidelity was used as opposed to on-site visits and observation. Although this method may not be as rigorous as the other methods, it does offer a more practical and sustainable method

of capturing this data as the intervention is scaled up. In Chapter 5, the entire design of the FMS² assessment tool revolves around creating a practical, easy to use tool for use in multiple settings. This was a key consideration made by the expert panel throughout the design process.

Aims and Objectives of the Study

Primary Aims of the Research

1. Evaluate the implementation process of the Moving Well-Being Well intervention in the Irish primary school setting (Chapter 3).
2. Evaluate the effectiveness of the Moving Well-Being Well intervention at improving the fundamental movement skill proficiency within an exploratory trial (Chapter 4).
3. Design and validate a new movement assessment tool to measure both the fundamental and functional movement skills of children aged 8-12 (Chapter 5 and Chapter 6).

Secondary Objectives of the Research

1. Assess whether the Moving Well-Being Well intervention is suitable for the Irish primary school environment (Chapter 3).
2. Inform future planning and refinement prior to future, mainstream implementation of the Moving Well-Being Well intervention (Chapter 3).
3. Determine whether the Moving Well-Being Well intervention has differential effects on gender (Chapter 4).
4. Examine how fidelity of implementation by the teachers affects the FMS improvement of the children participating in the Moving Well-Being Well intervention (Chapter 4).
5. Design an assessment tool that is practical for use with a large group of children, transferable across multiple environments (schools, sports clubs, clinical etc.) and can be easily implemented by users of varied levels of experience and expertise (Chapter 5).

6. Investigate the structural validity of the newly designed assessment tool among a cohort of Irish children (Chapter 6).
7. Examine the convergent validity of the newly designed assessment tool with two commonly used measurement tools (Chapter 6).

Research Questions and Hypothesise

1. Will the Moving Well-Being Well intervention be suitable for the Irish primary school environment?

Hypothesis: *The MWBW intervention will be suited to the Irish primary school environment and its model of implementation will benefit both participating children and teachers.*

2. Will the Moving Well-Being Well intervention have an impact on the fundamental movement skill proficiency of Irish primary school children?

Hypothesis: *The Moving Well-Being Well intervention will have a significant impact on Irish primary school children's fundamental movement skill proficiency.*

3. Will the Moving Well-Being Well intervention have differential effects on the fundamental movement skill proficiency of males and females?

Hypothesis: *The Moving Well-Being Well intervention will not have a significantly different impact on males' and females' fundamental movement skill proficiency.*

4. Will a group of expert academics, educators, sports coaches, and clinicians be able to reach consensus on key components of a new, practical, user-friendly tool to assess the fundamental and functional movement skills of children aged 8-12?

Hypothesis: *The group of experts will be able to reach consensus on all the key components of a new, practical, user-friendly assessment tool that will measure children's fundamental and functional movement skills.*

5. Will each of the skills included in the new assessment tool measure what they are supposed to measure?

Hypothesis: *The skills included in the assessment tool will significantly correlate to the area of MC it is designed to measure*

6. Will the children's performance scores in the new assessment correlate to similar performance scores measured in other, commonly used assessment tools?

Hypothesis: *The children's performance scores in the new assessment tool will significantly correlate to their performance scores that are measured by other assessment tools.*

Thesis Structure

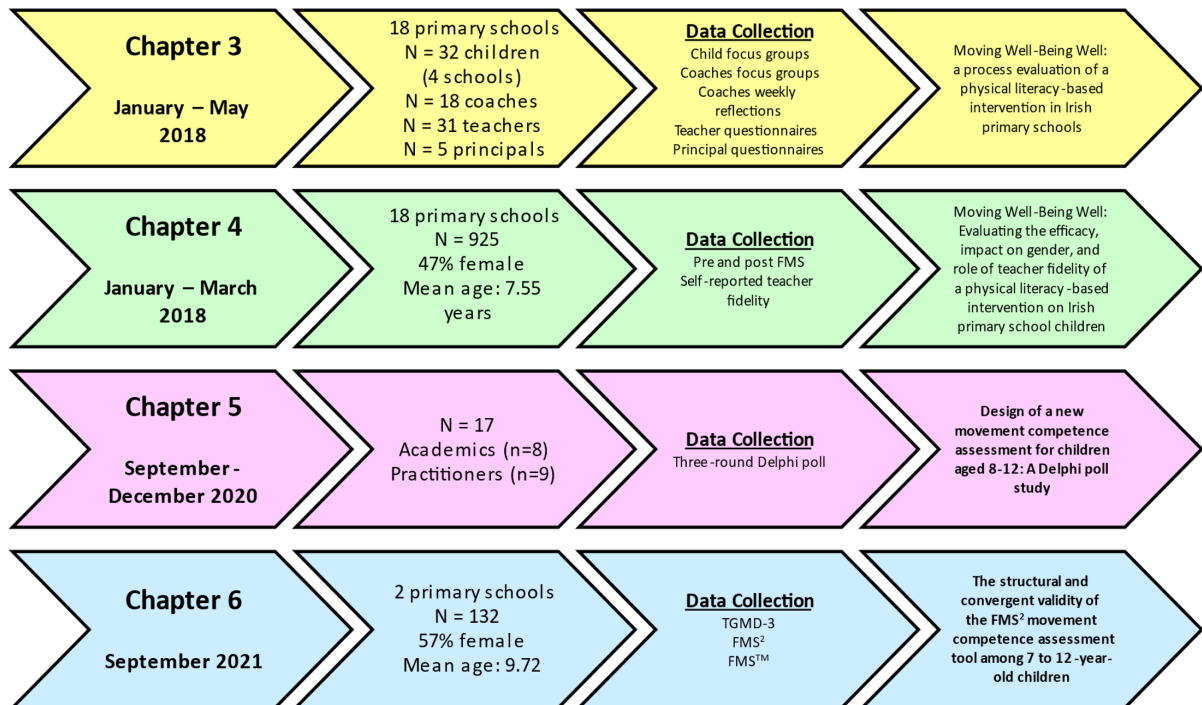


Figure 1.2: A schematic overview of the thesis

[FMS = fundamental movement skills, FMSTM = functional movement screen, TGMD-3 = Test of Gross Motor Development (3rd Edition)]

Chapter 1: Introduction to the Thesis

This chapter gives a broad overview of the thesis, including the aims and objectives of the study.

Chapter 2: Literature Review

This chapter gives a critical evaluation of the previous literature in the areas of physical activity, physical literacy, fundamental movement skills, school-based interventions, currently available assessment tools and functional movement skills. This chapter aims to give a comprehensive up to date review, highlighting gaps in the literature.

Chapter 3: Moving Well-Being Well: A process evaluation of a Physical Literacy based intervention in Irish primary schools

This chapter presents findings of the process evaluation of the Moving Well-Being Well intervention in the primary school setting.

Chapter 4: Moving Well-Being Well: Evaluating the efficacy, impact on gender, and role of teacher fidelity of a physical literacy-based intervention in Irish primary school children

This chapter seeks to evaluate the efficacy of the MWBW intervention in improving children's FMS within an exploratory trial. It also examines whether the intervention had differential effects on gender and identifies how fidelity of implementation affected the FMS improvement of the participating children.

Chapter 5: Design of a new movement competence assessment for children aged 8-12: A Delphi poll study

This chapter describes the design, and development process involved in creating the new FMS² assessment tool, as well as describing the key features that comprise the tool such as the layout, structure, marking criteria, equipment required and additional features etc.

Chapter 6: The structural and convergent validity of the FMS² movement competence assessment tool among 8 to 12-year-old children

This chapter explores the correlation between each skill included in the new assessment tool to the overall construct that it has been designed to measure. This chapter also examines the correlation between the skills examined by the new FMS² assessment tool, and the same skills measured by other, commonly used measurement tools.

Chapter 7: Conclusions and Future Directions

This chapter provides an overview of the thesis, presenting the main findings, strengths and limitations of the study, directions for future research, and the potential future for Moving Well-Being Well and FMS².

Definition of Terms

Physical Activity: Physical Activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization, 2018, p.46).

Non-Communicable Disease: A non-communicable disease is a medical condition or disease which is not contagious and is non-transmissible among people (British Heart Foundation, 2013).

Physical Literacy: Physical Literacy is defined as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life (IPLA 2017).

Physical Education: A school-based subject providing children with learning opportunities through the medium of movement and contributes to their overall development by helping them to lead full, active and healthy lives (Department of Education and Skills, 1999).

Movement Competence: Movement competence is a global term used to reflect terminologies that have been used in previous literature (i.e. motor competence, motor proficiency, motor performance, fundamental movement/motor skill, motor ability, and motor coordination) to describe the quality of goal-directed human movement (Robinson et al., 2015).

Fundamental Movement Skills: Fundamental movement skills are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018).

Functional Movement Skills: Functional movement skill is defined as the ability to produce and maintain an adequate balance of mobility and stability along the kinetic chain while integrating functional movement patterns with accuracy and efficiency (Bagherian et al., 2018; Mills, Taunton, and Mills, 2005).

Mastery/Near Mastery: In the context of fundamental movement skills, mastery is defined as correct performance of all components of a skill. Near mastery is defined as correct performance of all components but one (Van Beurden et al., 2002).

Validity: Validity is a determination of the extent to which an instrument measures what we think it's supposed to be measuring (Suresh, Thomas, and Suresh, 2011).

List of Abbreviations

AfL = Assessment for Learning

BMI = Body Mass Index

BOT = Bruininks-Oseretsky Test of Motor Proficiency

CAMSA = Canadian Agility and Movement Skill Assessment

CAPL = Canadian Assessment of Physical Literacy

CPD = Continuous Professional Development

CSPPA = Child Sport Participation and Physical Activity

CVD = Cardiovascular Disease

DC = Dragon Challenge

DCDQ = Developmental Coordination Disorder Questionnaire

FMS = Fundamental Movement Skills

FMSTM = Functional Movement Screen

GAA = Gaelic Athletic Association

HRF = Health-Related Fitness

IPAQ = International Physical Activity Questionnaire

IPLA = International Physical Literacy Association

KTK = Körperkoordinationstest für Kinder

LESS = Landing Error Scoring System

MC = Movement Competence

MABC = Movement Assessment Battery for Children

MET = Metabolic Equivalent

MNM = Mastery/Near Mastery

MVPA = Moderate to Vigorous Physical Activity

MWBW = Moving Well-Being Well

NCD = Non-Communicable Disease

PA = Physical Activity

PDST = Professional Development Service for Teachers

PE = Physical Education

PL = Physical Literacy

SDT = Self-Determination Theory

TGMD = Test of Gross Motor Development

TOC = Theory Of Constraints

WHO = World Health Organisation

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Chapter 2: Literature Review

Literature Review

Overview of Literature Review Sections

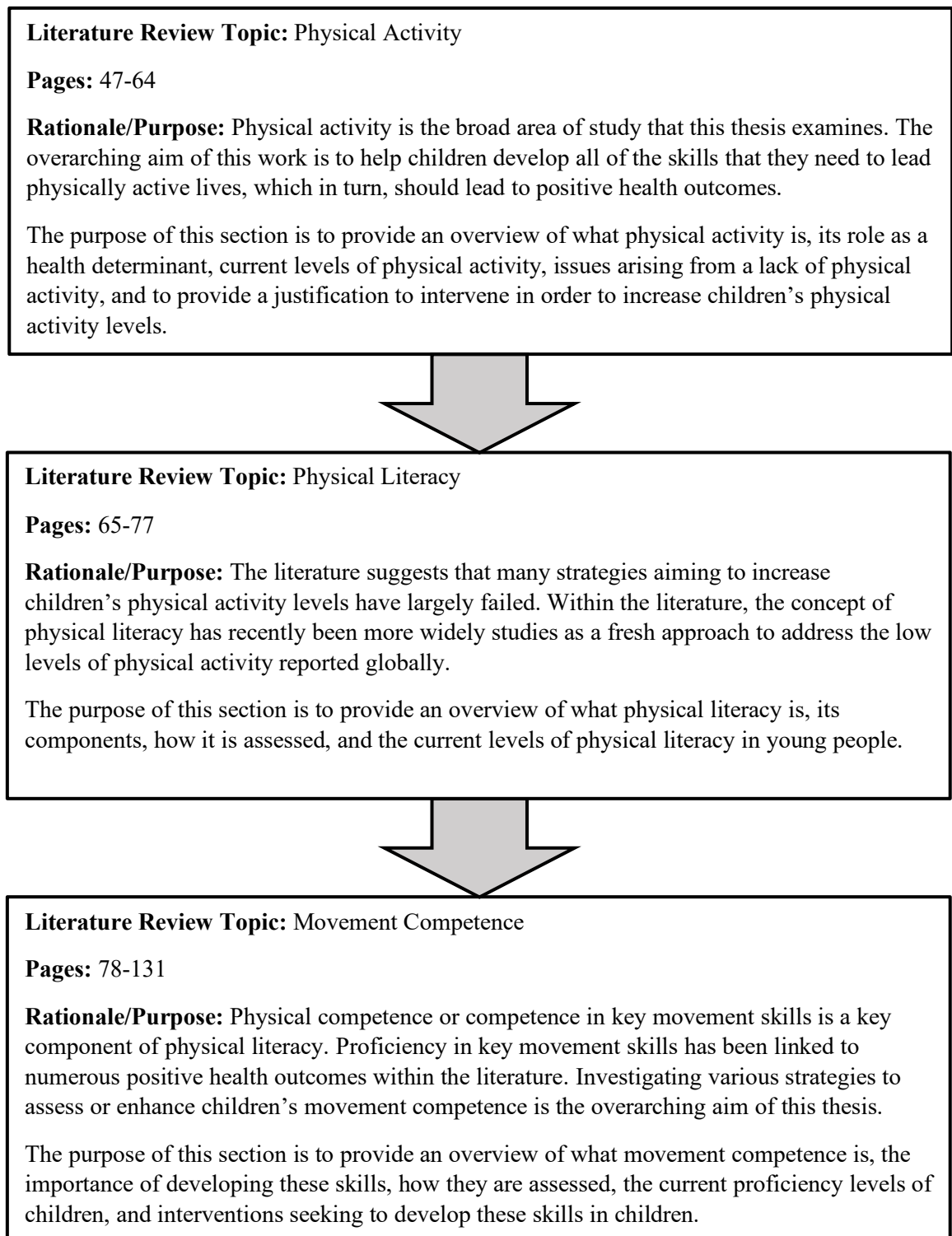


Figure 2.1: Overview of the Literature Review Sections

Physical Activity

Physical Activity: An Introduction

Physical Activity (PA) is defined by the World Health Organisation (WHO) as “any bodily movement produced by skeletal muscles that requires energy expenditure” (World Health Organization, 2018, p.46). This definition is a derivation of the most popular and widely cited definition of PA published by Caspersen and colleagues in 1985. They define PA as “any bodily movement produced by the skeletal muscles that result in energy expenditure” (Caspersen and Christenson, 1985, p.126). Other iterations of this definition have been proposed and used; however, most are a derivation of the definition produced by Caspersen et. al (Strath et al., 2013). PA can be undertaken in many different ways such as walking, cycling, sports or other forms of active recreation. It can also be undertaken as part of work, such as lifting heavy items or as part of domestic tasks around the home such as cleaning (World Health Organization., 2018). There is an ever-growing body of research highlighting how across its various forms, PA has multiplicative health, social and economic benefits. The origins of this research may date back to 1939, to one of the earliest studies noting the association between coronary mortality and PA as part of one’s occupation (Macauley, 1994). This research found that the mortality of men aged 55-64 was considerably higher among business and professional groups than other groups, especially manual workers. Similar results were found almost 70 years ago through the works Morris et al. (Morris et al., 1961). Their research showed that the incidence in coronary heart disease in bus conductors who climbed up and down stairs of double-decker buses collecting tickets, and in postal carriers who delivered the post on foot, was lower than that of the relatively inactive bus drivers or postal workers who spent most of their time in work sitting down (Morris and Crawford, 1958). It is from these preliminary studies that sparked the beginning of many other investigations, up to the present day, confirming and exploring the strong link between PA and health in many different populations (Varela et al., 2018).

Physical Activity Intensities

Intensity refers to the rate at which the activity is being performed or the magnitude of the effort required to perform an activity or exercise (World Health Organization, 2014b). Activities are often classified into four different intensities – sedentary, light, moderate or vigorous, in accordance with the energy expenditure associated with the activity (Ainsworth et al., 2000, 2011; Ridley, Ainsworth and Olds, 2008). Energy expenditure is determined by metabolic equivalent (MET) values (Jetté, Sidney and Blümchen, 1990). One MET is defined as “the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O₂ per kg of body weight x min” and is used to express the energy cost of activities (Jetté, Sidney and Blümchen, 1990). MET values can range from as low as 0.9 METs (sleeping) to 18 METs (running at 10.9 mph) (Ainsworth et al., 2011). Pate et al. (1995) have used MET values to classify PA into light, moderate and vigorous intensities (Pate et al., 1995). These figures have also been included in the most recent publication of the Physical Activity Guidelines for Americans (Piercy et al., 2018). These values do however represent approximations due to various factors such as age, sex and body composition that can affect measures of resting energy expenditure, and therefore, MET values can vary by individual (McArdle, Katch and Katch, 2010). In order to address the age variations associated with MET values, Ridley et al. (2008) developed the Youth Compendium of Physical Activities. This resource may be used to assign energy costs to observational data when estimating total energy expenditure or time spent in varying intensities of activity. Nevertheless, this resource was not without its limitations, as only around 35% of the values listed in the compendium are based on data measured in youth, the rest are estimated from the adult compendium (Ridley, Ainsworth and Olds, 2008). More recently, this research was further cultivated by Butte et al. (2018) who enhanced this Youth Compendium, which presents the energy costs of 196 physical activities derived from paediatric data only (Butte et al., 2018).

Structured and Incidental Physical Activity

PA can also be categorised in two forms: structured and incidental PA. Structured PA or exercise is planned, purposeful activity undertaken to promote health and fitness benefits (Caspersen and

Christenson, 1985). Often the terms PA and exercise have been used interchangeably in nursing and medical literature, but the meanings of these are different (Speck, 2002; Guedes et al., 2013). The World Health Organisation, (2018), define exercise as “activity that is planned, structured, repetitive and aims to improve or maintain one or more components of physical fitness” (World Health Organisation, 2018, p.42). PA on the other hand is defined as “any bodily movement produced by skeletal muscles that requires energy expenditure” (World Health Organization, 2018, p.46). Exercise therefore, is not synonymous with PA, but rather a sub category of it (Caspersen and Christenson, 1985; World Health Organisation, 2018). Incidental activity is any activity that is part of one’s daily routine that is not carried out with the express purpose of recreation or health, and requires no sacrifice of discretionary time (Stamatakis et al., 2019). Examples of incidental activities are walking or cycling to move from one place to another, climbing stairs or active chores (Piercy et al., 2018). Consequently, incidental PA does not encounter the same barriers as structured PA such as lack of time, costs, equipment, lack of skills or poor fitness (Stamatakis et al., 2019). Structured and incidental PA has also been referred to as leisure time PA and non-exercise activity thermogenesis, which includes all activity-related energy expenditure that is not purposeful exercise in previous literature (Tremblay et al., 2007).

Dimensions and Domains of Physical Activity

Physical activity is a multi-faceted behaviour constructed from a number of different dimensions: i) frequency (of individual sessions), ii) intensity (rate of energy expenditure), iii) time (duration of an individual session) and iv) type (of activity involved) (Barisic, Leatherdale and Kreiger, 2011). Currently, the American College of Sports Medicine (ACSM) use the FITT principle (Frequency, Intensity, Time & Type) to clearly define the recommendation guidelines for prescribing exercise for public health (Starrett, Cordoza and Thompson, 2014). The FITT principle was developed from early research carried out by Pollock et al. (1978), where they presented recommendations for the type and amount of exercise needed to improve fitness (Pollock, 1978). A common finding in the research was that higher intensity exercise produced greater gains in fitness (Pollock, 1978). The same

principle also applies to PA, whereby appropriate bouts of moderate (3-5.9 MET's) to vigorous (6+ MET's) PA is required to gain the maximum health benefits (Saint-Maurice et al., 2018). In addition to the various dimensions, PA is also undertaken in different domains. The four common domains of PA are occupational, domestic, transportation and leisure-time (Strath et al., 2013). The intensity, duration and frequency within each of these domains are used to estimate the total amount of an individual's PA (Howley, 2001). Historically, approaches to promote PA have focussed around leisure-time PA and assessment instruments developed accordingly (Strath et al., 2013). Health enhancing PA can occur in any domain, and as such assessment strategies should examine all PA domains, otherwise, substitution effect can occur whereby an increase in one domain (e.g. occupation), may result in a decrease in another (e.g. leisure time). Hence, it is paramount that all domains are captured when measuring PA in research in order to generate a complete picture of an individual's PA.

The Importance of Physical Activity in Youth

Non-Communicable Diseases

Non-communicable diseases (NCDs), also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors (World Health Organisation 2013). The main types of NCD's are cardiovascular diseases (like heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma), and diabetes (World Health Organisation, 2013b). As the leading cause of death globally, NCD's were responsible for 38 million (68%) of the world's 56 million deaths in 2012. More than 40% of them (16 million) were premature deaths under age 70 years (Mendis et al., 2014). The leading causes of NCD deaths globally in 2012 were: cardiovascular diseases (17.5 million deaths, or 46.2% of NCD deaths), cancers (8.2 million, or 21.7% of NCD deaths), respiratory diseases, including asthma and chronic obstructive pulmonary disease (4.0 million, or 10.7% of NCD deaths) and diabetes (1.5 million, or 4% of NCD deaths). Thus, these four major NCD's were responsible for 82% of NCD deaths (Mendis et al., 2014).

A large body of evidence is growing to show that risk factors for cardiovascular disease (CVD), diabetes, stroke, and obesity manifest during childhood and adolescents (Uddin et al., 2020). This was evident in a large-scale study of adolescents in the US ($n = 3,383$, age range 12-19 years) (May, Kuklina and Yoon, 2012). It was found that prevalence of pre-diabetes and diabetes is increasing (9% in 1999-2000 compared to 23% in 2007-2008) (May, Kuklina and Yoon, 2012). Other CVD risk factors were also identified in this population including high blood pressure (14% of the adolescents studied), high low-density lipoprotein cholesterol (22%), and low high-density lipoprotein cholesterol (15%). Almost half (43%) of the participants had at least one CVD risk factor, and an overweight/obesity prevalence of 34% was found among this cohort (May, Kuklina and Yoon, 2012). The prevalence of CVD risk factors also increased with weight category, with normal weight (37%), overweight (49%), and obese (61%) participants respectively having at least one CVD risk factor.

Possessing any one of these CVD risk factors in childhood is strongly associated with poorer cardiovascular health in adulthood (Raitakari et al., 2003). Supportive findings of this were also identified in the Cardiovascular Risk in Young Finns Study (Raitakari et al., 2003). This study measured CVD risk factors in participants ($n = 2229$) at three time points: childhood (3-9 years), adolescence (12-18 years), and adulthood (24-33 years). Results showed that the presence of CVD risk factors in adolescence was directly and significantly related to carotid artery intima-media thickness (cIMT) in adulthood ($\beta = .017 - .032$, $p < .001$). Risk factors measured in childhood weakly predicted cIMT in adulthood for males ($\beta = .016 - .020$, $p < .02$) and did not significantly predict cIMT in adulthood for females (Raitakari et al., 2003). The measurement of IMT (the two inner layers of an artery), is used to assess the extent of plaque build-up in the arteries, or atherosclerosis. Atherosclerosis is a precursor to CVD and can arise in youth (Dalla Pozza et al., 2015). Whilst it is undoubtedly worrying that risk factors can develop in such a young population and carry a serious and negative effect on CVD health in adulthood, it is important to note that in this study CVD risk factors in childhood were only weakly related to cIMT in adulthood, compared to the much stronger relationship between CVD risk factors in adolescence and cIMT in adulthood (Raitakari et al., 2003).

These findings indicate that while risk factors may develop early in youth, if children can reduce their risk of developing these prior to, or during early adolescence, the risk of developing atherosclerosis and subsequent CVD in adulthood may also be reduced.

Not only linked to CVD, regular PA participation has been associated with the primary prevention of more than 25 chronic medical conditions (Warburton, Nicol and Bredin, 2006; Warburton and Bredin, 2016). The primary types of diabetes are type-1 and type-2. Type-1 diabetes (5%–10% of cases) results from cellular-mediated autoimmune destruction of the pancreatic β -cells, producing insulin deficiency (American Diabetes Association, 2016). Although it can occur at any age, β -cell destruction rates vary, typically occurring more rapidly in youth than in adults (Colberg et al., 2016). Type-2 diabetes (90%–95% of cases) results from a progressive loss of insulin secretion, usually also with insulin resistance (Colberg et al., 2016). Several mechanisms are thought to be involved with the favourable effects that regular PA has on glucose homeostasis and in the prevention of diabetes (LaMonte, Blair and Church, 2005). Acute responses are changes in glucose uptake, transport, and/or disposal that occur during and sometime after each bout of PA (American College of Sports Medicine, 2000). With augmented acute responses, repeated bouts of activity result in a greater effect than a single bout. Chronic adaptations are changes in structure or function that occur from prolonged exposure to a specified dose of PA (Goodyear and Kahn, 1998). Thus, it appears that the widest range of effects for improving or maintaining glucose homeostasis occur through participation in an adequate dose of PA on a regular basis (Piercy et al., 2018).

Physical activity has been traditionally linked with lower risks of colon and breast cancer (Boyle et al., 2012; Neilson et al., 2017). In recent times, prospective cohort studies and meta-analyses have claimed that PA may also be associated with cancer of bladder (Keimling et al., 2014), endometrial (Keimling et al., 2014), glioma (Niedermaier et al., 2015), kidney (Behrens and Leitzmann 2013), lung (Brenner et al., 2016), oesophageal (Behrens et al., 2014), gastric (Psaltopoulou et al., 2016), meningioma (Niedermaier et al., 2015), ovarian (Zhong et al., 2014), pancreas (Behrens et al., 2015) and prostate (Liu et al., 2011). Findings from a recent umbrella review summarising the evidence of associations between these cancer sites and PA revealed a negative and

statistically significant association ($P < 0.05$) with seven cancer sites (colon, breast, endometrial, lung, oesophageal, pancreas and meningioma). However, the same research found that only the associations with colon and breast cancer were supported by strong evidence and highly suggestive evidence respectively (Rezende et al., 2018). Several mechanisms have been proposed for the role PA plays in reducing colon cancer risk, including, reduced insulin resistance and hyperinsulinemia, anti-inflammatory action, direct immune action, decreased intestinal transit time or higher vitamin-D levels (Wolin et al., 2007). A number of symptoms presented, such as insulin resistance, show a commonality with those seen as risk factors for diabetes, thus, highlighting the role regular bouts of PA can also play as a preventative measure for the named cancers among children and youth (Neilson et al., 2017).

Regular PA has also been shown to be an effective intervention for reducing depression/depressive symptoms (Mammen and Faulkner, 2013; Pfaeffli et al., 2019), improving physical self-perceptions (Pfaeffli et al., 2019), improving wellbeing (Hyde, Maher and Elavsky, 2013), and being an effective antidepressant amongst individuals with depression (Schuch et al., 2016). Whilst the evidence examining the relationship between PA and mental health in children and youth is growing, the underlying mechanisms of this association are undefined (Rodriguez-Ayllon et al., 2019). Lubans et al. (2016) have suggested a number of plausible neurobiological, psychosocial and behavioural mechanisms that may underpin this relationship (Lubans et al., 2016). Firstly, PA may have a positive effect on the structure and function of the brain (Lubans et al., 2016). Using magnetic resonance imaging, a recent RCT in children indicated that a nine-month PA intervention improved the structure and function of brain networks related to cognitive function (Hillman et al., 2014). These findings suggest that it is possible that PA changes brain structure and function, which in turn has a positive effect on mental health (Hillman et al., 2014). Regarding the cellular and molecular bases of mental health, it is well documented that decreased levels of brain-derived neurotrophic factor, (which play a crucial role in the growth and healthy maintenance of neurons) (Leibrock et al., 1989), is associated with increased levels of anxiety and depression (Martinowich, Manji and Lu, 2007). PA is known to increase brain-derived neurotrophic factor levels in the central

nervous system, which may improve anxiety and depressive symptoms (Cotman, Berchtold and Christie, 2007). Another explanation may be that PA, by increasing brain dopamine, serotonin, and noradrenaline concentrations, may not only improve mood but also protect against the onset of mental disorders (Young, 2007). Secondly, evidence suggests a causal link between physical self-concept (i.e. perceived appearance, perceived fitness and perceived competence) and mental health (e.g. global self-concept, self-esteem) (Lubans et al., 2016). Social support and autonomy are also plausible psychosocial contributors to mental health in young people (Lubans et al., 2016). Therefore, the effects of PA on mental health in young people may be mediated by several psychosocial paths (Lubans et al., 2016). Finally, a range of potential behavioural mechanisms may explain the effect of PA on mental health outcomes, including sleep duration, sleep efficiency, sleep onset latency, and reduced sleepiness (Lubans et al., 2016). However, there is currently insufficient evidence to draw firm conclusions about any of these behavioural mechanisms (Rodriguez-Ayllon et al., 2019).

Despite the clear relationships in the literature between PA, NCD's and numerous potential health outcomes (Geidl et al., 2020), a large proportion of the world's population remains physically inactive (fail to meet the recommended guidelines for PA) (Lee et al., 2012). In fact, recent times have seen a greater increase in the incidence of these diseases in low- and middle-income regions (Wagner and Brath, 2012). Nearly 80% of NCD deaths occur in low- and middle-income countries and NCD's are the most frequent causes of death in most countries in the Americas, the Eastern Mediterranean, Europe, South-East Asia, and the Western Pacific, except in Africa (Wagner and Brath, 2012). In African nations, NCD's are rising rapidly and are projected to exceed communicable, maternal, perinatal, and nutritional diseases as the most common causes of death by 2030 (World Health Organisation 2013). Premature death is also a major consideration when evaluating the impact of NCD's on a given population, with approximately 42% of all NCD deaths occurring before the age of 70 years in 2012 (World Health Organisation, 2013a). In low- and middle-income countries, NCD's lead to death at a younger age, where 29% of NCD deaths occur among people under the age of 60, compared to 13% in high-income countries (Wagner and Brath, 2012). The rapidly growing burden of NCDs in low- and middle-income countries seems to be mainly due

to the negative effects of globalisation, rapid urbanisation and increasingly sedentary lifestyles (Popkin, 2006).

Physical Inactivity

At present, most research studies term physical inactivity to describe people who are performing insufficient amounts of MVPA and who fail to meet the recommended PA guidelines for their age (Sedentary Behaviour Research Network, 2012; Tremblay et al., 2017). Within the literature there remains confusion between sedentariness and physical inactivity (Thivel et al., 2018). Sedentary behaviour is defined as any waking behaviour characterised by an energy expenditure ≤ 1.5 MET's while in a sitting, reclining or lying posture (Sedentary Behaviour Research Network, 2012; Tremblay et al., 2017). Based on these definitions physical inactivity and sedentary behaviour are two distinct constructs (van der Ploeg and Hillsdon, 2017). For example, individuals can be classified as both active and sedentary, but not active and inactive. Tertiary employees are the most demonstrative example of sedentariness, as they spend a considerable part of their time seated in front of a computer screen. Whilst they may reach their recommended amounts of MVPA after work, they are still defined as highly sedentary (Genin et al., 2017). The inverse of this is also true, people with a standing occupation (e.g. hairdresser, shop sales person) will get little sedentary time during their day but may not do any MVPA, nor benefit from the associated health outcomes derived from meeting those recommendations (Warburton, Nicol and Bredin, 2006; Warburton and Bredin, 2016). Hence, they are inactive but not sedentary. In other words, sedentary behaviour and inactivity are indeed two distinct constructs, and sedentary behaviour and MVPA are not the inverse of each other (van der Ploeg and Hillsdon, 2017). These findings emphasise the need for intervention strategies to target both physical inactivity as well as sedentary behaviours, however, to date, a strong body of research highlights the health benefits of reaching the recommended guidelines for MVPA, and so, this should take precedence (van der Ploeg and Hillsdon, 2017). These findings should carry even more importance for children who are spending more time being physically inactive and more time

in sedentary behaviours such as screen time related activities (e.g. watching tv or playing games consoles) which is having a significant effect on their current and future health (Carson et al., 2016).

To quantify the effect of physical inactivity on the world's major NCD's, Lee et al. (2012) estimated how much of these diseases could be averted in the population if inactive people were to become active, as well as how much gain in life expectancy could occur at the population level. In this study they focused on the major NCD's emphasised by the United Nations as threats to global health (Beaglehole et al., 2011): coronary heart disease; cancer, specifically breast and colon cancers, which are convincingly related to physical inactivity; and type 2 diabetes. The authors estimated that worldwide, physical inactivity causes 6–10% of the major NCD's of coronary heart disease, type 2 diabetes, and breast and colon cancers (Lee et al., 2012). Furthermore, physical inactivity causes 9% of premature mortality, or more than 5.3 of the 57 million deaths that occurred in 2008 (World Health Organisation, 2013b). With the elimination of physical inactivity, life expectancy of the world's population might be expected to increase by 0.68 years according to the study (Lee et al., 2012). These findings make inactivity similar to the established risk factors of smoking and obesity. The added years of life, however, do need to be interpreted correctly: they seem low because they represent gains in the whole population (including inactive and active people), rather than in inactive people who become more active. Since all the gain accrues to people who move from being inactive to active, the increase in life expectancy in the inactive group alone is greater. For example, other research carried out in the USA estimated that inactive people would gain 1.3–3.7 years from age 50 years by becoming active (defined by meeting the recommended guidelines of 150 minutes of MVPA each week) (Paffenbarger et al., 1986; Franco et al., 2005).

The Economic Cost of Physical Inactivity

Physical inactivity is a global pandemic that causes not only morbidity and mortality, but also a major economic burden worldwide. In 2016, Ding et al. provided the first global estimate for the economic burden of physical inactivity (Ding et al., 2016). This calculation was based on data from 142

countries, representing 93.2% of the world's population. These figures were attained by estimating the effect physical inactivity had on five major NCD's (coronary heart disease, type 2 diabetes, breast cancer, and colon cancer) and all-cause mortality globally in 2013, by taking into account direct healthcare costs, productivity losses and disability-adjusted life-years (DALYs). Their calculations estimated that these five major NCD's and all-cause mortality due to physical inactivity cost the world economy more than \$67.5 billion through health-care expenditure and productivity losses each year (Ding et al., 2016).

Physical Activity Guidelines

One strategy for combatting inactivity and promoting PA has been the development of PA guidelines. PA guidelines define the amount of health-enhancing activity through which significant health gains can be achieved (World Health Organization, 2010). The first public health recommendations for PA in the United States were released in 1995 (Pate et al., 1995), and these were followed by additional and updated recommendations in 1996 (US Department of Health and Human Services 1996) and 2007 (Haskell et al., 2007; Nelson et al., 2007). In 2008, the body of evidence culminated in the first-ever federal guidelines for PA (US Department of Health and Human Services 2008). The 2008 guidelines simplified the message for the general public concerning health-enhancing levels of PA (Strath et al., 2013). In more recent times, the US Department of Health and Human Services have developed a new edition of the Physical Activity Guidelines for Americans (Piercy et al., 2018). These guidelines are grounded with the most recent scientific evidence in relation to PA and they recommend that: children and adolescents (age 6-17) should do 60 minutes or more of moderate to vigorous PA daily. As part of this 60 minutes per day, this activity should include vigorous activity 3 days per week, muscle-strengthening PA at least 3 days per week and bone-strengthening PA at least 3 days per week (Piercy et al., 2018). Both the World Health Organization (WHO) and the European Union have urged their member states to develop their own recommendations on a national level (World Health Organization, 2010). The Irish guidelines reflect the consensus internationally with current PA guidelines in Ireland recommending at least 60 minutes of MVPA per day for

children and adolescents, with bone and muscle strengthening exercises and flexibility exercises included at least three times a week.

Current Levels of Physical Activity in Young People

Comparisons of patterns of participation in PA between countries and regions were unachievable until twenty years ago (Ezzati et al., 2004). This was largely due to the lack of standardised instruments suitable for international use (Hallal et al., 2012). This limitation was significant, as evidence highlighting the benefits of PA had grown since the 1970's (Haskell et al., 2007), underpinning the key role that surveillance data could play in guiding national action or intervention (Bull and Bauman, 2011). Only in the late 1990's did an international group of academics develop a standardised instrument to measure PA in adult populations: the international physical activity questionnaire (IPAQ) (Craig et al., 2000). This work soon led to the development of the global physical activity questionnaire (GPAQ) (Bull, Maslin and Armstrong, 2009), which provided the much needed measurements to support national monitoring and the inclusion of physical inactivity in risk factor surveillance systems. As a result, IPAQ and GPAQ data of countries worldwide enable comparative assessment of global patterns of PA to be undertaken.

The amount of adults worldwide failing to meet the recommended guidelines for PA is well documented (Guthold et al., 2008, 2016; Hallal et al., 2012; Sun, Norman and While, 2013). These trends, however, are not reserved for adults. The prevalence of physical inactivity among children and adolescents is also high. In 2008, the global prevalence of school-going adolescents (aged 13-15 years) not meeting the PA recommendations was 80.3% (Hallal et al., 2012). This value was the first global estimate based on an international compilation of adolescent PA data, using information from school-based surveys from 105 countries. Estimates for the year 2010 for school-going adolescents (aged 11-17 years), including information from an additional 15 countries, revealed a similar global prevalence of 78.4% for boys and 84.4% for girls (Sallis et al., 2016). A more recent study by Guthold et al. (2020), used data from 298 school-based surveys from 146 countries, territories, and areas

including 1.6 million students aged 11-17 years to present the trends of adolescent PA for the first time. This data accounted for 81.3% of the global population of adolescents of this age. They found that more than four in five school-going adolescents aged 11-17 years were not meeting the recommended guidelines for PA in 2016 (81.0% [95% UI 77.8 - 87.7]) (Guthold et al., 2020). Between 2001 and 2016, prevalence decreased by 2.5 percentage (significant change) for boys (from 80.1% [78.3 - 81.6] to 77.6% [76.1 - 80.4]), whereas there was no significant change for girls (from 85.1% [83.1 - 88.0] to 84.7% [83.0 - 88.2]), leading to a significant global difference of 7.1 percentage points in insufficient activity between sexes in 2016 (Guthold et al., 2020) (see Figure 2.2).

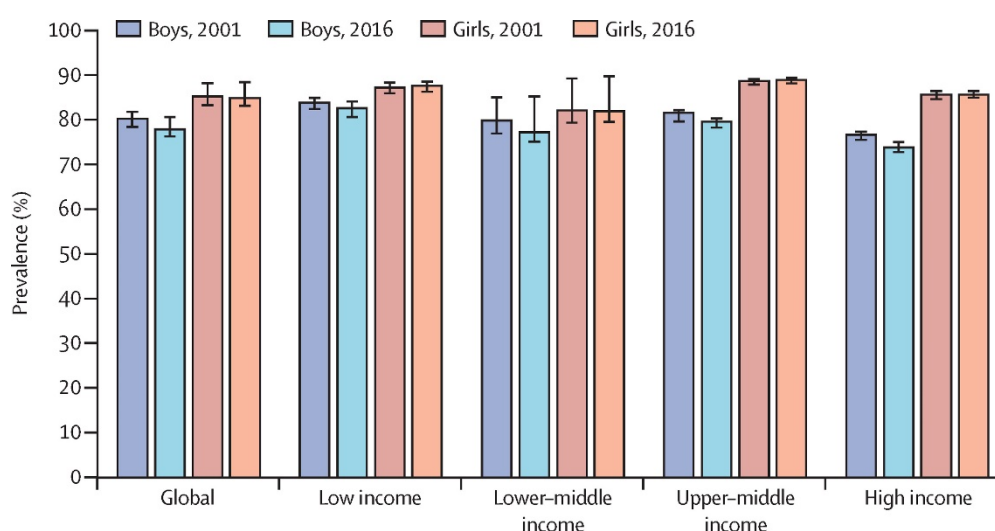


Figure 2.2: Prevalence of insufficient physical activity among school-going adolescents aged 11–17 years globally and by World Bank income group, 2001 and 2016

There was no clear pattern in prevalence according to country income group: insufficient PA was 84.9% (95% UI 82.6 - 88.2) in low-income countries, 79.3% (77.2 - 87.5) in lower-middle-income countries, 83.9% (79.5 - 89.2) in upper-middle-income countries, and 79.4% (74.0 - 86.2) in high-income countries in 2016 (Guthold et al., 2020). In 2016, prevalence of insufficient PA was

more than 80% in 71 (49%) of 146 countries analysed for boys versus 141 (97%) for girls, more than 85% in 20 (14%) countries for boys versus 112 (77%) countries for girls, and more than 90% in two (1%) countries for boys versus 27 (18%) countries for girls.

According to research by Marques et al., in 2020 these figures did not improve. Their study aimed to present the worldwide, regional, and national prevalence of PA participation according to its frequency in adolescents. The study was based on cross-sectional surveys of adolescent populations from 105 countries and all regions worldwide. The sample comprised 520,533 adolescents (251,788 boys; 268,745 girls). This study found that the prevalence of adolescents participating in sufficient PA was low (Marques et al., 2020). Less than 20% of the adolescents engaged in PA every day and almost 20% never engaged in PA (Marques et al., 2020). They also found that around half of boys (50.1%; 95% CI: 49.8, 50.2) engaged in PA up to 3 days per week and for girls, the prevalence was 63.6% (95% CI: 63.4, 63.8). For everyday PA, boys presented a higher prevalence than girls (22.1%; 95% CI: 21.7, 22.4 vs. 12.6%, 95% CI: 12.2, 12.9). The prevalence of the lowest level of PA (never) increases from 11 to 12 years to 16 to 17 years among boys and girls (Marques et al., 2020).

The above figures may support a notion that PA begins to decline in adolescence (Corder et al., 2015), however, an emerging body of evidence is beginning to suggest that this decline occurs much earlier (Telama et al., 2014; Farooq et al., 2018). Research conducted into PA participation in youth (ages 2.8 - 18.4 years) showed a large percentage of children failing to meet the recommended guidelines (Cooper et al., 2015). Accelerometer data from 27,637 participants in the study also showed that, cross-sectionally, for every year after the age of 5 years, there was a 4.2% decrease in PA (Cooper et al., 2015). This global research highlights that many children are failing to accumulate sufficient PA as required for health. This research would also suggest that increasing the PA levels of children could have a knock-on effect to the figures we see in adolescence.

Research on Irish youth points to a similar trend in PA to that reported internationally. In 2004, only 20% of Irish primary school children and 12% of post-primary school children met the recommended guidelines for PA (Fahey, Delaney and Gannon, 2005). The Children's Sport

Participation and Physical Activity (CSPPA) study conducted in 2010 reported that 19% of primary and 12% of post-primary students met these recommendations ($n = 5,397$) (Woods et al., 2010). In keeping with international research, girls were less likely to meet these recommendations than boys (10% vs 18%; $p < 0.001$) (Woods et al., 2010). This gender difference was evident in both primary (13% vs 27%) and post-primary (9% vs 15%) students. This study also found that these figures decreased with age, going from 19% (10-12 years) to just 6% (16-18 years) (Woods et al., 2010). Alarmingly, the same study conducted in 2018 found that figures had fallen yet again, with only 17% of primary (13% of girls & 23% of boys) and 10% of post primary students (7% of girls & 14% of boys) meeting the recommended 60 minutes of MVPA guideline for health (Woods et al., 2018), representing a 2% drop from the previous study. A significant gender imbalance remains also, with fewer females (9%) meeting the PA guidelines than males (17%). This gender difference was again consistently evident in both primary (13% vs 23%) and post primary (7% vs 14%) students. Studies have found that PA participation in childhood is associated with PA participation in adolescence, and that individuals who have high PA in childhood are more likely to maintain a higher level of PA into adolescence (Jaakkola and Washington, 2013; Lloyd et al., 2014). It is imperative therefore to ensure that appropriate interventions be implemented to target reversing the trend of childhood inactivity, and promote participation in regular PA (Amini et al., 2015).

COVID-19 and Physical Activity

The world experienced an extraordinary, life-altering challenge due to the COVID-19 pandemic. Many countries experienced a “new normal” to their everyday living with social distancing, isolating at home and local travel restrictions becoming the norm in many places. As previously mentioned, the COVID-19 pandemic was not the only health altering pandemic that we were faced with in recent times, physical inactivity is also one that we have been living and fighting with for a number of years (Kohl et al., 2012; Pratt et al., 2020). The COVID-19 pandemic suspended many opportunities for people of all ages to be physically active, such as, physical education in schools, extra-curricular and community sports clubs, fitness and athletic centres, public parks and other infrastructure to be

physically active (Hall et al., 2021). This compounded by travel restrictions and isolation posed concern that together, these factors may increase the risk of social isolation, which has been shown to negatively impact mental health, PA patterns and sedentary time across the lifespan as well as increase mortality risk in the elderly (Elovainio et al., 2017). For children and adolescents, social interactions and friendships significantly influence PA behaviours (Macdonald-Wallis, Jago and Sterne, 2012; Montgomery et al., 2020), a factor that has been negatively impacted by isolation restrictions and social distancing mandates as a result of COVID-19. The influence of social isolation and unhealthy lifestyle choices within a family unit has also been studied. Thompson et al. (2020), found a significant correlation between social isolation and an unhealthier lifestyle in parents with adolescent children, which also negatively influenced lifestyle behaviours of their adolescent children (Thompson et al., 2020). Although the lasting effects of the COVID-19 pandemic will not be fully realised for some time, given the change in lifestyle for many around the world it has been hypothesised that this health crisis will further impact in a negative way the global physical inactivity pandemic (Hall et al., 2021). Following the resumption of “normal life”, an evaluation into the lasting effects of the COVID-19 pandemic on PA will have to be made, particularly among children and adolescent cohorts. No doubt progress on many health benefitting interventions has been stalled, however now more than ever, intervention to help children become more active and promote their health has never been more important.

The Need to Intervene

Increasing the amount of PA children and adolescents achieve each day is a global priority (World Health Organisation, 2019). Evidence shows that risk factors for the major NCD's manifest during childhood and adolescents (Uddin et al., 2020). Hence, to get ahead of the curve, intervention in child and adolescent populations is key. The school environment has been highlighted as a key environment for which to implement PA interventions (Salmon et al., 2007; Khambalia et al., 2012). Nevertheless, the very nature of the classroom environment promotes sedentary behaviour with long periods of prolonged sitting (Holt, Bartee and Heelan, 2013). To date, numerous initiatives and

interventions have aimed at increasing PA (Salmon et al., 2007; Kriemler et al., 2011; Murillo Pardo et al., 2013), particularly in the adolescent population (Beets et al., 2016), however these seem to be failing to impact the low levels of PA in youth on a large scale (Beets et al., 2016).

The nature of the primary school curriculum is ideal for incorporating PA into it, and previous studies have shown that integrating PA into academic content improves children's PA levels during the school day (Donnelly et al., 2009; Erwin et al., 2011). Improving children's PA levels during the school day is one thing, creating a more permanent and sustainable change in behaviour is another. The research around school-based interventions is clear, and interventions have proven to be effective (Salmon et al., 2007; Kriemler et al., 2011; Murillo Pardo et al., 2013), although the results do not always result in the behavioural changes that the researchers intended (Beets et al., 2016). Notwithstanding the above studies, research frequently reports the small effect size that many PA interventions have (Metcalf, Henley and Wilkin, 2012). Metcalf et al. (2012) states that programmes only have an average increase of approximately four minutes on children's overall daily activity levels (Metcalf, Henley and Wilkin, 2012). These findings are not a significant change and indicate that in order to produce a more substantial change in behaviour a fresh approach is needed (Metcalf, Henley and Wilkin, 2012).

Physical Activity Summary

In summary, PA is a fundamental element of health. It is estimated that worldwide, PI causes 6-10% of the major NCD's of coronary heart disease, type 2 diabetes, and breast and colon cancers (Lee et al., 2012). This comes at great cost to the global economy (Ding, Lawson, Kolbe-Alexander, et al., 2016). To combat this, a large body of evidence is growing to show that risk factors for CVD, diabetes, stroke, and obesity manifest during childhood and adolescents (Uddin et al., 2020), and therefore preventative measures can be implemented. Irish and international guidelines advise children and adolescents to participate in at least 60 minutes of MVPA per day for health (US Department of Health and Human Services, 2008; Department of Health and Children, 2009; Piercy

et al., 2018). Recent research shows that many children and adolescents both in Ireland and globally are failing to meet these guidelines (Woods et al., 2018; Guthold et al., 2020). Many researchers also hypothesise that the current global COVID-19 pandemic will further negatively impact the global health crisis (Hall et al., 2021), highlighting the need for immediate and decisive intervention. To date however, PA interventions have reported insignificant changes to overall PA levels in children, highlighting the need for a fresh approach to increase children's PA (Metcalf, Henley and Wilkin, 2012).

Physical Literacy

Physical Literacy: An Introduction

In recent years, there has been a growing interest, worldwide, in the concept of physical literacy (PL) (Roetert and Couturier, 2015). This concept is not completely new to our society however, with one of the earliest uses of the term PL dating back to 1884, where an American, Captain Edward Maguire, used the term to describe the physicality of an indigenous culture in his professional notes in the Army Corps of Engineers (Maguire and United States Army Corps of Engineers, 1884). He used the term to capture the movement quality of the people he observed during a celebration that involved dance amongst other movements (Cairney et al., 2019). Following that early reference, there was considerable utilisation of the term from the 1920's onwards (Cairney et al., 2019). This was largely by American educators in response to a lifestyle threat emerging from modernisation, the need to prepare army recruits, and in response to the National Physical Education Service created by the United States Commissioner of Education in 1918, to promote "universal physical education" (Pennsylvania State Education Association, 1930, p. 12). At the time the commissioner stated that: *"We must prepare for physical literacy as well as for mental literacy. A physically fit America becomes more necessary with modern mechanical inventions. If education is preparation for life, then we must give to every American boy and girl that physical preparedness..."* (Pennsylvania State Education Association, 1930, p. 12). This statement highlights that from a very early stage there were significant concerns about some of the risks associated with modern living in relation to public health, an issue which remains a significant concern to this day. It is also evident from this early introduction of the concept that the school environment was identified as the optimum environment from which individuals could develop and grow these skills (Pennsylvania State Education Association, 1930, Cairney et al., 2019). This conclusion has been reiterated in more recent literature with numerous studies identifying the school environment as the optimum environment in which children could develop their PL skills (Morgan et al., 2013; Lundvall, 2015; Edwards et al., 2018).

Although PL has been referred to by several authors over the years, the concept was not systematically developed until early this century (Whitehead, 2001, 2010, 2013). In fact, much of

the philosophical foundation for our understanding of PL has been provided by Whitehead (2001, 2010, 2013). Whitehead defines PL as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the lifecourse” (Whitehead 2013, p.29). This definition captures the desire of individuals both to participate in PA as well as gain meaningful, fulfilling experiences through doing so (Whitehead, 2001), while also redefining how PA is understood; placing importance on the holistic development of an individual’s physical potential (Whitehead, 2001). The re-emergence and re-defining of the term PL by Whitehead has had widescale appeal (Tremblay and Lloyd 2009; Jurbala 2015) with many nations embracing the PL concept to promote health and wellbeing of their citizens (Shearer et al., 2018). Although the adoption of this concept is welcomed, there are concerns that different interpretations of PL across jurisdictions internationally may undermine or dilute the meaningful measurement of PL, interpretation of findings, and prevent any meaningful compilation of research findings (Keegan, Edwards and Bryant, 2015).

A recent literature review by Liu & Chen, (2020), identified twenty-two different definitions of PL (see Table 2.1). Today, the most commonly accepted definition of PL is the “motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life” (IPLA 2017). Regardless of the actual definition, there seems to be an indirect consensus with all definitions of PL containing similar components (Edwards et al., 2017). Most acknowledge that being competent in motor skills to partake in PA is insufficient (Edwards et al., 2017), that an individual must also be confident to apply these skills and engage in a variety of activities in different environments to encourage lifelong participation in PA (Shearer et al., 2018; Cairney, Dudley, et al., 2019). In theory, should a child embody these characteristics they would have the capacity to lead an active lifestyle, resulting in numerous, well-established, positive health outcomes (Lee et al., 2012; Uddin et al., 2020). In theory therefore, it would seem logical to look at PL as a means of addressing the worldwide problem of physical inactivity (Shearer et al., 2018; Whitehead, Durden-Myers and Pot, 2018). First of all, however, it would seem logical to examine these components in more detail, as well as the links establishing PL as a health determinant.

Author (Year)	Approach	Setting	Definitions
Morrison (1969: 5)	Performance-Driven	PE	... be creative, imaginative, and clear in expressive movement, competent and efficient in utilitarian movement and inventive, versatile, and skillful in objective movement.
Whitehead (2001: 131)	Holistic	General	... moves with poise, economy and confidence in a wide variety of physically challenging situations.
DCMS (2002: 127)	Performance-Driven	Youth Sport	... the development of agility, balance, coordination, and skill (the ABCs) across a wide range of activities.
Whitehead (2005: 5)	Holistic	General	... the ability and motivation to capitalize on our motile potential to make a significant contribution to the quality of life.
Whitehead (2007: 282)	Holistic	General	... the motivation, confidence, physical competence, understanding and knowledge to maintain physical activity at an individually appropriate level, throughout life.
Higgs et al. (2008: 5)	Performance-Driven	Youth Sport	... the development of fundamental movement skills and fundamental sport skills that permit a child to move confidently and with control, in a wide range of physical activity, rhythmic (dance) and sport situations.
Mandigo et al. (2009: 6-7)	Performance-Driven	PE	... ability to move with competence and confidence in a wide variety of physical activities in multiple environments that benefit the healthy development of the whole person.
Whitehead (2010: 11)	Holistic	General	... the motivation, confidence, physical competence, knowledge and understanding to maintain physical activity throughout the life course.
Whitehead (2013a: 29)	Holistic	General	... a disposition to capitalize on our human-embodied capability wherein the individual has the motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for maintaining purposeful physical pursuits and activities throughout the life course.
The Aspen Institute (2015b: 9)	Performance-Driven	Youth Sport	... the ability, confidence, and desire to be physically active for life.
Sport for Life Society (2015: 1) & Tremblay et al. (2018)	Holistic	Youth Sport	... the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life.
UNESCO (2015: 20)	Holistic	PE	... the motivation, confidence, physical competence, knowledge and understanding to maintain physical activity throughout life, and refers to the skills needed to obtain, understand and use the information to make good decisions for health.
Jurbala (2015: 377)	Holistic	Sport	... the dynamic communication between the embodied self and the physical environment, which continuously integrates perceptive reading of, and appropriate response to, physical challenges.
Sport for Life Society (2016: 73)	Performance-Driven	Sport	... the fundamental movement skills, fundamental sports skills, motivation, knowledge, and understanding that enable an individual to read their environment and make appropriate decisions while moving confidently and with control in a wide range of physical activities in both indoor and outdoor environments.

Sport for Life Society (2016: 73)	Performance-Driven	Sport	... have acquired the skills and confidence to enjoy a variety of sports and physical activities.
Sport for Life Society (2016: 73)	Performance-Driven	Sport	... demonstrate competence and confidence in fundamental movement skills and foundation sport skills combined with the ability to read their environment and make appropriate decisions. ... enjoy a variety of sports and physical activities.
Sport for Life Society (2016)	Performance-Driven	Sport	Same as PHE Canada (2007).
Allan et al. (2017: 523)	Integrated	Sport	... the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life.
IPLA (2017)	Holistic	General	... the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life.
Keegan et al. (2019: 111)	Holistic	General	... lifelong holistic learning acquired and applied in movement and physical activity contexts.
PHE Canada (n.d.)	Holistic	General	... a journey upon which children and youth, and everyone, develop the knowledge, skills, and attitudes they need to enable them to participate in a wide variety of activities.
SHAPE America (n.d.)	Performance-Driven	Youth Sport	Same as Mandigo et al. (2009)

Table 2.1: A summary of Physical Literacy definitions (listed chronologically) (Taken from Liu & Chen, (2020))

Physical Literacy Components

The International Physical Literacy Association (IPLA) definition indicates that PL is made up of several components, namely: motivation, confidence, knowledge and understanding, and physical competence (see Figure 2.3) (IPLA 2017). Physical literacy involves the development of all three elements, therefore it entails holistic development or development of the whole person, i.e. their feelings (affective), movements (physical) and thoughts (cognitive) (Jurbala, 2015). Motivation and confidence is defined by Whitehead as the ability to “capitalise on innate movement/physical potential to make a significant contribution to the quality of life” (Whitehead 2013 p.28). Whitehead suggests that if an individual is confident in their movement capabilities in various environments, then their motivation to engage in an active lifestyle should increase (Whitehead, 2013). The component of knowledge and understanding refers to a person’s ability to identify what is required to move effectively, and to understand the basic principles of health (namely exercise, nutrition and

sleep) (Whitehead, 2013). The third component “physical competence” refers to an individual’s musculoskeletal fitness and anthropometric properties (e.g. cardiovascular fitness, muscular strength, body composition) (Tremblay et al., 2017) as well as their ability to perform basic motor skills (Logan et al., 2018), more commonly referred to as “fundamental movement skills” (FMS). An individual who is competent in these FMS, should in theory be confident in performing them, and their motivation to engage in activities may therefore increase (Barnett et al., 2009).

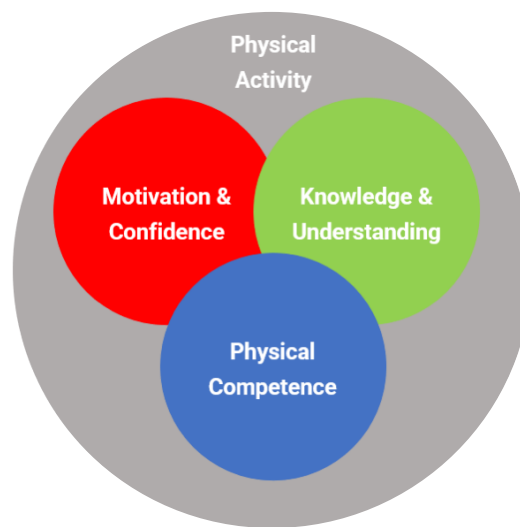


Figure 2.3: Physical Literacy Components

Assessment of Physical Literacy

As previously alluded to, the assessment of PL and its various components is an emerging research area (Liu and Chen, 2020). Some studies have measured the various separate components of PL using a number of existing valid and reliable tools (Gu, Chen, and Zhang 2019; Tremblay et al., 2018; Behan et al., 2019; Belton et al., 2019). There are currently a number of valid and reliable assessments for physical competence; for example, the Test of Gross Motor Development (TGMD) (Ulrich, 2000, 2019) is commonly used to assess motor competence and the FITNESSGRAM is widely used for physical fitness measures (Meredith & Welk, 2010). Many have researched motivation (Owen et al.,

2014) and confidence towards PA (Murphy et al., 2015), however there is a lack of research that measures knowledge and understanding (Edwards et al., 2018). The plurality of PL definitions has reportedly contributed to confusion in relation to PL assessments with studies employing different methodologies across various institutions (Edwards et al., 2018) and even within the same country.

In Canada, a number of PL assessments have been developed; PLAY tools were developed in 2009 and released by Canadian Sport for Life in 2012 (Sport for Life, 2014), the Passport for Life tool was developed by PHE Canada (Physical and Health Education Canada 2013) and the Canadian Assessment of Physical Literacy (CAPL) by the Healthy Active Living and Obesity Research Group (2014). The PLAY tools were designed as research and programme evaluation tools, whilst the Passport for Life tool was designed for formative assessment in education, and the CAPL was primarily designed as a population surveillance tool.

The PLAY tools are a set of assessments that were developed using the COSMIN checklist for health instruments (Mokkink and Terwee, 2010) and are consistent with the model of PL domains identified in the Canadian Physical Literacy Consensus Statement (Sport for Life, 2014). These assessment tools were designed for children aged 7+ (Sport for Life, 2014). The current set of PLAY tools includes PLAY Fun; an assessment of motor competence, confidence and comprehension; PLAY Self; a self-assessment tool; PLAY Parent; a parental assessment of the child; PLAY Coach; an assessment of the child by the coach or physical education (PE) teacher; PLAY Inventory; a child's self-report of participation in PA. The PLAY tools are open source with the recording sheets and workbooks available online (Sport for Life, 2014). The physical competence domain is assessed using the PLAY Fun tool which assesses movement competence in 18 movement tasks which are linked to their PE curriculum, as well as the confidence and comprehension of the child to execute the selected movement task. The psychological domain (affective and cognitive) of PL is assessed using the PLAY Self tool. The PLAY Self tool has three sections: one assessing participation in various environments, one assessing the affective and cognitive domains, and one examining the valuing of literacies. Self-assessment of perceived movement competence, confidence and enjoyment among other constructs is assessed using a 13-item questionnaire. The behavioural

domain is assessed using PLAY Inventory which assesses active participation in society. Notably, and based upon the PL conceptual framework (Kozera, 2017), the PLAY tools do not include PA, fitness or performance measures as they are viewed as outcomes of PL.

The Passport for Life tool was developed for use in the educational environment as a formative assessment tool for generalist and PE specialists to utilise (Physical and Health Education Canada, 2013). This tool assesses four components of the PE curriculum related to PL: Active Participation, Living and Personal Skills, Fitness and Movement Skills. The Passport for Life tool uses a four-point scale which was designed to partially align with the PLAY tool movement competency anchors (emerging, developing, meeting expectations and accomplished) (Physical and Health Education Canada, 2013).

The CAPL assessment tool measures multiple domains of PL, including physical competence, physical fitness, motivation and knowledge (Francis et al., 2016). The CAPL tool is targeted for children aged 8-12 (Francis et al., 2016). The physical competence components of the CAPL tool includes MC but also assesses health related fitness and body composition measures. The CAPL tool includes an assessment of sedentary and MVPA time, a health knowledge category that includes knowledge of PA, sedentary and screen time guidelines, and a motivation & confidence category. The original CAPL prioritised the physical domain by weighting the physical components more strongly than the other constructs (Francis et al., 2016). This goes against some of the PL philosophies outlined by Edwards et al. (2018) however, and the revised version of the CAPL gave equal weight to each of the physical competence, motivation & confidence, and daily behaviour components, with the knowledge & understanding component carrying less weight (Gunnell et al., 2018; Longmuir et al., 2018). Upon completion, scores are totalled, and participants are put into one of the following categories: beginning, progressing, achieving or excelling (Longmuir et al., 2018).

Current methods of assessing children's PL, particularly the MC element, come with a number of limitations, such as: being too resource intensive to administer and analyse (Wiat and Darrah, 2001), not assessing skills in an ecologically valid manner (Longmuir et al., 2017), not having sufficient research supporting them in terms of validity or reliability (Bonazza et al., 2017;

Eddy et al., 2020), not assessing all components of FMS (Rudd et al., 2015), or not being feasible for use in practical settings (Klingberg et al., 2019). These limitations will be further discussed later in the review.

The Importance of Physical Literacy in Youth

Although not an entirely new concept, research linking PL to PA and health outcomes is an emerging area (Cairney et al., 2019). Substantial research has linked individual PL components (for example FMS) to health outcomes (Barnett et al., 2009; Cliff & Okely, 2009; Logan et al., 2015; Stodden et al., 2012). This relationship will be discussed further later in the review. In terms of PA motivation, studies have found that in children, autonomous motivation positively predicts greater levels of PA, as well as positive attitudes towards PA (Vierling, Standage and Treasure, 2007; Sebire et al., 2013), with intrinsic motivation displaying a positive association with MVPA (Sebire et al., 2013). Thus far, limited research has been able to make conclusions on the holistic concept of PL and long term health outcomes (Cairney et al., 2019). This could be due to the longitudinal nature of the concept. For example, it is reasonably easy to accept PL as a determinant of health through its role in shaping lifelong participation in PA. Yet, providing empirical evidence would require rigorous longitudinal research tracking components of PL, PA participation, health outcomes amongst other factors for a significantly long period of time (childhood through to adulthood), which simply has not been done yet. The possibility of such evidence being gathered is also inhibited by the lack of consensus surrounding the definition and assessment tools used to measure the concept of PL (Cairney et al., 2019; Longmuir et al., 2017; Liu and Chen 2020). In fact, due to the varying definitions and philosophical beliefs that various jurisdictions internationally have, the methods of assessing PL and its components are different (Giblin, Collins and Button, 2014; Edwards et al., 2017; Liu and Chen, 2020).

Jurbala (2015) argued that in order for PL to succeed as a new approach in promoting PA, advocates must provide substance to their claims. Cairney et al. (2019), were the first to present a

conceptual model positioning PL as a health determinant (Cairney et al., 2019). Their paper presents existing evidence from fields outside of PE, which has long been the common context for PL research. The authors also proposed that by viewing PL as a determinant of health, this would provide conceptual direction for empirical PL research in the future (Cairney et al., 2019). Whilst this represents one of the first steps to highlight the role PL may play in promoting health behaviours, the model itself is limited by drawing heavily from motor competence research (Stodden et al., 2008) and neglecting the cognitive and affective domains of PL. In saying that, a large study of Canadian children ($n = 2956$) identified that knowledge and understanding of PA principles was not related to PA or sedentary behaviour guideline adherence as measured by the CAPL, pedometers and self-report questionnaires (Belanger et al., 2018). Whilst there are many published articles in the form of commentaries, opinion pieces, and recommendations, this conflation of findings poses more questions than answers, highlighting the need for primary empirical evidence to support PL as a holistic concept and health determinant.

Following on from Cairney's paper, Cornish et al. (2020) produced a rapid scoping review to reinforce our understanding of PL in the context of health (Cornish et al., 2020). They found seven studies that explored the association between various health indicators and PL in children (Belanger et al., 2018; Comeau et al., 2017; Nyström et al., 2018; Holler et al., 2019; Lang et al., 2018; MacDonald et al., 2018; Saunders et al., 2018). Health indicators including BMI, waist circumference, body weight, grip strength, and cardiorespiratory fitness were found to be predictors of PL levels, specifically within the physical domain (Comeau et al., 2017; Nyström et al., 2018). Belanger et al. (2018) identified that children with higher PL scores were more likely to meet daily PA and sedentary behaviour recommendations; similarly, physical and affective domains of PL were negatively associated with screen and non-screen sedentary time (Saunders et al., 2018). In three articles included in the Cornish (2020) review, participants considered to be of a healthy weight recorded higher PL scores than those classified as overweight or obese (Comeau et al., 2017; Nyström et al., 2018; Holler et al., 2019). Participants with higher BMI, and greater waist circumference and weight were more likely to have a lower overall PL score than participants

considered to be within the healthy BMI, weight, and waist circumference for their age and height (Comeau et al., 2017; Nyström et al., 2018). Findings from one study also indicated that children with higher cardiorespiratory fitness scores had greater PL across all domains of PL, regardless of age or gender (Lang et al., 2018); another found cardiorespiratory fitness to be linked to children's perceived levels of adequacy and predilection for PA (MacDonald et al., 2018). These findings would suggest that PL can be a gateway to increase PA and its associated health outcomes in children (Jurbala, 2015). These findings also support the need to develop appropriate PL-based interventions targeting children to develop these skills at the appropriate stages of their development (Whitehead, 2013), as well as designing appropriate assessment tools to track the progress of said interventions (Tremblay and Lloyd 2009).

Current Levels of Physical Literacy in Young People

Although pioneering work is underway in some jurisdictions, there is currently a dearth of research establishing PL trends in many countries (Gu, Chen and Zhang, 2019). The largest and most comprehensive PL study was conducted in Canada (Tremblay et al., 2018) where the CAPL (Tremblay and Lloyd 2009; Longmuir 2013; Longmuir et al., 2015) was used to assess the PL of children. In this study data were collected from 11 sites across Canada, yielding a total sample of 10,034 participants (50% female, age range 8-12, mean 10.1). The CAPL incorporates 25 measures within four interrelated domains; physical competence, daily behaviour, knowledge and understanding, and motivation and confidence (Tremblay and Lloyd 2009; Longmuir 2013; Longmuir et al., 2015). This study found that total PL scores (out of 100) were on average 63.1 ± 13.0 for males and 62.2 ± 11.3 for females. For males and females respectively, domain scores were: 19.9 ± 4.7 and 19.3 ± 4.1 for physical competence (out of 32 points); 18.6 ± 7.9 and 18.5 ± 7.4 for daily behaviour (out of 32 points); 12.7 ± 2.8 and 12.2 ± 2.6 for motivation and confidence (out of 18 points); and 11.8 ± 2.8 and 12.2 ± 2.6 for knowledge and understanding (out of 18 points). These findings demonstrated that on average, the total PL score, as well as the physical competence, daily behaviour, and motivation and confidence domains were at the “progressing” level, and only the

knowledge and understanding domain were at the desired “achieving” level in Canadian children (Tremblay et al., 2018).

Similarly in the US, Gu et al. (2019) carried out a study to examine students’ current level of PL in third grade (Gu, Chen and Zhang, 2019). Data were gathered from 4 elementary schools from the same independent school district in northern Texas, with a total sample of 342 (54.3% male, age range 7-9, mean 8.74 years) (Gu, Chen and Zhang, 2019). Four dimensions of PL were assessed in this study which were identified from the SHAPE America five national PE standards; FMS, health-related physical fitness, school-based MVPA, and health-related fitness knowledge (Gu, Chen and Zhang, 2019). FMS were assessed using the PE Metrics™ motor skill assessments (SHAPE America 2019), health-related physical fitness was measured by the FitnessGram testing battery (Welk & Meredith 2010), School-based MVPA was measured using the Actical activity monitors (Koninklijke Philips Electronics N.V., Amsterdam, The Netherlands), and a standardised written test for third-grade students was used to measure students’ knowledge about health-related fitness. The test was validated using the known-group method, and had been previously used in elementary school children (Zhu et al., 2009). The results of this study highlighted varying levels of FMS, health-related fitness, school-based MVPA time, and fitness knowledge. The majority of students achieved satisfactory competency for their core body strength (i.e. abdominal and trunk ~80% reached the healthy fitness zone) and PA level (102.20 min/day). Participants showed relatively lower competency levels for FMS (particularly locomotor skills, which are lower than the national average for kindergarteners), body composition (55% in the healthy fitness zone), and fitness knowledge (M = 57%, SD = 16%). Over two-thirds of participants were in the healthy fitness zone for upper body strength (69%) and flexibility (67%), whilst cardiorespiratory endurance was within an appropriate range for 10-year-olds (Gu, Chen and Zhang, 2019). Although a significantly smaller sample size than the previous study, these findings highlight that there is significant room to improve children’s PL (Gu, Chen and Zhang, 2019).

In an Irish context, Behan et al. (2020) & Peers et al. (2020), investigated the PL levels of 2,148 primary school children (n = 2098, 47% girls, age range 5-12 years) using five core research

measurements; fundamental movement skill, physical activity and motivation quality, perceived movement skill quality, physical self-efficacy and physical activity levels. The findings from this research showed a dearth of proficiency across all FMS components throughout primary school, with only 60.6% of children achieving Mastery/Near Mastery (MNM) in balance skills, 52.8% achieving MNM in locomotor skills and 54.8% achieving MNM in object manipulation skills (Behan et al., 2019). Their findings also highlighted that children have low levels of perceived self-efficacy and their quality of motivation is poor (Peers et al., 2020). This results in low levels of PL, and therefore, low levels of PA (Peers et al., 2020).

Similarly, Belton et al. (2019), investigated the levels of PL in Irish adolescents. In this study data were collected from 535 ($12.78 \pm .42$ years) adolescents across 20 schools. Data were gathered on PA (accelerometer data and habitual PA questionnaire), physical competence (FMS, VO_2 max, BMI), and psychological correlates (self-efficacy questionnaire, perceived benefits of PA questionnaire, motivation in PE class questionnaire) (Belton et al., 2019). Results of this study found that Irish youth are performing “below par” in terms of PL (Belton et al., 2019). Out of a standardised “optimum score” of 100, males were at 70% and females were at 64% respectively in relation to PA. In relation to FMS, males averaged a score of 80 in comparison to 73 in females. BMI results found 25% of participants to be classed as overweight/obese. For VO_2 max males obtained 45% of their optimal score, while females were at 67%. For psychological correlates males scored significantly higher than females for all three measures ($p = 0.006$, $p = 0.37$, and $p < 0.001$ respectively). For both males and females, self-efficacy was the lowest scoring psychological correlate in terms of percentage of the optimal score (53% for males and 46% for females).

The evidence provided by these studies clearly highlight the urgent need to improve children’s PL (Tremblay et al., 2018). The lack of similar studies also highlights the dearth of population data on PL (Gu, Chen and Zhang, 2019). Such surveillance studies are valuable as they provide a “state of the nation” baseline from which appropriate intervention strategies can be developed (Tremblay et al., 2018). Another element to consider is the fact that all of these studies used completely different assessment tools to evaluate children’s PL. This results in a lack of

consistency and the ability to compare populations (Giblin, Collins and Button, 2014; Liu and Chen, 2020), warranting further research into the assessment of each element of PL going forward.

Physical Literacy Summary

Whilst not being new in historical terms, the concept of PL could be considered to be in its infancy in terms of research concerning children's health (Edwards et al., 2017, 2018; Mandigo et al., 2009; O'Brien, Belton, and Issartel 2015; Tremblay et al., 2018). The IPLA define PL as the "motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" (IPLA 2017). This definition suggests that PL is made up of several components, which entails holistic development or development of the whole person (i.e. their feelings (affective), movements (physical) and thoughts (cognitive)) (Jurbala, 2015). Emerging research suggest that PL could be a key determinant in engaging children in lifelong PA (Cairney et al., 2019; Edwards et al., 2017, 2018; O'Brien, Belton, and Issartel 2015; Mandigo et al., 2009; Belanger et al., 2018). Considering the fact that many children have not developed these skills to the desired level for their age (Tremblay et al. 2018; Gu, Chen, and Zhang 2019) and given the well-established health benefits associated with PA (Hall et al., 2021), research seeking to examine or develop some or all of these components in children would be welcome. The assessment of the various components of PL has proven to be a barrier in this emerging research (Liu and Chen, 2020), with many tools not being practical for settings such as schools where interventions could take place (Robinson and Randall, 2017). Physical literacy is a multi-faceted complex construct, with each component inter-linking to contribute to the holistic development of each individual (Whitehead, 2010). Considering that limited research to date has been able to make conclusions on the holistic concept of PL and long term health outcomes (Cairney et al., 2019), delving into a component such as physical competence, which has established such links (Barnett et al., 2009; Cliff and Okely, 2009; Logan et al., 2015; Stodden et al., 2012), may help in gaining a deeper understanding about the construct as a whole.

Movement Competence

Movement Competence: An Introduction

Movement competence (MC) is a global term used to reflect terminologies (e.g. motor competence, motor proficiency, motor performance, fundamental movement/motor skill, motor ability, and motor coordination) that have been used previously in the literature to describe the quality of goal-directed human movement (Robinson et al., 2015). Movement competence development is an important area of PL (Pill and Harvey, 2019), and as a concept has gained attention in recent times, largely due to its positive association with PA (D'Hondt et al., 2014; Lloyd et al., 2014). Research suggests that developing a strong foundation of MC is critical to promoting and sustaining positive trajectories of PA and health-related fitness (HRF) (Jaakkola et al., 2019; Robinson et al., 2015; Stodden et al., 2008). A core aspect of MC is proficiency in the performance of FMS (Stodden et al., 2008).

Fundamental movement skills are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018). Fundamental movement skills are typically classified into three areas: locomotor, object manipulation and stability skills (Gallahue and Ozmun, 2006; Goodway, Ozmun and Gallahue, 2019). Locomotor skills involve moving the whole body (e.g. running, jumping, hopping etc.), object manipulation skills are those which involve manipulating an external object (e.g. kicking, catching, throwing etc.), while stability relates to balancing skills (e.g. static balance, beam balance, one foot balance etc.) (Gallahue and Ozmun, 2006). Research suggests that children have the potential to master most of these movement skills as early as six years of age (Gallahue and Ozmun, 2006), with it further suggested that mastery of all FMS should be acquired by nine or ten years of age (Hardy et al., 2010). Once refined and combined, these FMS support the acquisition of more advanced movement skills that allow participation in sport and PA (McKenzie and Lounsbery 2009; Clark and Metcalfe 2002), with increased proficiency leading to increased PA participation in children (Barnett et al., 2009; Cliff et al., 2009; Logan et al., 2015). Traditionally, it was believed that these skills develop naturally, however research has shown that FMS must be taught and developed (Clark 2007; Haywood and Getchell 2019; Cools et al., 2009; Stodden et al., 2008). While children may naturally

develop a rudimentary form of fundamental movement pattern (Lubans et al., 2010), a more mature form of FMS proficiency is likely to be achieved with appropriate practice, encouragement, feedback and instruction (Lubans et al., 2010) in both educational and free play settings (Clark 2007; Haywood and Getchell 2019).

Movement Competence and Physical Activity

The relationship between MC and PA has been widely studied. Evidence suggests there is a reciprocal relationship between MC and PA that changes with age (Stodden et al., 2008). It is also recognised that the reciprocal relationship between MC and PA may be influenced by other variables. Stodden et al. (2008) suggest that health-related fitness (HRF) and perceived competence (PC) play a role in mediating the MC-PA relationship, and accordingly have developed a theoretical conceptual model to depict these interacting relationships (See Figure 2.4).

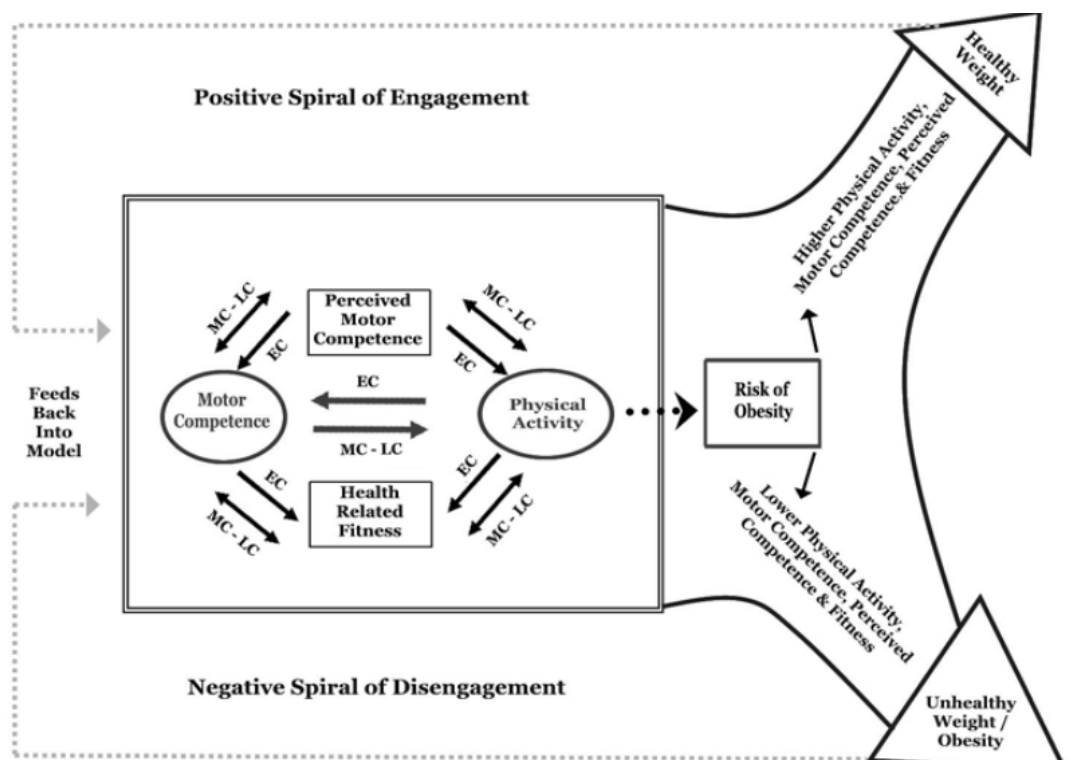


Figure 2.4: Stodden et al.'s (2008) Conceptual Model

This conceptual model depicts a spiral of engagement which can be either positive or negative. That is, individuals with higher actual and perceived MC are likely to be more positively inclined towards PA, and by engaging in PA may further enhance their actual and perceived MC. This positive spiral of engagement is hypothesised to promote health through the maintenance or development of a healthy weight status (Stodden et al., 2008). Stodden et al.'s (2008) conceptual model suggests that HRF and perceived MC mediate the relationship between actual MC and PA, with each of these variables combining to positively or negatively affect weight status. Research examining interrelationships between some of the variables in Stodden et al.'s (2008) model provide supporting for the inclusion of factors such as MC, HRF and PC in a model that aims to provide a guide for future research on PA behaviours and health outcomes in youth (Barnett et al., 2008; Mitchell et al., 2012; Babic et al., 2014; Khodaverdi et al., 2015; Robinson et al., 2015).

Measurement of Fundamental Movement Skills

The choice of assessment tool depends on a range of factors, such as: the purpose of assessment, administrative properties (i.e. user friendliness, required time, cost), target group (i.e. age, disability), or the psychometric quality of the assessment instrument (e.g. test-retest reliability, construct validity) (Bardid et al., 2019). Current assessments can be categorised as either using a process or product-oriented methodology (Logan et al., 2017). Product-oriented assessments evaluate the outcome of a movement or skill (how fast/how many). This offers an objective evaluation of the outcome of a task, but not on how it was achieved (Bisi et al., 2017). Alternatively, process-oriented assessments analyse how a movement or skill is performed, but does not examine outcome (Logan et al., 2017). The relationship between process and product-based assessments is neither clear, nor comprehensive (Logan et al., 2017). For example, recent studies have found low (5.3%; 4 - 11 year olds) (Valentini et al., 2015) to moderate amounts of variance explained (24%; 3 - 6 year olds) (Logan, Robinson, and Getchell 2011) (27%; 5 - 8 year olds) (Logan et al., 2015) between overall performance on the process-oriented Test of Gross Motor Development (2nd Edition) (TGMD-2) and the product-oriented Movement Assessment Battery for Children – 2nd edition (MABC-2). It has

therefore been suggested that a combined use of product-oriented and process-oriented measures can provide a more comprehensive assessment of children's MC (Robinson et al., 2015; Bardid et al., 2019), however, to date, few assessment tools adopt this methodology.

The most commonly used product-oriented assessments are the MABC (Henderson, Sugden and Barnett, 2007), the Körperkoordinationstest für Kinder (KTK) (Kiphard and Schilling, 2007) and the Bruininks-Oseretsky Test of Motor Proficiency 2 (BOT-2) (Bruininks, 2005). The MABC is suitable for children and youth, aged 3 - 16 (Henderson, Sugden and Barnett, 2007) and is used to identify impairments in FMS across three skill categories: manual dexterity, aiming and catching, and balance (Henderson, Sugden and Barnett, 2007). The MABC has been used over several age groups (Brown and Lalor 2009; Logan, Robinson, and Getchell 2011; Logan et al., 2012; Vedul-Kjelsås et al., 2012; Hua et al., 2013; Zoia et al., 2019), with the tasks of the assessment changing based on the participant's age (Brown and Lalor, 2009). Normative scores are provided for each age category (3-6 years, 7-10 years, 11-16 years) and individuals at risk of movement difficulties are identified using a traffic light system. A benefit of the MABC in comparison to some other tools (e.g. TGMD) is that it assesses all components of FMS, and that an assessor can focus on just one component without having to complete the full test battery. There are, however, a number of limitations to this tool also. One such limitation of the MABC, as is the case with all product-oriented assessments, is the fact that it does not identify movement quality (i.e. if the components of a skill are correctly executed during their execution). A systematic review by Eddy et al. (2020), which examined the validity and reliability of observational assessment tools in school-aged children found the MABC to be the tool with the largest number of psychometric properties evaluated (Eddy et al., 2020). Yet, the evidence for the validity and reliability of the MABC was very mixed, and the quality of the studies that found strong evidence for its psychometric properties was questionable (Eddy et al., 2020). Moreover, the MABC requires specialist equipment such as mats, which contribute to making the measure expensive to buy, making this a much less feasible option to use in many environments (e.g. schools) (Eddy et al., 2020). The MABC also takes an extended period of time to

administer (30 - 60 minutes), and must be delivered 1-to-1 by a trained professional (Eddy et al., 2020), once again, significantly impacting its feasibility for use with a large group of children.

The KTK is validated for children aged 5 - 14 (Cools et al., 2009) and consists of four subtests: walking backwards, moving sideways, hopping for height, and jumping sideways, of which the outcome of each is measured (Vandorpe et al., 2012). It has been used extensively in research, clinical and school practices (Iivonen, Sääkslahti and Laukkanen, 2016), however, it does have a number of limitations. The KTK only records the overall gross FMS score, and there is no breakdown of the FMS components, even though the four assessments focus on stability skills (Cools et al., 2009). The normative data provided is also relatively old (1974) (Schilling and Kiphard, 1974) and may not still be relevant (Cools et al., 2009).

The BOT-2 is used to identify individuals aged 4 - 21 years with mild to severe motor coordination problems (Bruininks, 2005; Bruininks, Bruininks and Case, 2013). The BOT-2 measures fine and gross movement skill using 53 test items in eight subtests: fine motor precision (seven items), fine motor integration (seven items), manual dexterity (five items), bilateral coordination (eight items), balance (nine items), running speed and agility (five items), upper limb coordination (seven items) and strength (five items) (Fransen et al., 2014). The BOT-2 Short Form is derived from the BOT-2 and is shorter and easier to administer and features a total 14 items, with at least one from each of the BOT-2 subtests (Bruininks, 2005). Similarly to the MABC, the BOT has a number of significant limitations with regards feasibility (Eddy et al., 2020). It is again notably costly to purchase and takes between 45 - 60 minutes to assess each child (Eddy et al., 2020). Another significant limitation that applies to all the tools mentioned is how varied they are to one another considering that they are meant to be measuring the same construct. When examining the convergent and discriminant validity between the BOT-2 Short Form and KTK, Fransen et al. (2014) found only reasonable proof of convergent and discriminant validity as well as relatively low agreement in children with relatively high and relatively low MC, concluding that two assessment tools would need to be used for children with lower and higher levels of MC (Fransen et al., 2014).

Get Skilled: Get Active (GSGA) is a process-oriented assessment tool that measures 12 FMS (NSW Department of Education and Training, 2000). This tool was designed as a tool to help teachers improve the MC proficiency of children and adolescents (NSW Department of Education and Training, 2000). The tool itself includes twelve skills (run, balance, vertical jump, catch, hop, side gallop, skip, overarm throw, leap, kick, two-handed strike and dodge) representing each component of FMS (locomotor, object manipulation, stability) (Gallaghue and Ozmun 2006; Haywood and Getchell 2019; Rudd et al., 2015). These particular set of skills were selected as they were deemed to form the platform for the development of specialised skills, enabling students to participate in a wide range of physical activities (NSW Department of Education and Training, 2000; Okely and Booth, 2004). Each of the twelve skills are composed of observable components that together constitute a mature performance of the skill (Okely and Booth, 2004). Teachers are then provided with checklists to help identify student performance and identify what stage of learning the student may be at (NSW Department of Education and Training, 2000). Early research from Australia, such as Barnett et al., (2009), (n=42) suggested that GSGA was reliable (alpha coefficient ranges from 0.13 – 0.95), showed moderate inter-rater reliability ($\kappa = 0.61$), and was a culturally acceptable tool (designed following consultation with 52 consultants, such as teachers, coaches, sports scientists, and university lecturers). Despite this initial research indicating that the GSGA FMS assessment protocol is an appropriate, reliable, culturally acceptable and valid instrument for measuring levels of gross motor skill proficiency amongst children and adolescents (Okely and Booth 2004; Barnett et al., 2009, 2010; Hardy et al., 2010), more recent research has raised questions over its validity and reliability, creating doubt over whether or not the results can be trusted (Eddy et al., 2020).

One of the most commonly used assessments of FMS in children is the process-oriented, TGMD-2 (Ulrich 2000). The TGMD-2 is a standardized norm- and criterion-referenced test designed to be used with children from 3 - 10 years of age (Ulrich 2000), but has recently be validated for use with adolescent populations (Issartel et al., 2017). The TGMD-2 has been extensively used in research (Belton et al., 2014; Logan et al., 2017; O'Brien, Belton, and Issartel 2016; Barnett et al., 2009; Behan et al., 2019; Peers et al., 2020) due to its consistently good evidence of validity and

reliability (Eddy et al., 2020; Hulteen et al., 2020). Now in its third iteration, the TGMD-3 contains six locomotor skills (run, gallop, hop, skip, horizontal jump, slide) and seven object control skills (two-handed strike of a stationary ball, one-hand forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw, underhand throw) (Ulrich, 2019) and includes one more skill than the previous TGMD-2 with the addition of the one-handed strike. Each skill is made up of between three and five components to determine the proficiency level of the participant. A participant performs a familiarisation trial version of the skill, then two trials in which the skill components are assessed. The TGMD-2 provides normative scores for both the locomotor and object manipulation skill subtests, with gender specific tables for the object manipulation subtest (Ulrich, 2019). Normative values for the TGMD-3 are currently being compiled and are set to be published in the near future. Although the TGMD-2 and TGMD-3 has reported strong reliability, validity and interrater reliability in previous research (Wagner, Kipling Webster, & Ulrich, 2017; Wagner, Webster, & Ulrich, 2015; Webster & Ulrich, 2017), it is not without its limitations. Arguably, its most significant flaw is that it fails to assess stability (Rudd et al., 2015), which, along with locomotor and object manipulation skills, is a key component of FMS (Gallahue and Ozmun 2006). It is also not feasible to use with a large group of children due to the significant time and human resources required to administer the test with a large group (Eddy et al., 2020).

In addition to a lack of feasibility for use with large groups, another common criticism of assessments such as the TGMD is that they focus on isolated skill performance (Lander et al., 2017), which limits their authenticity. Hence, more dynamic, hybrid forms of assessment have emerged in recent times. The Canadian Agility and Movement Skill Assessment (CAMSA) (Longmuir et al., 2017) was the first hybrid-form of assessment to be created. This assessment was developed as part of the CAPL (Longmuir et al., 2015). This assessment requires a series of seven movement tasks (two-footed jump, side slide, catch, throw, skip, hop, and kick) to be completed in a continuous, dynamic obstacle course format (Longmuir et al., 2017). Performances are then evaluated using the aggregate of time taken to complete the course, and the quality of the observed skill performance (Longmuir et al., 2017). Despite making the first step in creating a more dynamic and ecologically

valid assessment of children's MC, the CAMSA is also not without its limitations. For instance, it does not include any specific stability skill, a key component of MC, and a key limitation it shares with the TGMD. In addition, the scoring of the assessment is unbalanced between locomotor and object manipulation criteria, as well as between product and process criteria (Tyler et al., 2018). Considering that males have previously been reported to outperform females in object manipulation skills, and the inverse in locomotor skills, having an imbalanced scoring system may favour one gender over the other. There is also limited empirical evidence for the CAMSA. Longmuir et al., (2017) (n=53, 34% female) found moderate effect sizes for inter-rater (ICC=0.69), intra-rater (ICC=0.52) and test-retest reliability (ICC=0.46-0.66), as well as internal consistency. Lander et al., (2017) (n=34, 100% female) found strong evidence for test-retest reliability (ICC=0.91), however this study was reported to have a lower quality rating than Longmuir et al., (2017) (49% compared to 77%) (Eddy et al., 2020).

The Dragon Challenge (DC) (Tyler et al., 2018) is a dynamic and practical assessment that does contain a stability component. The DC consists of nine tasks (balance bench, core agility, wobble spot, overarm throw, basketball dribble, catch, jumping patterns, T-agility, accelerate-sprint) completed in a timed, continuous circuit (Tyler et al., 2018). Performances are then evaluated using a combination of process (performance criteria) and product (time taken to complete circuit) indicators (Tyler et al., 2018). Findings from Tyler et al., (2018) (n=4355, 50% female, aged 10-14 years) suggest that the DC has good structural validity (CFI, 1.00; TLI, 1.00; RMSEA, 0.038), test-retest reliability (ICC=0.80), inter- and intra-rater reliability (ICC=>0.85). Despite this assessment tool once again proving to be an advancement to previous tools, it too has its limitations. It does not examine the kick, a key skill in many popular physical activities as well as representing lower-body ball skill motor competence (Brian et al., 2021). It also fails to examine asymmetry (the ability to perform skills using both sides of the body), a factor which has been linked to increased musculature and non-contact related injuries when partaking in sports and other physical activities (Abraham, Rajasekar and Rohit, 2015). Considering that FMS only represents one construct of overall MC (O'Brien et al., 2021), a tool which examines functional movement patterns or considers the risk of

injury would be a welcomed advancement to the field and be one step closer to creating a more holistic assessment of MC.

Importance of Movement Competence in Youth

Developing MC to a sufficient proficiency at a young age has far-reaching consequences for one's health (D'Hondt et al., 2014; Lloyd et al., 2014). Failure to develop MC proficiency in childhood can negatively impact PA in adolescence (Barnett et al., 2009; Green et al., 2011) and into adulthood (Lloyd et al., 2014). As highlighted earlier in this review, low levels of PA can result in serious short and long-term negative health outcomes for youth (Raitakari et al., 2003; Warburton, Nicol, and Bredin 2006; Lubans et al., 2016; Geidl et al., 2020; Uddin et al., 2020).

Studies have shown that individuals with lower competency in motor skills are at risk of low levels of PA (Barnett et al., 2009; Lloyd et al., 2014). A five year longitudinal study in young children ($n = 285$; 49.8% female; mean age at baseline = 6 years) showed that MC at age 6 was a significant predictor of PA over the course of a five year period (Lopes et al., 2011). These results suggested that children with initial low levels of MC, declined the most in terms of PA participation across childhood (2.58 units/year), followed by those with mid-level initial MC (2.47 units/year) (Lopes et al., 2011). In contrast, children with high initial levels of MC showed stable levels of PA over time that were higher than children with lower initial levels of MC (Lopes et al., 2011). Interestingly, PA levels across the three categories of MC in this study (low, medium, and high competency) were not significantly different at age 6, yet by age 10 there were significant differences in PA between groups in favour of children who were more competent in motor skills at baseline (high competency: negligible change, medium competency: -2.47 METS each year, low competency: -2.58 METS each year) (Lopes et al., 2011). This finding indicates that the negative consequences of low MC in childhood may not be apparent immediately, but may manifest later in childhood. Barnett et al., (2009) also found an association between childhood MC and adolescent PA, but only for object manipulation skills. Children ($n = 276$) who were more proficient in object manipulation skills at age

10 were 10-20% more likely to report participation in vigorous PA at age 16 than their lower competent peers (Barnett et al., 2009).

This relationship between MC and PA was further explored by Lloyd et al. (2014). They conducted a 20-year longitudinal study that tracked participants from childhood (age 6) to adulthood (age 26), measuring MC and PA at four time points (Lloyd et al., 2014). At age 6, MC was assessed using the TGMD-2. Children ($n = 100$) were identified as being either low ($\leq 10^{\text{th}}$ percentile) or high ($\geq 84^{\text{th}}$ percentile) MC (Lloyd et al., 2014). A five-year follow-up with these participants ($n = 60$) found that children who had been identified as low MC at age 6 continued to score lower in MC (TGMD-2 sum of raw scores; 36.50 ± 2.12 versus 40.75 ± 2.96 , $p < .01$) and reported lower levels of PA than children who had been identified as high MC. Subsequent follow-up studies on these same participants found lower levels of PA in the low MC group at ages 16 ($n = 43$) and 26 ($n = 17$) (Lloyd et al., 2014). The 20-year follow-up element of this study required participants ($n = 17$) to recall their MC at age 16, and to report their current MC at age 26 using the Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A). The DCDQ-A is an adult version of the questionnaire (Cantell, Crawford and Tish Doyle-Baker, 2008). The self-report and recall method of measuring MC at age 16 and 26 is a limitation of this study and casts some uncertainty over the 10- and 20-year follow-up MC scores due to the questionable ability of individuals to correctly self-report their MC ability for 10 years prior. Nevertheless, it is acknowledged that until recently, there had been no available MC tests validated for use with adolescents and adults (Hands, Licari and Piek, 2015; Issartel et al., 2017). Interestingly, from a long-term health and PA maintenance perspective, in results obtained from the adult part of this study, not only were adults who were identified as high MC in childhood reporting higher levels of MVPA in adulthood (62.73 ± 57.64 minutes vs 31.67 ± 60.14 minutes for low MC group), but those who scored high in locomotor skill proficiency at age 6 also reported higher levels of active transport at age 26, and lower levels of time spent in a motor vehicle (Lloyd et al., 2014). The fact that MC at a young age may have such an effect on future PA behaviour (Lloyd et al., 2014) demonstrates the importance of developing MC in youth for the

purpose of maintaining sufficient levels of PA for health (Barnett et al., 2009; Lopes et al., 2011; Green et al., 2011; Lloyd et al., 2014).

The previously mentioned longitudinal studies have highlighted the association between MC in childhood and PA in adolescence (Barnett et al., 2009) and adulthood (Lloyd et al., 2014), and have identified MC as factor that may enhance the likelihood of maintaining PA participation over time. It is important to note however, that contrary to some of the research examining MC and its effect on PA, other longitudinal studies have not found childhood MC to predict later PA (McKenzie et al., 2002; Green et al., 2011). Green et al. (2011), found that childhood MC predicted future PA in boys, but not girls. McKenzie et al., (2002) did not find MC at age 4, 5 and 6 years to predict PA at age 12 years in either boys or girls ($n = 207$). The method of MC assessment used in this study may go some way to explaining why childhood MC did not predict PA at age 12, as only one skill for each component of MC was assessed (i.e. balance on one foot - stability, jumping laterally - locomotor, catching a ball - object manipulation). The authors of the study also noted that the assessment of MC in childhood was carried out prior to entry into school and organised sport (McKenzie et al., 2002). From the age of about six years children are more likely to be exposed to PA and organised sport through both school and sports club involvement, providing opportunities to enhance MC (Gallahue and Ozmun, 2006). Participants in McKenzie et al.'s (2002) study may not have had this opportunity due to their young age (age range 4-6 years). The results from this study indicate that just because a child may have low MC at a very young age, does not mean they cannot develop MC given the opportunity (i.e. in school/organised sport). Sufficient development of said skills can lead to them avoiding the reported negative effect of low childhood MC on later PA (McKenzie et al., 2002), and the associated negative health outcomes (Raitakari et al., 2003; Warburton, Nicol, and Bredin 2006; Lubans et al., 2016; Geidl et al., 2020; Uddin et al., 2020).

Fundamental Movement Skills as a Precursor to Sport Specific Skills

Participation in organised sport is an important contributor to PA in youth (Marques, Ekelund, and Sardinha 2016). Research carried out in Australia ($n = 4273$, aged 11-16 years, $M = 13.3$ years) showed that more than 50% of total PA was acquired through organised PA, such as sports (Hardy et al., 2014). According to Gallahue, Ozmun & Goodway (2012), proficiency in FMS acts a precursor for the acquisition of more advanced, sports specific skills (SSS), that support the ongoing successful participation in both recreational and organised sports (Gallahue, Ozmun and Goodway, 2012). Evidence of this positive association between FMS proficiency and participation in sports has been shown during early (Queiroz et al., 2014) and middle childhood (Vandorpe et al., 2012), as well as during adolescence (Fransen et al., 2012). A recent study that followed 213 Austrian middle-school students (57% male; age at baseline: 10.4 ± 0.6 years) over a 4-year period found that higher FMS proficiency was associated with increased participation in sports clubs (Drenowatz and Greier, 2019). This finding echoes that of another longitudinal study carried out by D'Hondt et al. (2013), who also found a positive association between FMS proficiency and organised sport participation in early and late childhood (D'Hondt et al., 2013). These findings demonstrate that increased FMS proficiency is associated with increased sports participation (D'Hondt et al., 2013), however, it must also be acknowledged that regular participation in sport and PA may also contribute to an increase in FMS proficiency (Vandorpe et al., 2012). Without engaging in a “chicken and egg” debate, it is evident that children must establish a proficient level of FMS in order to successfully engage in sport and organised PA (Drenowatz and Greier 2019; D'Hondt et al., 2013). As a result of positive engagement in these activities, FMS proficiency can continue to grow, supporting sustained participation in regular PA and all the associated health outcomes it brings (Drenowatz and Greier, 2019).

Proficiency in FMS is not limited to promoting participation in organised sport, but also to the attainment of more proficient SSS (Kokstajn and Musalek, 2019; Duncan et al., 2021). This is demonstrated by Duncan et al. (2021), who examined the role of FMS and perceived competence in the relationship between physical fitness and technical soccer skills in children (Duncan et al., 2021). As part of this study FMS were measured using the TGMD-2, and technical skill was determined

from three tests examining dribbling, passing and shooting. Results of this study show that FMS proficiency significantly contributes to the performance of sport-specific technical skills (Duncan et al., 2021). These findings align with those exhibited by Kokstejn et al. (2019), who determined that FMS was a key factor in the relationship between fitness and soccer dribbling performance in elite youth players (Kokstejn and Musalek, 2019). Such findings, therefore, emphasise the need for children to develop proficiency in FMS, in order to successfully engage in, develop and sustain their engagement in sport and PA.

Current Levels of Movement Competence in Young People

Although it is well documented that appropriate MC development contributes to children's physical, mental, and social development, as well as to their health and wellbeing (Piek, Baynam and Barrett, 2006; Haga, 2008; Payne and Isaacs, 2017), the literature in recent times suggests that the MC levels of children and adolescents worldwide is lower than the recommended MC proficiency levels (Lopes et al., 2021).

One of the first studies to highlight the low levels of MC among youth populations was carried out by Okely and Booth (2004) in New South Wales who presented findings on the levels of children's (n = 1288, school years 1-3) FMS mastery. They found that across six FMS, the level of mastery did not exceed 35%, and apart from balance, the level of near-mastery did not exceed 50% in all ages (6 - 9 years) (Okely and Booth, 2004). Mastery of a skill is attained when a maximum score for a skill is achieved (i.e. all skill criteria are met for both trials) (Booth et al., 1999). Thus, near-mastery is defined as when all but one skill criteria was performed over the two trials (Booth et al., 1999). Following the study by Okely and Booth (2004), Hardy et al. (2013) conducted a secondary analysis of representative, cross-sectional, Australian school-based surveys from 1997, 2004, and 2010 (n = 13,752 children age 9-15 years) (Hardy et al., 2013). Their analysis found that children's FMS competency was consistently low, with prevalence rarely above 50% (Hardy et al., 2013). A similar proficiency was found in a New Zealand study where less than half of participants

(n = 701; age range 5-13 years) showed competency in striking (40%), throwing (31%), or kicking (21%) at baseline (Mitchell et al., 2013).

Low levels of MC proficiency are not exclusive to the southern hemisphere. Bardid et al. (2015) sought to compare the MC of 244 (43.4% boys) Belgian children and 252 (50.0% boys) Australian children, aged 6–8 years) using the Körperkoordinationstest für Kinder (KTK) (Bardid, Rudd et al., 2015). Although overall MC was low, Belgian children demonstrated a higher level of MC (17% higher) than their Australian counterparts (Bardid et al., 2015). Interestingly, despite the fact that Belgian children outperformed Australian children within this study, both groups scored significantly lower than the German standardisation sample from 1974 (Bardid et al., 2015). This finding illuminates the stark and concerning decline in children's overall MC proficiency over time, emphasising the urgent need for intervention to reverse this decline. Another study by Chow et al. (2001), compared the MC of children (age range 4-6 years) from China (Hong Kong) (n = 255) and the United States (n = 493) using the MABC. Results revealed differences between the groups, with Chinese children performing significantly better on manual dexterity and balance tasks, whilst American children outperformed Chinese children on throwing and catching tasks (Chow, Henderson and Barnett, 2001).

This clear lack of MC proficiency is also evident in Irish children. Cross sectional data as part of a national PL study (n = 2098, 47% girls, age range 5 - 12 years, $M = 9.2 \pm 2.04$) found a dearth of proficiency across all FMS components throughout primary school (Behan et al., 2019). In this study only 60.6% of children achieved mastery/near mastery (MNM) in balance skills, while just over half achieved MNM in the locomotor (52.8%) and object manipulation skills (54.8%) (Behan et al., 2019). Similar findings were reported by Kelly et al. (2018), who reported that primary school children (n = 414, age 6 - 12 years) have poor levels of FMS mastery. These trends are also evident in late childhood and adolescent children in Ireland. Research shows that the majority of Irish adolescents do not possess the expected level of MC for their age, with only 11% of a sample of 12-13 year old adolescents (n = 242) reaching mastery, or near-mastery, across nine FMS (O'Brien, Belton and Issartel, 2016). Even more recently, in a study carried out by Belton et al. (2019), that

examined the PL components of 535 Irish adolescents ($12.78 \pm .42$ years), the mean overall FMS score for males was 80 out of the optimal score of 100, while females scored only 73 out of this optimal score (Belton et al., 2019).

Differences in FMS ability according to gender have been widely observed with varied outcomes. Research suggests that males are generally more competent in overall FMS than their females counterparts (Barnett et al., 2009; Cantell et al., 2008; O' Brien et al., 2015; Breslin et al., 2012; Lopes et al., 2011). Research is consistent in showing that males score significantly higher than females in object manipulation skills (van Beurden et al., 2002; Okely and Booth 2004; Barnett et al., 2010; Bardid et al., 2016; Kelly et al., 2019). Definitive gender differences in locomotor skills are somewhat more elusive, with some studies reporting that there are no gender differences in locomotor skill proficiency level (Barnett et al., 2010), while other studies report females as more proficient (Barnett et al., 2008). Van Beurden et al. (2002), suggests that sport participation may explain this gender disparity, with girls favouring more locomotor skill dominant activities (such as gymnastics and dance), whilst boys often favour activities predominantly involving object manipulation skills (such as football and rugby). This theory has merit if you consider the most recent CSPPA national surveillance report in Ireland (Woods et al., 2018). This report shows that soccer, Gaelic games and basketball are among the most popular sports for males, whereas females partake in more athletics and dance-based activities than males (Woods et al., 2018). Consequently, to further investigate these differences, studies examining the MC proficiency of children should not only consider the overall composite scores, but also the scores of each sub-component (i.e. locomotor, object manipulation, stability). If not reported, gender differences may not be identified (e.g. if females score higher in locomotor skills, and males score higher in object manipulation skills, both groups could still have the same overall composite score). In addition, interventions seeking to enhance FMS proficiency in children may be better placed incorporating more generic games, rather than having a sports specific focus, in order to be equally fun and motivating for both gender groups.

The Importance of Fundamental Movement Skills in the School Setting

The school setting is considered the optimum setting to develop FMS (McKenzie and Lounsbery 2009), particularly during the PE lessons. Primary school is a particularly salient environment for children, with PE identified as an important contributor towards children developing active and healthy lifestyle behaviours (McKenzie and Lounsbery 2014). The importance of FMS being taught by qualified teachers, coaches and others who work with children has been recognised in the literature (Strong et al., 2005). Okely and Booth (2004) also state that FMS should be a key feature of primary school PE programmes. This declaration was also reciprocated in the most recent CSPPA report stating that FMS programmes aimed towards developing skills in children are warranted (Woods et al., 2018). The Irish primary school PE curriculum does have a focus on FMS, “stressing personal and social development, physical growth and motor development” (Department of Education, 1999, p.6). Given these intentions, it is worrying that Irish children have such low levels of FMS mastery (Behan et al., 2019; Bolger et al., 2018; Kelly et al., 2019; O’ Brien, Belton, and Issartel 2015; Belton et al., 2019).

There are several possible contributing factors to the low levels of FMS mastery that we see in Irish children. One possibility could be down to the lack of specialised PE teachers in Irish primary schools. The Irish system utilises generalist teachers at primary level. Ní Chróinín (2017) suggests that the gap between the curriculum and actual teaching and learning experiences in Irish PE may largely be as a result of issues with the confidence and competence of generalist teachers due to insufficient preparation (i.e. teacher education) and supports (i.e. equipment, teaching resources, continuous professional development) (Ní Chróinín 2017). Another potential contributing factor is time. Out of the typical 27.5-hour school week, just one hour is allocated to PE in Irish primary schools (Department of Education and Skills, Government of Ireland, 1999). The harsh reality is that many Irish primary school children do not receive this time each week, with the most recent CSPPA report suggesting that 18% of Irish primary school children receive less than 30-minutes of PE each week (Woods et al., 2018). Another potential factor is the role of assessment in PE. Less than a decade ago, Ireland, along with Malta and Norway were the only three countries in Europe who did

not have a formal PE assessment in primary school (Eurydice, 2012). Since then, there is little evidence to suggest that assessment strategies are widely used in primary school PE in Ireland (Ní Chróinín and Cosgrave 2013; Macken, MacPhail, and Calderon 2020), suggesting that PE may not be perceived as important as other formally assessed subjects (e.g. literacy and numeracy).

For many children, the school environment may present the only opportunity to develop their FMS proficiency and engage in PA (Trudeau and Shephard 2005; Coulter, McGrane, and Woods 2020). Since almost all children attend school, a quality PE programme has the potential to significantly enhance children's FMS proficiency and provide them with opportunities to be physically active (Coulter and Woods 2016). It is evident however, that gaps remain between the curriculum intentions and what is actually implemented (Ní Chróinín 2017), highlighting the urgent need for change in how PE is being delivered in the majority of Irish primary schools. The impact of FMS-based interventions in the school setting has been the focus of a number of systematic reviews and meta-analysis (Lubans et al., 2010; Morgan et al., 2014; Lai et al., 2014; Veldman, Jones, and Okely 2016). The results of these studies demonstrate that a wide variety of intervention types and durations can be effective in producing a sustained impact (Lai et al., 2014). Yet, the most effective school-based interventions aimed at improving FMS proficiency in children appear to be multi-component interventions (Kriemler et al., 2011), that are delivered by a specialist or trained teacher (McKenzie et al., 1997; Mitchell et al., 2013) in a mastery-oriented climate that provides quality instruction feedback and encouragement (Martin, Rudisill, and Hastie 2009).

Interventions Targeting Fundamental Movement Skills in Children

Interventions that consist of multiple interacting components have proven to be the most successful in developing children's FMS according to previous research (Craig et al., 2008). Studies have shown that the components of school-based interventions can vary significantly depending on a wide range of factors (i.e. financial support, socioeconomic status, facilities, school size etc.), also resulting in a wide range of outcomes.

The SPARK programme was one of the first multi-component, school-based intervention programmes which sought to develop children's FMS proficiency. Initiated in the United States, in 1989 for upper elementary students ($\approx$ 7-10 years), the SPARK programme consisted of a PE curriculum designed to provide sufficient amounts of PA in class, a behavioural self-management curriculum to promote PA outside of school, and extensive teacher training and support (McKenzie, Sallis, and Rosengard 2009). The PE element of the programme consisted of three 30-minute lessons, and various studies implementing the programme reported success on several outcomes, such as; increased PA during PE ($n = 955$, mean age = 9.56, 53% male, $p < 0.001$) (Sallis, McKenzie, and Alcaraz 1997), increased physical fitness levels ($n = 955$, mean age = 9.56, 53% male, $p = 0.03$, $d = 0.318$) (Sallis, McKenzie, and Alcaraz 1997), and increased FMS proficiency ($n = 709$, mean age = 9.5, 50.4% male, $p = 0.005$, $d = 0.29$) (McKenzie et al., 1998), demonstrating that positive outcomes can be accrued from shorter PE lessons when subsidised by an "out of school" intervention component.

The SCORES programme also successfully utilised FMS-based active homework to subsidise the content covered in the interventions PE lessons (Cohen et al., 2015). This programme is a 12-month school-based intervention designed to increase PA and FMS proficiency of primary school aged children in low-income communities (Lubans et al., 2012). SCORES is guided by self-determination theory (SDT) and was delivered to 460 children (199 children in intervention group and 261 in control group) (54.1% female, $M = 8.5 \pm 0.6$ years) from eight primary schools (Cohen et al., 2015). The intervention was delivered through two 30-minute sessions per week over the course of a year (Cohen et al., 2015). Results of this study showed that following the programme, the intervention group averaged 13-minutes more MVPA per day in comparison to the control group (Cohen et al., 2015). In addition, this study found that all FMS assessed using the TGMD-2 increased from pre- to post-intervention (Cohen et al., 2015). Similar to the results found by McKenzie et. al (1997), this study illustrates that multi-component interventions consisting of short PE lessons which are subsidised by FMS-based home activities can produce effective results for primary school children from low socioeconomic backgrounds.

Process-oriented assessment tools such as the TGMD-2 have also been used in other studies as a means to develop FMS proficiency through an assessment-based intervention that emphasises fun, mastery, and support (Chan et al., 2019). The A+ FMS intervention is a teacher-led FMS intervention, evaluated using a cluster randomised controlled trial in five primary schools ($n = 282$; mean age 8.4 years, SD 0.56) in Hong Kong (Chan et al., 2019). The intervention consisted of 550-minutes of PE classes delivered over a 13-week period (45- or 75-minute classes depending on the school's context). Teachers in the experimental group were asked to integrate assessment for learning (AfL) into their FMS teaching and assessment, whilst teachers in the control group delivered the usual PE curriculum where summative assessment was conducted at the end of a teaching unit or a school term for reporting (Chan et al., 2019). Results from the intervention showed significant increases in locomotor skills (horizontal jump, hop, skip) ($B = 2.47$, $SE = 0.85$, 95% CI [0.81, 4.14], $p = 0.004$) and overall FMS ($B = 3.72$, $SE = 1.17$, 95% CI [1.43, 6.01], $p = 0.001$) (Chan et al., 2019). Despite improving, there was no significant difference between the intervention and control group in object manipulation skills (overhand throw, catch, dribble) ($B = 1.23$, $SE = 0.79$, 95% CI [-0.31, 2.77], $p = 0.116$) (Chan et al., 2019). These results highlight the value of assessment when implementing effective programmes, as appropriate assessment allows practitioners to identify areas for development, provide specific feedback, targeted instruction and developmentally appropriate tasks (Lander et al., 2017). Interestingly though, students perceived competence declined slightly ($B = -0.16$, $SE = 0.08$, 95% CI [-0.31, -0.01], $p = 0.029$) in the intervention group. The authors of this study suggest that this minor change could be due to an overemphasis on structure and instruction within the programme (Chan et al., 2019). It could therefore be suggested that a greater emphasis on autonomy within the programme may elicit greater results, as previous research has emphasised the importance of autonomy in the learning environment when aiming to develop children's FMS (Tompsett et al., 2017).

The importance of autonomy in the PE learning environment was demonstrated by Martin et al. (2009), who compared the delivery and outcomes of a teacher-led intervention using a mastery-motivational approach and a low-autonomy approach (Martin, Rudisill, and Hastie 2009). A mastery

climate is one in which individuals value the learning process, have a desire for skill development, and believe that effort leads to success or improvement (Nicholls et al., 1989). In contrast, the more traditional, low-autonomy method is teacher-centred, uses direct instruction to improve FMS, and is visibly a very “orderly” class (Silverman, 1991). Using the TGMD-2 as the measurement tool, participants in the mastery climate achieved significant improvements in FMS from pre- to post-intervention ($p = 0.001$), while the low-autonomy group failed to elicit any significant change (Martin, Rudisill, and Hastie 2009).

Results of Chan et al. (2019) could also stem from an inability of the teachers to provide appropriate feedback and instruction, which could also affect FMS improvement and perceived competence (Lander et al., 2017). Evaluation of the delivery of the SPARK programme for example, found that superior outcomes were achieved when a PE specialist delivered the intervention (McKenzie et al., 1997). Within the same study, trained teachers also achieved significantly greater results than the control group (McKenzie et al., 1997). Evidence would therefore suggest that the teacher training element of school-based interventions may significantly contribute to the overall effectiveness of the programme.

In New Zealand, Project Energize has proven to be a sustainable and cost-efficient intervention. Project Energize is a multi-component, school-based programme that aims to improve the overall health and reduce weight gain of primary school children, by increasing their PA and encouraging healthy eating (Mitchell et al., 2013). The development of FMS is also a key consideration for the programme as these skills are a prerequisite to participation in PA (Mitchell et al., 2013; Rush et al., 2016). The intervention is delivered by external providers (Sport Waikato), known as “Energizers”, who are also responsible for training classroom teachers to be able to effectively deliver PE lessons that seek to improve the FMS proficiency of their students (Mitchell et al., 2013). Mitchell et al. (2013) reported that all skills substantially improved ($p > 0.001$) following the implementation of the programme ($n = 598$), with the biggest improvements seen in kicking, throwing and striking (Mitchell et al., 2013). Interestingly, the 2006 evaluation of Project Energize in 124 schools, reported that out of 900 teachers, only 11 teachers had a PE degree and just

74 were reported as having some PE training or expertise, suggesting that the capacity of schools to enhance children's FMS was limited (Mitchell et al., 2013). Nevertheless, with the support and training provided by the "Energizers", teachers were able to substantially improve the FMS proficiency of the participating children (Mitchell et al., 2013). These findings echo those of McKenzie et al. (1997) in suggesting that when provided with adequate support and guidance from an expert provider, generalist classroom teachers can effectively deliver high-quality PE, resulting in significant, positive outcomes for participating children.

Project Spraoi is an Irish adaptation of the original Project Energize programme. This version was tailored for implementation in the Irish school setting, accounting for cultural, environmental, and curricular differences. In order to establish the most effective version of the intervention to roll out, two iterations of the intervention were designed, both based on the original Project Energize programme (Bolger et al., 2018). Intervention one was designed to promote MVPA and was delivered to 187 children (91 children in control school) from senior infants ($\approx$ 6 years old) and fourth class ($\approx$ 10 years old). Intervention two was designed to promote the development of FMS, and was delivered to 357 (162 children from control school) children, also from senior infants ($\approx$ 6 years old) and fourth class ($\approx$ 10 years old) (Bolger et al., 2018). Both interventions were delivered by a qualified specialist (Energizer). Children in the control schools participated in their regular PE lessons for the year. Results from the study found that intervention one significantly improved locomotor standard score, however, there were no significant changes in object manipulation standard score (Bolger et al., 2018). Similarly, among the control group for intervention one, there were no significant changes in locomotor, or object manipulation standard score (Bolger et al., 2018). For intervention two, results found that the intervention group significantly improved locomotor and object manipulation standard score from pre- to post-intervention (Bolger et al., 2018). In contrast, the control group significantly dis-improved in locomotor and object manipulation standard score (Bolger et al., 2018). Considering that the intervention focussing on MVPA was not effective at significantly improving children's FMS proficiency, it would be fair to say that PA opportunities alone are insufficient to develop children's FMS proficiency to a satisfactory level, and that FMS

must be learned and practiced in an environment that provides quality instruction feedback and encouragement (Lubans et al., 2010; Bolger et al., 2018). Furthermore, it could also be suggested that developing FMS to support PA participation, as opposed to lessons solely focussing on MVPA at primary level, may be the most effective long-term strategy for policy makers in Ireland, however further research should explore this.

Kelly et al. (2021) also examined the effectiveness of a mastery-oriented FMS-based intervention in an Irish context. Similarly to Project Spraoi, this intervention was also delivered by a qualified expert. This study examined the immediate and long-term effects of an 8-week FMS intervention programme on 255 3rd and 4th class Irish primary school children (50% male, 7.4 ± 0.6 years) (Kelly et al., 2021). The 8-week intervention consisted of two 45-minute sessions per week (instead of regular PE class) amounting to 720-minutes of contact time and was delivered by an expert coach (Kelly et al., 2021). Using the TGMD-3, participants FMS were assessed pre- and post-intervention as well as 13-months post-intervention (follow-up). Results from the intervention demonstrate significant improvements in locomotor ($p < 0.001$), object manipulation ($p < 0.001$) and overall FMS ($p < 0.001$) at both post-intervention and follow-up (Kelly et al., 2021). The findings from Kelly et al. (2021) demonstrate that significant and lasting improvements can be made to children's FMS proficiency within a short period of time if the optimum environment is created, and sufficient time is afforded to the subject each week.

A limitation to both Irish studies (Bolger et al., 2018; Kelly et al., 2021) is that both were delivered by a qualified expert. In Ireland, a growing number of primary schools are committing resources to external providers for partial delivery of the PE curriculum (Mangione et al., 2020). Although these providers may (or may not) deliver content which is aligned with the curriculum, this mode of delivery comes at an expense to schools and the majority of responsibility for PE lesson delivery will still fall onto the generalist classroom teacher. As previously discussed in this review, interventions that incorporate a teacher training element in collaboration with external providers can produce positive results (Sallis et al., 1997; Mitchell et al., 2013) and is a method which may offer more sustainability in an Irish context.

Moving Well-Being Well

Considering the key strategies mentioned above, the Moving Well-Being Well (MWBW) intervention was designed as an evidence-based approach to target the low levels of FMS proficiency seen across Ireland (Behan et al., 2019). The MWBW intervention is underpinned by both the theory of constraints (TOC) (Newell, 1986) and SDT (Deci and Ryan, 2010), and was designed using the comprehensive framework outlined by the behaviour change wheel (Michie, Stralen and West, 2011). Behan (2020) describes how these theories culminate to form a “refraction framework” from which the design of this intervention is underpinned (Behan, 2020).

The design of the intervention was initiated with a formative evaluation of the PL components in Irish children (n = 2098, age range 5-12 years, 47% female) in order to better understand the determinants of their health behaviour (i.e. physical competence, motivation, confidence, knowledge and understanding) (Behan et al., 2019). Results of this study show that the level of Irish children’s PA, FMS proficiency, autonomous forms of motivation towards PA, self-efficacy towards PA, perceived FMS competence, and their PA knowledge and understanding (of how to be active, and the benefits of being active) were low (Behan, 2020).

In addition to these determinants, information on the environment around Irish children and consideration for the tasks in which they could avail of within their environment was also considered. It was theorised that the interaction between these levels of constraints (i.e. task constraints: intervention components, individual constraints: children’s determinants of PL, environment constraints: school/home contexts) marry well with the TOC, which suggests that behavioural change occurs from the interplay between the task, the individual and his/her environment (Newell, 1986). The dynamical interaction between these three constraints effectively influences a change in movement quality and efficiency (Behan, 2020).

Self-determination theory represents another key component of this behaviour change (Deci and Ryan, 2010). This theory proposes a multi-dimensional conceptualisation of motivation, in which

types of motivation are of different quality, with self-determined (or autonomous) types of motivation (intrinsic motivation and identified regulation) considered to be higher quality than less self-determined (or controlling) types of motivation (introjected and external regulation) (Deci and Ryan, 2010). According to SDT, the quality of motivation is important, with more autonomous forms of motivation facilitating learning, performance, greater interest, and increased effort (Grolnick and Ryan, 1987). It is also suggested that three psychological needs are required in order to foster autonomous types of motivation, namely: i) competence (self-belief in one's ability), ii) autonomy (choice is available in one's actions), and iii) relatedness (feeling a sense of connectedness/belonging to others) (Deci and Ryan, 2010). Behan (2020) suggests that SDT and the TOC are linked, as competence, autonomy and relatedness are impacted by constraints relating to the task and the environment. Consequently, the foundations of positive movement experiences and positive changes in behaviour potentially lie in a marriage between the TOC and SDT, where constraints relating to the organism (learner, performer etc.), the task (activity etc.) and environment (equipment, feedback, instruction etc.) are adapted, specifically in line with the learner's needs and their surrounding context (Behan, 2020). In conclusion, the underpinning framework of this intervention suggests that when this adaptation is achieved, you can "refract" a learners current movement experiences towards more positive ones, leading to more positive outcomes associated with PL (i.e. motor competence, autonomous motivation, self-efficacy).

As recommended in the literature, the MWBW intervention consists of multiple interacting components that includes family, community, active classroom, teacher training, and external provider components. In recent times there has been an increase in the use of external providers for the delivery of PE in primary schools (Ní Chróinín and O'Brien 2019). Whilst it is accepted that there is benefit to this practice, it is also acknowledged that as a result of seeing the external provider as the "expert", classroom teachers generally take a "back seat" when the external provider is delivering the content (Ní Chróinín and O'Brien 2019). This outcome can therefore be detrimental, as the class teacher is undoubtedly best placed to deliver content to their class in a child-centred and integrated manner (Coulter et al., 2009). The MWBW intervention seeks to address this by having

the class teacher and expert coach co-deliver the intervention, with the expert coach acting as a tutor to the class teacher.

The MWBW project is in partnership with the Gaelic Athletic Association (GAA). The GAA is Ireland's largest sporting organisation and promotes indigenous Gaelic games such as Gaelic football, hurling, camogie, handball and rounders. The GAA are the largest external provider in primary schools, providing specialised sport specific support through their community-based GAA coaches. Prior to the implementation of the MWBW intervention, participating coaches attend specifically designed continuous professional development (CPD) training designed and delivered by the experts involved in the project (a PhD candidate, the two (now graduated) PhD candidates who delivered the first phase of the project, and two associate professors in PE with experience in leading large-scale intervention projects). The intervention is then delivered over an eight-week period through three main elements: (i) two 30-minute FMS-based PE classes per week, (ii) 5-10-minute active classroom activities performed at least once daily, (iii) home activity sheets completed once per week (see Table 2.2).

Week	Component	Delivery responsibility	Frequency (Days per week)	Duration (minutes)	Focus of the Core Activities	
1	PE class	Coach	1	30	Hopping, Throwing	Catching,
1	PE class	Teacher	1	30	Hopping, Throwing	Catching,
1	Classroom Activities	Teacher	5	5-10	Vertical Jump & Catch	
1	Home Activity Worksheet	Parent/Guardian	1	10-15	Jumping	
2	PE class	Coach	1	30	Hopping, Throwing	Catching,
2	PE class	Teacher	1	30	Hopping, Throwing	Catching,
2	Classroom Activities	Teacher	5	5-10	Hop & Kick	
2	Home Activity Worksheet	Parent/Guardian	1	10-15	Jumping	

3	PE class	Coach	1	30	Hopping, Throwing	Catching,
3	PE class	Teacher	1	30	Hopping, Throwing	Catching,
3	Classroom Activities	Teacher	5	5-10	Skip & Stride	
3	Home Activity Worksheet	Parent/Guardian	1	10-15	Skipping	
4	PE class	Coach	1	30	Skipping, Throwing	Catching,
4	PE class	Teacher	1	30	Skipping, Throwing	Catching,
4	Classroom Activities	Teacher	5	5-10	Horizontal Jump & Throw	
4	Home Activity Worksheet	Parent/Guardian	1	10-15	Hopping	
5	PE class	Coach	1	30	Skipping, Throwing	Catching,
5	PE class	Teacher	1	30	Skipping, Throwing	Catching,
5	Classroom Activities	Teacher	5	5-10	Vertical Jump & Catch	
5	Home Activity Worksheet	Parent/Guardian	1	10-15	Catching	
6	PE class	Coach	1	30	Skipping, Kicking, Jumping	
6	PE class	Teacher	1	30	Skipping, Kicking, Jumping	
6	Classroom Activities	Teacher	5	5-10	Hop & Kick 2	
6	Home Activity Worksheet	Parent/Guardian	1	10-15	Throwing	
7	PE class	Teacher	1	30	Jumping, Kicking	
7	PE class	Teacher	1	30	Jumping, Kicking	
7	Classroom Activities	Teacher	5	5-10	Skip & Stride 2	
7	Home Activity Worksheet	Parent/Guardian	1	10-15	Striking with the hand	
8	PE class	Teacher	1	30	Jumping, Kicking	
8	PE class	Teacher	1	30	Jumping, Kicking	
8	Classroom Activities	Teacher	5	5-10	Horizontal Jump & Throw 2	
8	Home Activity Worksheet	Parent/Guardian	1	10-15	Kicking	

Table 2.2: Moving Well-Being Well Intervention Delivery Components

During the first six weeks of the intervention, the first 30-minute FMS-based PE class each week is delivered by the expert GAA coach. These classes are delivered in a holistic manner, with a focus on creating a mastery environment (Nicholls et al., 1989). While delivering these lessons, the coaches also upskill the class teachers on how to effectively deliver an FMS-based PE lesson. The class teachers must then repeat that class in a second 30-minute lesson on their own, before the coach

returns the following week to deliver the next lesson. After week six, the class teacher delivers both lessons each week, with the coach offering a supportive role. By constructing the interventions delivery in this manner the aspiration is twofold; to enhance the participating children's FMS, while also developing the teachers ability to deliver an FMS-based lesson effectively (Behan, 2020). On a broader scale, restructuring external provision of PE lessons to a more professional development approach has the potential to increase both primary teachers' belief and confidence in their own expertise to deliver effective PE lessons.

The lesson content of the FMS-based PE lessons is derived from the Move Well, Move Often resource, a programme developed by the Professional Development Service for Teachers (PDST) seeking to develop PL through FMS, and one which is aligned with the Irish primary school curriculum (Department of Education and Skills, 1999). The PDST are Ireland's largest support service offering professional learning opportunities to teachers and school leaders in a range of pedagogical, curricular and educational areas (Kilcoyne, 2021). The skill content of these lessons focuses on just three locomotor (hop, skip, jump) and three object manipulation skills (kick, catch, throw), which were selected as the skills in most need of intervention based on the findings from the initial formative evaluation (Behan et al., 2019).

The active classroom component of the intervention is delivered by the class teacher each day. Active classrooms have been shown to be an important component of effective, multicomponent interventions in a school setting (Martin and Murtagh 2017). This component was designed as an interactive whiteboard resource, that consists of simple, fun, and easy to follow activities. The activities are designed to last between 5-10 minutes and aim to supplement the key movement skills that are the focus of that week's PE lesson. Through this component, the intention is to increase children's daily PA, develop their PA knowledge and understanding, and increase teacher confidence in engaging in active classroom activities (Behan, 2020).

The final intervention component is the home activity sheets. These sheets are distributed by the class teacher once each week and consist of two main elements: (i) active homework, to encourage

participants to be active with a parent/guardian at home, and (ii) a short, written exercise, to help to develop their knowledge and understanding.

Following the design of the intervention, it was piloted in 10 schools ($n = 417$, 52% female, mean age 7.6 ± 0.66 years). Intervention schools ($n = 5$) received the MWBW intervention with control schools ($n = 5$) continuing with their regular PE lessons. Both arms comprised of schools of various sizes, genders, and socioeconomic status. Participants FMS proficiency was primarily assessed using the TGMD-3, with the addition of the vertical jump (from the Victorian Fundamental Motor Skills manual (Walkley et al., 1996)) and the balance subtest from BOT-2 Short Form (Bruininks, 2005). In line with existing literature, baseline results from this study found that children were below the expected levels of FMS proficiency for their age (Behan et al., 2019). Results however also highlighted that the intervention group significantly increased FMS proficiency from baseline (74.43) to post-intervention (86.36) and retention (91.98) (6-months post-intervention), in comparison to the control group (baseline – 77.67, post-intervention – 75.47, retention – 81.93) (Behan, 2020). These findings suggest that the MWBW intervention has the potential to help develop the FMS proficiency of Irish children by offering an intervention model that has potential benefits for both participating children and teachers.

Best practice when developing complex interventions is to systematically, using a carefully phased approach, start with pilot research, and move on to an exploratory and then a definitive evaluation (Craig et al., 2008). Despite the results of the pilot study indicating that the MWBW intervention can be effective in improving the FMS proficiency of children, it is known that a range of factors can impact the outcomes of complex interventions (Moore et al., 2015). Thus, exploring the mechanisms through which these outcomes occurred is crucial if the desire is to replicate or improve its implementation in the future (Moore et al., 2015; Ma et al., 2021). The next critical stage of development for MWBW is to implement and evaluate its effectiveness and feasibility with a larger, more diverse sample.

Movement Competence Summary

In summary, MC is an important area of PL (Pill and Harvey, 2019). Fundamental movement skills are a key construct of MC and are described as the basic building blocks of more advanced movement skills (i.e. the movement pattern of the overhand throw lays the foundation to develop the technique for the serve in tennis or the overhead clear in badminton) (Logan et al., 2018). Children have the potential to master these skills at a young age, with evidence suggesting that developing proficiency as a child may be critical to promoting and sustaining positive trajectories of PA and HRF throughout the lifespan (Jaakkola et al., 2019; Robinson et al., 2015; Stodden et al., 2008). Despite this acknowledgment, the literature in recent times suggests that the MC levels of children and adolescents worldwide is lower than expected (Okely and Booth, 2004; Hardy et al., 2013; Bardid et al., 2015; Behan et al., 2019). The majority of research studies also suggest that males are generally more competent in overall FMS than their female counterparts (Barnett et al., 2009; Cantell et al., 2008; O' Brien et al. 2015; Breslin et al., 2012; Lopes et al., 2011).

Primary school PE has been identified as an important contributor towards children developing active and healthy lifestyle behaviours (McKenzie and Lounsbery 2014), and as such, this environment is deemed to be the optimum setting to develop children's FMS proficiency (McKenzie and Lounsbery 2009). At present however, a gap exists in Ireland between the curriculum intentions and the actual teaching and learning experiences, possibly as a result of issues with the confidence and competence of generalist teachers, insufficient preparation and supports, or time afforded to the subject (Ní Chróinín 2017). In an attempt to address this, there have been a wide variety of school-based interventions developed seeking to improve children's FMS (Beurden et al., 2003; Mitchell et al., 2013; Cohen et al., 2015; Bolger et al., 2018; Chan et al., 2019; Kelly et al., 2021). Consistently, intervention results, including previous systematic reviews and meta-analyses, provide support for the effectiveness of interventions to improve FMS in children (Logan et al., 2012; Morgan et al., 2014).

Evaluation of existing interventions would suggest that to maximise their effectiveness, school-based interventions seeking to develop children's FMS proficiency should; have multiple

components (Craig et al., 2008), include at-home practice and parent involvement (Tompsett et al., 2017), be delivered by a specialist or trained teacher (Mitchell et al., 2013), provide multiple engagements per week (Tompsett et al., 2017), be suitable for all socio-economic backgrounds (Cohen et al., 2015), and be delivered in a mastery-oriented climate that provides quality instruction feedback and encouragement (Martin, Rudisill, and Hastie 2009; Chan et al., 2019). These recommendations pose a potential challenge within an Irish context, where PE is delivered by generalist classroom teachers who have previously reported feeling ill-prepared and lack confidence to deliver effective PE (Fletcher and Mandigo, 2012). In which case, identifying strategies to improve generalist teacher's competence and confidence in delivering PE should be a key consideration in efforts to improve the quality of PE in the primary school setting (Fletcher and Mandigo, 2012).

Considering the recommendations in the literature, the MWBW intervention was designed as an evidence-based approach to target the low levels of FMS proficiency in Irish children (Behan et al., 2019). Initial piloting of the intervention would suggest that it has the potential to be both an effective intervention and approach to teacher upskilling (Behan, 2020). Despite these potential benefits, further research is required to ascertain whether similar benefits can be identified when the intervention is scaled up. In which case, the next phase of development for the intervention should examine the feasibility of delivering the intervention and acceptability to providers and participating children as it is scaled up to a larger, more diverse population (Campbell et al., 2000).

The assessment of children's MC is an essential aspect of their MC development (Chan, Ha, and Ng 2016). Assessment is also a critical consideration of intervention programmes, as it allows practitioners to evaluate children's actual level of MC, identify their specific needs, assist them in developing and refining programmes, and also provides them with specific feedback from which to give targeted instruction or create developmentally appropriate tasks (Lander et al., 2017). In this regard, there are currently several MC assessments that are available and designed for a range of environments (schools, sports clubs, research, clinical settings etc.) (Bardid et al., 2019). Each of these assessment tools have been designed for a range of purposes and have varied functions (Bardid et al., 2019). In fact, a systematic review conducted by Hulteen et al. (2020), identified 57 different

tools across 107 studies used to measure children's MC. Consequently, it is becoming increasingly difficult for users to identify which assessment is best suited for them to identify children with low MC proficiency (Klingberg et al., 2019).

Research also suggests that existing process-oriented assessment tools are often limited in their authenticity, as they focus on isolated skill performance (Lander et al., 2017). These static testing environments do not adequately assess combined and complex movement, nor reflect the open, dynamic, and complex PA environments typical of childhood play, PA, and sport (Longmuir et al., 2015). Such findings have resulted in the development of more dynamic layouts as well as the creation of a more hybrid model of assessment. It has been suggested that this mode of assessment would incorporate not only FMS execution, but evidence of the child's ability to combine simple movements and demonstrate complex movement capabilities (Longmuir et al., 2017). It would be expected that children with higher levels of PL would be able to control body movements, speed, and balance in order to optimise their performance for each PA environment, making this a more authentic mode of assessment that many existing tools (Longmuir et al., 2017).

Additionally, many existing tools are not suitable for "real-world" use with large groups of children in places like schools or sports clubs (Lander, Morgan, et al., 2017). In more recent times, new, more dynamic assessments with greater ecological validity such as the CAMSA or DC have been developed (Longmuir et al., 2017; Tyler et al., 2018). Yet, these tools do not satisfy the needs of both clinicians and practitioners from whom such assessments would be beneficial to their work, nor do they consider the wide breadth of movement skills that have been previously considered as MC, namely, functional movement skills (O'Brien et al., 2018; Basman, 2019). Furthermore, each of these tools examined in this review have varied amounts of research supporting them in terms of feasibility, validity and reliability (Bardid et al., 2019; Eddy et al., 2020; Klingberg et al., 2019). At present, the psychometric properties of many assessment tools are underreported in the literature, creating doubt over whether or not the results can be trusted (Eddy et al., 2020; Hulteen et al., 2020). Hence, despite the range of MC assessment tools available, this dearth of adequately developed and

researched tools means that there remains no “gold standard” MC assessment for any setting (Bardid et al., 2019).

Considering these factors, it would be a significant advancement if a tool could be created that could meet the needs of researchers, practitioners, and clinicians to aid greater comparison and collaboration, is simple and easy to use to make skill assessment and development more accessible for all, that is fun and more ecologically valid for participating children and finally, is a valid and reliable tool to ensure good quality data could be gathered.

Functional Movement Skills

Functional Movement Skills: An Introduction

A functional movement pattern is described as a basic movement utilised to simultaneously examine muscle strength, flexibility, range of motion, coordination, balance, and proprioception (Cook, Burton and Hoogenboom, 2014; Bagherian et al., 2018). Hence, functional movement skill is defined as the ability to produce and maintain an adequate balance of mobility and stability along the kinetic chain while integrating functional movement patterns with accuracy and efficiency (Mills, Taunton and Mills, 2005; Bagherian et al., 2018). It has also been described as movement efficiency that minimises the risk of injury (Cook, Burton and Hoogenboom, 2006; Coker, 2018; Fitton Davies et al., 2022). Although the concept of functional movement skills has been well established in the literature (Bonazza et al., 2017), the last decade has seen an increase in interest in the importance of functional movement skills in the areas of health and sports performance. This peak in interest likely stems from the suggested link between functional movement proficiency and injury risk, making it a significant area of interest for sports medicine and sports science practitioners.

The beneficial outcomes of regular PA on physical, cognitive and mental health in school-aged children have been well documented in the literature (Ekblom and Astrand, 2000; Hallal et al., 2012). Despite the plethora of beneficial outcomes, participation in regular PA and sports also increases the risk of injury (Collard et al., 2010; Bloemers et al., 2012). Although most PA-related injuries in children are not life-threatening, they may coincide with direct pain, short-term disability, school absence, and long-term consequences such as osteoporosis in later life, all of which lead to a financial burden (Abernethy and MacAuley, 2003; Collard et al., 2010; Bloemers et al., 2012). Moreover, children may lose enthusiasm for participating in PA due to negative associations with injuries (Maffulli et al., 2010).

A systematic review carried out by Nauta et al. (2015) sought to examine the risk of injury in the four main PA behaviours among 6-12 year old children (active commuting, leisure time PA, PE and sports) (Nauta et al., 2015). Unsurprisingly, leisure time PA recorded the highest incidence rate of injuries, most commonly acute injuries, followed by sports, PE and active commuting (Nauta

et al., 2015). Whilst a wide range of injury rates were observed across the four domains (from 0.14 to 2.20 injuries per 1,000 hours of PA exposure), the total number of injuries found in children was high (Nauta et al., 2015). Interestingly, a high incidence rate of injury is not exclusive to children who engage in large volumes of PA. Studies have suggested that children with low habitual levels of PA may in fact be at an increased risk of injury (Bloemers et al., 2012; Martin-Diener et al., 2013). A potential underlying risk factor acute injuries in children are dysfunctional movement patterns (Vehrs, Uvacsek and Johnson, 2021).

Dysfunctional movement patterns performed during regular PA manifest from limitations in mobility, stability, or neuromuscular control and prevent proper motion from occurring (Coker and Herrick, 2020). For example, a lack of dorsiflexion mobility in the ankle can negatively impact the movement patterns seen in the squat, step-down activities and landing from a jump (Coker, 2018). It has been theorised that these dysfunctional movement patterns may be a significant contributor to the injury incidence in children in both the high and low PA categories (Bloemers et al., 2012; Nauta et al., 2015). This is significant, as the prevention of first time injuries has been identified as the most impactful method of reducing injury incidence (Räsänen et al., 2018). In addition to the increased risk of injury, it is suggested that these dysfunctional movement patterns can also impede children's development of MC proficiency and impact sporting performance (Coker, 2018). In which case, establishing good movement patterns and correcting dysfunctional movement patterns in childhood is essential (Duncan, Stanley and Wright, 2013; Malina and Kozieł, 2014b, 2014a).

Measurement of Functional Movement Skills

A recent review of PL and injury prevention literature recommends that it is important for new PL-based assessments to incorporate injury prevention and injury screening strategies, specifically in the 8–12 age group, due to the increased risk of injury after the age of 12 (Miller et al., 2018, 2020).

The assessment of functional movement typically involves the measurement of muscle strength, flexibility, range of motion, coordination, balance, and proprioception (Cook, Burton and

Hoogenboom, 2014; Bagherian et al., 2018). There are a number of tools purported to assess functional movement proficiency, such as the Landing Error Scoring System (LESS) (Padua et al., 2009) and marker-based biomechanical assessments (Kraus et al., 2014). The LESS is a valid and reliable field-based assessment tool designed to identify those who have high-risk movement patterns during a drop-landing task (Padua et al., 2009). Despite its validity, many clinicians and practitioners may be impeded from using this tool in many “real-world” settings due to the amount and cost of equipment required to perform the test (participants have to be videotaped from the frontal and sagittal planes) (Mauntel et al., 2017). In addition, some studies have also found the LESS to be a poor predictor of injuries (Smith et al., 2011; James et al., 2015). Similarly, high costs and small capture volume (single joint) make marker-based biomechanical assessments impractical for most clinical or sporting applications (Wade et al., 2022). Hence, the FMSTM has been established as the predominant tool used for functional movement assessment (dos Santos Bunn, Rodriguez and Da Silva, 2019; Fitton Davies et al., 2022).

The functional movement screen (FMSTM) was designed to identify functional movement deficits and asymmetries that may be predictive of general musculoskeletal conditions and injuries, with an ultimate goal of being able to modify the identified movement deficits through individualised exercise prescription (Cook et al., 2014). It does this by measuring the quality of movement patterns to specifically determined performance criteria (Fox, O’Malley and Blake, 2014). The seven movement tests included in the FMSTM require an interplay of muscular strength, flexibility, range of motion, coordination and balance, which form the basis of more complex athletic movements (Martin, Olivier, & Benjamin, 2017). The seven tests included in the assessment are; 1) The Deep Squat: which assesses bilateral, symmetrical, and functional mobility of the hips, knees and ankles, 2) The Hurdle Step: which examines the body’s stride mechanics during the asymmetrical pattern of a stepping motion, 3) The In-Line Lunge: which assesses hip and trunk mobility and stability, quadriceps flexibility, and ankle and knee stability, 4) Shoulder Mobility: which assesses bilateral shoulder range of motion, scapular mobility, and thoracic spine extension, 5) The Active Straight Leg Raise: which determines active hamstring and gastrocnemius flexibility while maintaining a

stable pelvis, 6) The Trunk Stability Push-Up: which examines trunk stability while a symmetrical upper-extremity motion is performed, and 7) The Rotary Stability Test: which assesses multi-plane trunk stability while the upper and lower extremities are in combined motion (Cook, Burton and Hoogenboom, 2006; Kiesel, Plisky and Voight, 2007; Tompsett, Burkett and McKean, 2014).

Each item in the FMSTM is scored on an ordinal scale from zero to three (Cook, Burton and Hoogenboom, 2006). If an individual performs the movement correctly without any pain or compensation, they get a score of three. If an individual has to use a compensation to perform the movement, a score of two is awarded. If an individual is unable to perform the movement, a score of one is given. Finally, a score of zero is awarded if an individual experiences pain at any stage during the movement (Cook, Burton and Hoogenboom, 2006). The seven individual scores are then summed, resulting in a maximum composite score of 21. Bilateral scores are also taken for five of the seven screening items (with the exception of the deep squat and the trunk stability push-up). These scores are compared to show the imbalance between the right and left sides of the individual. It is important to note that the lowest score between the right and left side is counted as part of the overall composite score (Cook, Burton and Hoogenboom, 2006).

The literature has cited a wide range of benefits of the FMSTM, and describe it as a robust, time-efficient, non-invasive, inexpensive and easily administered method of functional movement assessment that can be used in both athletic and the general population (Cook, Burton and Hoogenboom, 2006; Tompsett, Burkett and McKean, 2014; Abraham, Rajasekar and Rohit, 2015; Fitton Davies et al., 2022). Administration of the FMSTM also requires minimal training and can be conducted using multiple assessors with varying levels of experience, with reliable scoring data being gathered regardless of the assessor's level of training (Bonazza et al., 2017). This reliability has been examined extensively in the literature, albeit mainly with adult populations, with results demonstrating that the FMSTM shows strong inter- and intra-rater reliability (range 0.11-0.89 and 0.52-0.96 respectively) (Minick et al., 2010; Gulgin and Hoogenboom, 2014; Reid et al., 2015; Stanek, Smith and Petrie, 2019).

Yet, despite the various advantages of the FMSTM, significant concerns still remain surrounding its validity (Moran et al., 2016). Studies examining validity of the tool have identified flaws in both internal consistency and external validity (Bonazza et al., 2017; Kazman et al., 2014; Li et al., 2015). For example, Li et al. (2015) used exploratory factor analysis to explore the factor structure of the FMSTM, finding that each skill in the assessment battery did not assess the same underlying variables (Cronbach's alpha 0.58) (Li et al., 2015). The significance of this finding is that many studies use the FMSTM to evaluate injury risk using the sum score from the seven tests. The use of a sum score would suggest that it is a unidimensional instrument (Li et al., 2015). If it is testing a unidimensional construct, you would expect it to have good internal consistency among the scores of the seven tasks and analysis would show a single factor with high loadings of all seven tasks (Li et al., 2015). The lack of internal consistency raises concerns as to the tool's accuracy as an injury prevention measure. Furthermore, due to dearth of data on children (O'Brien et al., 2022), significant questions on its suitability for this population remain.

In response to these concerns, Jimenez-Garcia et al. (2020) designed the ChildFIRST assessment tool. The ChildFIRST is a process-based MC assessment tool that incorporates musculoskeletal injury screening techniques (Jimenez-Garcia et al., 2020). The aim of the ChildFIRST was to bridge the gap between MC assessment tools and musculoskeletal injury screening tools (Jimenez-Garcia et al., 2020). This tool was designed for children aged 8-12 and focuses on musculoskeletal injury prevention (Jimenez-Garcia et al., 2020). The tool was designed using a modified Delphi method, a method which establishes good face and content validity (Francis et al., 2016). The ChildFIRST assessment tool consists of 10 movement skills, each with four associated evaluation criteria (Jimenez-Garcia et al., 2020). The 10 tasks assessed include: 1) Bodyweight Squat and 2) Walking Lunge: to assess individuals' neuromuscular control, stability, strength, and mobility within the kinetic chain, 3) Running: help to determine if children are at risk of lower-body injuries, 4) Single-leg Hop and 5) Leaping: to identify differences in the execution of lower body muscular imbalances and observable biomechanical deficits, 6) Horizontal Jump and 7) Vertical Jump: as landing mechanics are crucial to injury risk screening, 8) Two to One-foot Hop

and Hold, 9) Single-leg Sideways Hop and Hold, and 10) 90-degree Jump and Hold: to assess the ability to maintain balance in the transition from dynamic movement to a static state and use a single-leg landing to stabilisation component to assess dynamic postural stability (Jimenez-Garcia et al., 2020).

Similar to the FMSTM, the ChildFIRST assesses the quality of movement using specific performance criteria. The research team creating the tool proposed seven evaluation criteria associated to each movement skill selected to be a part of the assessment which the expert panel chose from to represent each skill included in the assessment (Jimenez-Garcia et al., 2020). These evaluation criteria were compatible with current process-oriented assessment tools, based on injury prevention literature (based on neuromuscular risk factors for lower-body injuries), and intended to identify movement patterns in different movement planes (Jimenez-Garcia et al., 2020). Each skill has common evaluation criteria related to specific movement patterns, such as trunk position, stability, and hip, knee, and ankle motion in the sagittal and frontal plane (Jimenez-Garcia et al., 2020).

Preliminary research conducted on the tool suggests that it demonstrates moderate-to-excellent inter-rater reliability for 9 of 10 movement skills (two-to-one-foot hop and hold movement skill demonstrates poor reliability ($ICC = -0.306$)), while intra-rater reliability and overall evaluation criteria reliability range from good to poor (Miller et al., 2020), however, additional research is required to establish these figures in a broader population. Furthermore, despite this tool representing a positive step towards creating an assessment tool that represents a more inclusive, evolving definition of MC, it too is not without its limitations. During the tool creation process, the expert panel in the Delphi study achieved consensus on including the single-leg balance and the skip into the assessment, however, the research team left these out because they did not feel that they had enough evaluation criteria (Jimenez-Garcia et al., 2020). Even more significantly, this assessment does not contain any object manipulation skills, which represent a key component of MC. In order to create a more holistic tool, future research should address this limitation. Nevertheless, the creation of this tool emphasises the importance of considering risk factors of injury in children, and having

specifically designed assessment tools for this population can enhance movement-based interventions by identifying individuals who may benefit from injury prevention strategies (Miller et al., 2018).

Relationship Between Fundamental Movement Skills and Functional Movement Skills

Over time, the terms used to describe MC have shifted and evolved (Basman, 2019). Even in recent times, both proficiency in FMS and proficiency in functional movement skills have been separately used to define MC within the literature (Basman, 2019). More recently, this definition has once again evolved to acknowledge that neither of these skill constructs alone reflect the broad diversity of skills utilised in all PA pursuits across the lifespan (Hulteen et al., 2018). Hence, the meaning of MC is broadening to incorporate skills such as functional movement skills along with FMS (Lester et al., 2017; O'Brien et al., 2021). This evolution has been reflected in a recent model of motor development proposed by Hulteen et al. (2018) (see Figure 2.5).

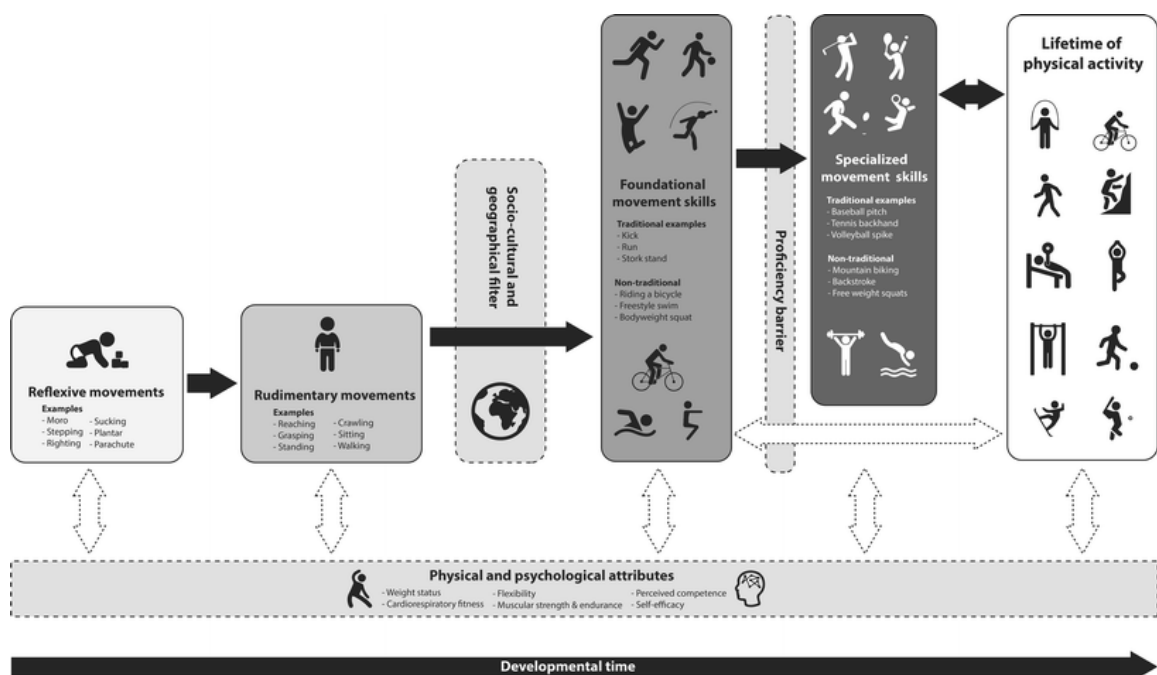


Figure 2.5: Hulteen's Conceptual Model for Physical Activity Across the Lifespan

Numerous conceptual models of motor development have been proposed throughout time to depict the possible progression of MC throughout the lifespan (Clark & Metcalf, 2002; Goodway et al., 2019; Seefeldt, 1980). Until recently, these models have centred around the development of the traditional FMS as key to facilitating participation in future PA. The latest model proposed by Hulteen et al. (2018) suggests that focussing on FMS alone is too narrow and does not encapsulate the full range of skills that may promote continued PA participation across the lifespan (Hulteen et al., 2018). They suggest that the term “foundational movement skills”, which includes skills such as swimming, bodyweight squat and push-up, better reflects the wide variety of skills an individual should develop competency in so that they can enhance PA participation and promote health across the lifespan (Hulteen et al., 2018). This development is significant, as the deep-squat and the trunk stability push-up are two specific assessments within the FMSTM (Cook, Burton and Hoogenboom, 2014), which is the most commonly used functional movement assessment, and were directly mentioned in the new model (Hulteen et al., 2018). This conceptualisation of foundational movement skills therefore outlines the emerging value of functional movement skills as a key construct of overall MC (Hulteen et al., 2018; O’Brien et al., 2021). This sentiment is also mirrored by Cook’s model of motor development (Cook, 2003) which states that functional movement underpins both physical conditioning (functional strength – what an individual can do with their own body) (Edelson et al., 2016) as well as skill (Cook, 2003).

In addition to this theoretical viewpoint, recent studies have quantified the emerging relationship between both functional and fundamental movement skills, outlining their interconnected, yet distinct qualities (Bahram, Bahmani and Ghadiri, 2016; O’Brien et al., 2021; Wu et al., 2021). A small, early study in this space examined the effect on an 8-week core stability training programme on FMS proficiency ($n = 15$, 100% male, means age = 8.89 years, SD = 1.06) (Bahram, Bahmani and Ghadiri, 2016). Core stabilisation has been identified as a key element of functional movement in numerous pieces of research (Leetun et al., 2004; Willson, Ireland and Davis, 2006; Peate et al., 2007). The results of this study found that, in comparison to the control group, the training group displayed significant improvements in both locomotor ($p < 0.05$) and object

manipulation ($p < 0.05$) skills (Bahram, Bahmani and Ghadiri, 2016). Although it must be acknowledged that the sample size in the study was very small, this finding is aligned with the viewpoint of Kraus et al. (2014), who argues that core stability in addition with functional mobility underpin performances in the basic observable patterns of FMS skills, such as running and jumping (Kraus et al., 2014).

This relationship was explored further by O'Brien et al. (2021), who examined the convergent validity between fundamental and functional movement assessments in a large cohort of adolescent youth ($n = 583$, 44% male, mean age = 14.42 ± 0.94 years) (O'Brien et al., 2021). In this study, FMS were measured using the TGMD (skip) (Ulrich and Sanford 1985), TGMD-2 (run, horizontal jump, two-handed strike, stationary dribble, catch, kick and overhand throw) (Ulrich 2000) and the Get Skilled Get Active resource (vertical jump and balance) (NSW Department of Education and Training, 2000). Functional movement skills were assessed using the FMSTM (Cook, Burton and Hoogenboom, 2006). The results of this study found that the FMSTM and the three FMS subsets (locomotion, object manipulation and balance) were not unanimously found to have a collective level of common convergent validity (O'Brien et al., 2021). Nevertheless, findings did demonstrate a moderate association between FMSTM and the stability and locomotor subsets (O'Brien et al., 2021). The significance of these findings is twofold; (i) both constructs of MC (fundamental and functional movement skills) are inextricably linked to one another, and (ii) at present, two assessment tools, such as the TGMD and the FMSTM, are currently required to capture a holistic picture of a child's MC. Thus, additional research is required to further explore this emerging area of research examining the relationship between these two constructs. Moreover, research should also seek to examine ways to capture both of these skill constructs in one holistic assessment tool.

Considering that functional movement has previously been described as the movement pattern that underpins all other movements (Duncan, Stanley and Wright, 2013), examining the individual components of locomotor skills may further explain the interconnected relationship highlighted by O'Brien et al. (2021). For example, several assessments of the FMSTM require

adequate thoracic mobility (i.e. deep squat, in-line lunge, shoulder mobility), with recent research also purporting that all locomotor skills require thoracic mobility (Ditcher et al., 2017). Additionally, shoulder mobility and ankle mobility, both of which are assessed by the FMSTM, play a role in jumping activities (O'Brien et al., 2021). Furthermore, ankle mobility has been previously reported as being related to vertical jump performance (Papaiakovou, 2013). These findings would suggest that for children, establishing good functional movement patterns could play an important role in establishing proficiency in locomotor skills. This finding may be significant, as previous research has reported that locomotor skills are the first subset of MC to be associated with sports participation (Henrique et al., 2016), as well as some research showing it to be more strongly associated with PA participation than other MC subcomponents in childhood (Hamstra-Wright et al., 2006). Hence, this research would suggest that the emerging relationship between these skill constructs certainly warrants further investigation, as well as providing further evidence to support the development of an assessment tool that could capture key functional movement patterns as well as FMS.

In another recent study, Wu et al. (2021) examined the relationship between FMS, functional movement skills and motor fitness in a cohort of Chinese primary school children ($n = 117$, mean age = 8.9 ± 1.2 years) (Wu et al., 2021). Motor fitness comprises of several components of physical fitness, including strength, speed, flexibility, and agility (Caspersen and Christenson, 1985), which have also been positively associated with enhanced performance in sports and PA (Ortega et al., 2015). Participants were assessed using the TGMD-2, the FMSTM and four items from the Chinese National Student Physical Fitness Standard (speed, flexibility, coordination, and strength) (Wu et al., 2021). Results from the study found that overall competence on all test batteries were low, with males slightly outperforming females in object manipulation skills, and females slightly outperforming males on the FMSTM (Wu et al., 2021). The results of this study also found that 48.9% of children who classified as the “high FMSTM group”, also scored highly on the TGMD-2 (Wu et al., 2021). Interestingly, children who were classified in either the high or low proficiency groups for the TGMD-2 and the FMSTM respectively, were also more likely to be classified in the high and low

proficiency categories for motor fitness also (Wu et al., 2021). Hence, although the sample size is small and can only offer preliminary findings, the results of this study would suggest that both fundamental and functional movement skills contribute to the development of motor fitness, as well as supporting the notion that good functional movement skill is required in order to perform FMS well (Cliff et al., 2009; O'Brien et al., 2021), however, this remains an emerging area of research.

The Importance of Functional Movement Competence in Youth

In 1980, Seefeldt proposed the concept of a “proficiency barrier” (Seefeldt, 1980), which can be viewed as a threshold, above which a child has sufficient MC to engage in a wide range of PA (Meester et al., 2018). A child with MC below the threshold is deemed less likely to engage in certain activities since they would not have the required skills, confidence, and motivation to successfully participate (Meester et al., 2018). Over the last decade, this same concept has been applied to functional movement competence and injury (Kiesel, Plisky and Voight, 2007). Kiesel et al. (2007) suggest that, in adults, a proficiency barrier or threshold exists, whereby those who score below 14 on the FMSTM have an eleven-fold increased risk of injury during PA or sports participation (Kiesel, Plisky and Voight, 2007). In children, the composite FMSTM score of 14 has been shown to be a poor predictor of injury (Abraham, Rajasekar and Rohit, 2015; Rusling et al., 2015; Chang et al., 2020). Rather, some studies suggest that the threshold is higher in youth than it is for adults (see Table 2.3) (Sulowska et al., 2015; Pfeifer et al., 2019; Wang et al., 2021).

Study	Population	n	Gender	Mean age (years)	Cut point	off
Sulowska et al. 2015	Floorball athletes	23	100% male	18 ± 0.8	17	
Wang et al. 2021	Wushu athletes	81	51% male	15.1 ± 4.5	16	
Pfeifer et al. 2019	American football, soccer, volleyball, lacrosse athletes	136	46% male	16.01 ± 1.35	15	

Table 2.3: FMSTM cut off score and injury incidence in children and adolescents

Other studies challenge whether there is a threshold at all (Monaco and Schoenfeld, 2019). Regardless of whether there is consensus on the existence or location of a proficiency barrier for functional movement skills in children, the literature indicates that there is a relationship between functional movement proficiency and the risk of injury (Lloyd et al., 2015). Thus, if children can develop proficiency in functional movement skills, they could potentially be at reduced risk of missing PA exposure or losing enthusiasm to participate in PA (Maffulli et al., 2010; Duncan, Stanley and Wright, 2013). In addition to the risk of injury, suboptimal movement patterns in children may also impede skill development and performance (Duncan, Stanley and Wright, 2013). Tompsett et al. (2014) suggested a link between functional movement and FMS such as running, jumping, hopping, throwing, kicking, and striking (Tompsett, Burkett and McKean, 2014). A similar theory was proposed by Duncan and Stanley (2012), who proposed that children with functional limitations may not develop their FMS to the same level of proficiency as those without functional limitations (Duncan and Stanley, 2012).

Weight status is another factor that has been linked to MC proficiency (Cliff et al., 2012) as well as injury risk (Rinaldo, Gualdi-Russo and Zaccagni, 2021). Excess weight in childhood has been linked to numerous negative health outcomes (Bull and Bauman, 2011). Two studies carried out by Duncan et al. (Duncan and Stanley, 2012; Duncan, Stanley and Wright, 2013) found that overweight/obese children demonstrated significantly poorer functional movement proficiency compared to their normal-weight counterparts. More recently, Molina-Garcia et al. (2019) investigated the associations between several fatness indicators and fitness components with functional movement quality in overweight/obese children (Molina-Garcia et al., 2019). In this study, 56 children (59% female, aged 8-12 years) were examined using the body mass index (BMI), waist circumference, bioelectrical impedance measures (fatness), one repetition maximum bench and leg press, and ALPHA test battery (fitness), and the FMSTM (functional movement) (Molina-Garcia et al., 2019). Results from the study found that (i) all fatness indicators (except waist circumference) were negatively associated with total FMSTM score, regardless of fitness, (ii) fitness was positively associated with total FMSTM score regardless of BMI, and (iii) total FMSTM score was worse in

overweight/obese children (Molina-Garcia et al., 2019). The findings from this study would therefore suggest that developing proficiency in functional movement skills can have a potentially positive impact on weight status in childhood, but also physical fitness, which can provide positive outcomes to both overall health as well as performance in a range of PA.

Functional Movement Skills and Athletic Performance

Understanding how functional movement might impact PA and sports performance in youth is important in developing positive trajectories of movement aligned with lifelong PA and sports participation (Fitton Davies et al., 2022). The Youth Physical Development (YPD) model proposed by Lloyd and Oliver (2012) identified agility, speed, power, strength, and endurance as key aspects of sports performance (Lloyd & Oliver, 2012). Agility is defined as rapid whole-body movement with a change of velocity or direction in response to a stimulus (Sheppard and Young, 2006). Speed has a range of definitions, however it can be considered as sprinting ability (Di Domenico and D'Isanto, 2019). Power can be defined as the ability to perform fast, forceful, and propulsive movements (Isaacs, 1998). Strength is defined as the ability to exert force to overcome resistance (Fitton Davies et al., 2022). Finally, endurance is described as the ability of the heart, lungs, and blood vessels to supply the muscles with oxygen (Mylsidayu, 2019).

Until recently, research examining this relationship in children and adolescents has been sparse, with the majority of studies focussing on individual sports. For example, Yildiz (2018) examined this association in a population of youth tennis players ($n = 28$, 100% male, mean age = 9.6 ± 0.7 years). This study found an association between functional movement proficiency, flexibility ($r=0.74$), counter movement jump performance ($r=0.57$), agility ($r=0.45$), acceleration ($r=0.44$), dynamic balance ($r=0.67$) and static balance ($r=0.84$) (Yildiz 2018). The same author found additional associations between functional movement proficiency, flexibility ($r=0.74$), power ($r=0.52$) and strength ($r=0.74$) in a group of young karate athletes ($n = 32$, 60% female, age range 6-18) (Yildiz 2018). Lloyd et al. (2015) found that selected tests (in-line lunge, deep overhead squat,

active straight leg raise and rotary stability) within the FMSTM explained a portion of the variation in athletic performance in a population of youth soccer players (n = 30, 100% male, age range 11-16 years) (Lloyd et al., 2015). The same level of association may not be evident if examining the entire test battery however, as it has been previously reported that the movements within the FMSTM have poor internal consistency and do not assess the same underlying variables (Li et al., 2015).

A recent systematic review by Fitton Davies et al. (2022) is the first study to synthesise evidence relating to FMSTM scores and athletic performance tasks (Fitton Davies et al., 2022). The results of this review suggest that children and youth who score highly on the FMSTM also tend to have better scores for agility, running speed, strength, cardiovascular endurance and some, albeit lighter, evidence that this is the case for tests of balance also (Fitton Davies et al., 2022). The strength of the association between functional movement proficiency and athletic performance was reported as varied (broadly weak to moderate in magnitude) (Fitton Davies et al., 2022). The significance of this finding is that functional movement proficiency is not a complete predictor of athletic performance, however, acquiring proficiency in these skills in youth can aid the development of key components of athletic performance which aid in sport and PA participation.

Current Levels of Functional Movement Skills in Young People

The early 2000's saw a significant rise in the number of children participating in both organised and individual sports in addition to their leisure time PA (Abraham, Rajasekar and Rohit, 2015). As a direct consequence of this, the number of sports-related injuries has risen dramatically also (Maffulli et al., 2010). Until 2015, there existed no published normative data on the functional movement skill proficiency of children or adolescents (Abraham, Rajasekar and Rohit, 2015).

More recently, O'Brien et al. (2022) conducted a systematic review and meta-analysis which sought to establish normative reference values for functional movement skills proficiency (using the FMSTM) in children and adolescents. While the previous study by Abraham et al. (2015) did establish normative values, O'Brien et al.(2022) synthesised a far more comprehensive set of data from

Europe, North America, the Middle East, and South Asia (O'Brien et al., 2022). Their analysis identified only 19 studies for inclusion (see Table 2.4), all of which were conducted between 2012 and 2020, highlighting just how recently this area of study has emerged in children and adolescents. The meta-analytic mean score of 14.06 reported in this study indicates that primary and secondary school-aged children exhibit potential deficits in functional movement and that they may be at risk of developing dysfunctional movement patterns and injury over the course of an important period of maturation (O'Brien et al., 2022). This finding identifies a direct need for further assessment, monitoring and development of functional movement skills among typically developing groups of children and adolescents (O'Brien et al., 2022).

Study	Year	Country	N	Sex (M, F)	Age (years)	School stage	Design	Live or retrospective scoring	Training level of raters	Average FMS score	95% confidence interval
Abraham et al.	2015	India	100	548, 5	10 - 17	Secondary	CS	Unclear	Trained	14.59	14.44; 14.74
Coker	2018	USA	120	54, 66	13.2 ± 0.4	Secondary	CRCT	R	Trained	15.48	15.14; 15.82
Duncan and Stanley	2012	UK	58	29, 29	10.7 ± 0.4	Primary	CS	Unclear	Trained	14.00	13.19; 14.81
Duncan et al.	2013	UK	90	38, 52	9.6 ± 1.4	Primary	CS	Unclear	Trained	13.20	12.58; 13.82
García-Jaén et al.	2018	Spain	40	20, 20	8.5 ± 0.5	Primary	CS	R	Trained	14.53	13.58; 15.18
García-Pinillos et al.	2019	Spain	172	89, 83	9.7 ± 1.6	Primary	CS	Unclear	Trained	14.58	14.11; 15.05
García-Pinillos et al.	2018	Spain	333	164, 169	9.7 ± 1.5	Primary	CS	Unclear	Trained	14.59	14.26; 14.92
Ghasempoor et al.	2018	Iran	700	350, 350	9-18	Not specified	CS	Unclear	Trained	14.93	14.66; 15.20
Karuc et al.	2020	Croatia	652	331, 321	16 - 17	Secondary	CS	Unclear	Trained	12.45	12.27; 12.63
Karuc et al.	2020	Croatia	730	362, 368	16 - 17	Secondary	CS	Unclear	Trained	12.5	NR
Lester et al.	2017	Ireland	181	108, 73	14.4 ± 1.0	Secondary	CS	R	Trained	14.05	13.66; 14.44
Mitchell et al.	2015	Moldova	77	39, 38	9.3 ± 0.1	Primary	CS	R	NR	14.90	14.48; 15.32
Molina-Garcia et al.	2019	Spain	56	23, 33	8 - 12	Not specified	QE	R	FMS TM certified	07.30	05.50; 09.10
Nourse et al.	2015	USA	20	11, 9	14.5 ± 2.1	Not specified	SAT	Unclear	NR	13.00	12.12; 13.88
O'Brien et al.	2019	Ireland	219	120, 99	14.5 ± 1.0	Secondary	CS	R	Trained	14.09	13.76; 14.42
Philpott et al.	2020	Ireland	373	195, 178	12 - 16	Secondary	CS	R	Trained	12.01	11.83; 12.19
St. Laurent et al.	2018	USA	28	13, 15		Not specified	RCT	Unclear	Trained	14.89	13.86; 15.92
Vernetta-Santana et al.	2020	Spain	35	11, 24	12.2 ± 0.4	Secondary	CS	R	Trained	15.85	NR
Wright et al.	2015	UK	22	NR	13.4 ± 1.0	Secondary	MPE	R	NR	12.05	11.27; 12.83
Average										14.06	13.48; 14.64

CRCT cluster randomised controlled trial, CS cross-sectional, MPE matched pairs experiment, QE quasi-experiment, RCT randomised controlled trial, SAT single-arm trial

FMSTM Functional Movement ScreenTM, R retrospective, M male, F female, N study sample size, NR data not reported
Ages were reported in studies either as a range or as mean age ± standard deviation

Table 2.4: The characteristics and average FMSTM scores of studies included in O'Brien et al. 2022 study

In an Irish context, research in this area has solely focussed on adolescents (Lester et al., 2017; O'Brien et al., 2018). These studies examined data gathered from 592 Junior Cycle students from three mixed-gender secondary schools (55% male, mean age = 14.45 ± 0.96 years). Results found that overall functional movement proficiency was at a consistent level to that found by Abraham et al. (2015), with an average composite score of 14.05 ± 2.48 out of a possible total of 21 (Lester et al., 2017; O'Brien et al., 2018). The results of this study also identified that no participant achieved complete mastery (maximum score of three for all) across all seven tests (Lester et al., 2017). These findings highlight that there is considerable room for improved functional movement proficiency amongst Irish adolescents. The lack of data available for primary school-aged children is stark, as these movement patterns are developed in childhood, and further improved throughout adolescence. Without assessment of these skills, appropriate intervention cannot take place (Tidén, Redelius and Lundvall, 2017). It is therefore evident that there is a considerable need to firstly measure the functional movement proficiency of Irish primary school children to ascertain the level that they are at, before assessing whether intervention is necessary and to what extent.

Gender differences in FMS proficiency has been widely observed in the literature (Barnett et al., 2009; Cantell et al., 2008; O'Brien et al., 2015; Breslin et al., 2012; Lopes et al., 2011). In relation to functional movement skills, much less is known. O'Brien et al (2018), found that females (mean = 14.70 ± 2.16) outperformed males (mean = 13.58 ± 2.59) in their overall functional movement, suggesting that gender-based differences may exist among Irish adolescents (O'Brien et al., 2018). The most recent evidence provided by O'Brien et al.'s systematic review and meta-analysis revealed that, on average, females exhibit greater functional movement proficiency (a small but substantial effect magnitude of Cohen's $d = -0.27$) when compared with males (O'Brien et al., 2022). This gender difference, however, was not statistically significant, suggesting that there were possible interaction effects observed, potentially with age (O'Brien et al., 2022). Considering many studies included in this research spanned an age range of 9-14 years, it would be reasonable to assume that maturation may have had an effect, with females likely to have commenced puberty during this time (Malina and Kozielec, 2014a, 2014b).

Evidence of maturation was also identified by O'Brien et al. (2022), when examining differences in FMSTM variability between primary and secondary school-aged participants (O'Brien et al., 2022). Results demonstrated that variability in mean FMSTM score was approximately five times greater in secondary school adolescents than it was in primary school children (O'Brien et al., 2022). This significant variability can be explained by the substantial physical and hormonal changes, particularly changes in limb length, body mass and composition, and neuromuscular control experienced by adolescents as they mature (Ghasempoor, Alizadeh and Minoonejad, 2018). Adolescents at this stage could potentially lack the bodily competence and coordination to negotiate the demands of the FMSTM. Comparatively, primary school children are far less likely to be undergoing such intense physiological and hormonal changes, meaning that their performance in the assessment will likely display greater homogeneity (Malina and Kozieł, 2014a, 2014b). The findings described in the above studies emphasises the importance that children and adolescents establish adequate movement patterns prior to the onset of maturation, so that they can be practiced and further developed during adolescence. Additionally, there is a dearth of research examining the functional movement skill proficiency of primary school-aged children in Ireland. This is an area in which future research should explore. Considering the greater homogeneity seen in primary school children's functional movement skills data in comparison to their adolescent counterparts, establishing normative data for primary school-aged children would allow for more accurate comparisons between genders and populations. Furthermore, if functional movement proficiency is being examined in adolescent populations, maturation should also be considered when examining the results.

Functional Movement Skills Summary

The definition of MC is evolving (Hulteen et al., 2018; O'Brien et al., 2018; Basman, 2019). It is now being acknowledged that a more holistic view of MC consists of skills from both FMS and functional movement skill constructs (Hulteen et al., 2018; O'Brien et al., 2018; Basman, 2019). Functional movement skill can be defined as the ability to produce and maintain an adequate balance

of mobility and stability along the kinetic chain while integrating functional movement patterns with accuracy and efficiency (Mills, Taunton and Mills, 2005; Bagherian et al., 2018). Functional movement has also been defined as the movement patterns that underpin all other movements, suggesting that they may be an important contributor to the successful development of FMS and overall MC (Duncan, Stanley and Wright, 2013; Fitton Davies et al., 2022).

Within the literature, proficiency in functional movement skills has been positively associated with sport skill acquisition (Zalai, 2015), injury risk reduction (Duncan and Stanley, 2012; Lloyd et al., 2015; Pfeifer et al., 2019; Wang et al., 2021), FMS proficiency (Wu et al., 2021), perceived FMS competence (Coker and Herrick, 2020), weight status (Duncan and Stanley, 2012; Duncan, Stanley and Wright, 2013) and athletic performance (Fitton Davies et al., 2022). Despite the literature highlighting the value in children developing proficiency in these skills, research has shown that the proficiency levels of children both nationally and internationally is low (Abraham, Rajasekar and Rohit, 2015; Ghasempoor, Alizadeh and Minoonejad, 2018; O'Brien et al., 2018, 2022).

Considering the low level of functional movement proficiency reported in the literature, in conjunction with emerging research highlighting the inter-connected relationship to FMS, it is critical that research continues to explore this. To date, the majority of studies that have examined this have used the FMSTM as a means to measure these skills. Although the FMSTM has been described as a robust, time-efficient, non-invasive, inexpensive and easily administered method of functional movement assessment, significant concerns still remain surrounding its validity (Moran et al., 2016).

In response, new tools such as the ChildFIRST have emerged that seek to incorporate musculoskeletal injury screening techniques into an assessment of MC (Jimenez-Garcia et al., 2020). Whilst such a tool represents a progression towards a more holistic assessment of MC, it too has its limitations (i.e. fails to assess object manipulation skills). Hence, future research should seek to develop a tool which can assess all key elements of MC whilst also incorporating musculoskeletal injury screening techniques.

Literature Review Summary

By 2030, Ireland is projected to be Europe's most obese nation (Keaver et al., 2013; World Health Organization, 2013), with inactivity in children being one of the forefront contributors (House of the Oireachtais, 2011; Keaver et al., 2013). Numerous studies have highlighted the direct relationship between physical inactivity and negative health outcomes (Cools et al., 2009; World Health Organization, 2014a; Ding, Lawson, Kolbe-alexander, et al., 2016; González, Fuentes and Márquez, 2017). Despite this, the literature indicates that the PA levels of children in Ireland and across the world are well below the recommended level to promote and sustain positive trajectories of health throughout the lifespan, and these figures are only decreasing (Li, Kearney, Keane, Harrington, & Fitzgerald, 2017; Marques et al., 2020; Woods et al., 2018).

Emerging research suggests that PL could be a key determinant in engaging children in lifelong PA (Cairney et al., 2019; Edwards et al., 2017, 2018; O'Brien, Belton, and Issartel 2015; Mandigo et al., 2009; Belanger et al., 2018). The concept of PL is made up of three interconnected components, which together, seek to develop the whole person (i.e. their feelings (affective), movements (physical) and thoughts (cognitive)) (Jurbala, 2015). Movement competence is considered an important element of PL (Pill and Harvey, 2019). Similar to PA, the literature also highlights that the MC levels of children and adolescents in Ireland and worldwide are at a low level (Okely and Booth, 2004; Hardy et al., 2013; Bardid et al., 2015; Behan et al., 2019).

In response to the low levels of MC proficiency observed nationally and globally, researchers and practitioners have sought to develop appropriate intervention strategies, with the school setting deemed to be the optimum setting to develop children's MC proficiency (McKenzie and Lounsbery 2009). Recently, new evidence-based programmes such as MWBW have emerged to tackle this problem at a national level (Behan et al., 2019). Although such programmes have shown effect at a pilot stage (Behan, 2020), further implementation and evaluation is critical if they are to be a viable solution for national implementation. This is an area which future research must explore.

In addition to the development of new intervention strategies, researchers should also consider the development or refinement of assessment tools used to evaluate such programmes

(Hulteen et al., 2020). It is well established in the literature that apart from use by researchers, many existing MC assessment tools are not practical for use in many “real-world” settings (Lander et al., 2017). If practitioners are unable to accurately assess children, their ability to enhance children’s MC will be limited, regardless of their level of expertise (Chan et al., 2016; Lander, Morgan, et al., 2017). In recent times, a number of new assessment tools have emerged which begin to address some of these practical concerns. For example, the CAMSA (Longmuir et al., 2017) and DC (Tyler et al., 2018) try to assess skills in a much more ecologically valid manner than many existing tools. Their design addresses a number of common constraints affecting the use of existing MC assessments, such as time efficiency, and being feasible and realistic for use in settings such as schools or sport clubs. Another concern with regard to existing tools is that they fail to consider movement patterns related to an increased risk of injury in children (Miller et al., 2018). The recently developed ChildFIRST assessment is the first MC assessment tool that aims to consider musculoskeletal injury screening techniques for children (Jimenez-Garcia et al., 2020), making it potentially appealing for use by clinicians or sports coaches. It could therefore be assumed that the next, exciting stage of evolution for these type of assessments is to develop a tool that can meet the needs of all practitioners (i.e. researchers, teachers, coaches, athletic therapists and physiotherapists), that is practical for use in a number of settings, that is fun for participating children, is time efficient and more ecologically valid than many existing tools, whilst also having the capacity to incorporate musculoskeletal injury screening techniques.

Building upon this review of the literature, this PhD study sought to address two broad study areas. The first area of study (chapter 3 and 4) seeks to extend the knowledge base around PA and PL in Irish children, by evaluating the efficacy and implementation process of the MWBW PE and PL intervention in Irish primary schools. These studies seek to satisfy calls from policy makers to increase the number of FMS-based programmes and fun physically active experiences in Irish schools (Sollars, 2020; The Department of Education and Skills, 2012; Woods et al., 2018). In addition, these studies seek to address significant gaps in the literature by examining the implementation process of the intervention, as well as looking at the effect of teacher fidelity on the

overall FMS improvement of participating children. The second area of study (chapter 5 and 6) of this thesis seeks to address several of the key barriers that prevent the use of MC assessments in practical settings. The study presented in Chapter 5 brings together worldwide expert academics and practitioners from research, education, sport, athletic therapy, and physiotherapy to co-design a tool to meet the needs of all, and that also aligns with the evolving definition of MC that considers both fundamental and functional movement skills. Chapter 6 extends this work by examining the structural and convergent validity of the newly designed tool, an area of study commonly underreported in the literature.

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Chapter 3: Moving Well-Being Well: A process evaluation of a physical literacy-based intervention in Irish primary schools

Moving Well-Being Well: A process evaluation of a physical literacy-based intervention in Irish primary schools

Abstract

Background: Many Irish children are failing to meet the recommended guidelines for physical activity (Woods et al., 2018). Research shows that children are failing to develop the necessary physical literacy skills to reverse this trend (Behan et al., 2019; Peers et al., 2020; Belton et al., 2019). Early childhood has been identified as a critical period to intervene (Hardy et al., 2013), with the school environment identified as key environment to do so (Morgan, Barnett and Cliff, 2013; Lundvall, 2015; Edwards et al., 2018). Qualitative research is increasingly included in intervention studies to aid the development of acceptable, attractive, effective and sustainable interventions (Cathain et al., 2013). The aim of this study was to evaluate the implementation process of the MWBW intervention (Exploratory trial) in the primary school setting, allowing the research team to assess the quality of the intervention's implementation. Objectives included assessing whether the intervention is suitable for the primary school environment, and to inform for future, mainstream implementation through a comprehensive process evaluation.

Methods: The intervention is underpinned by both the theory of constraints and self-determination theory (Deci and Ryan, 2010), and is designed using the comprehensive framework outlined by the behaviour change wheel (Michie, Stralen and West, 2011). The intervention was delivered in 18 primary schools (22% DEIS) to 925 participants (age range 6 – 10 years, mean 7.55). The intervention was co-delivered by trained coaches and class teachers who were being upskilled (by trained coaches) whilst the intervention was being delivered. Qualitative data were gathered in the form of child focus groups (N=32, 62% Male), teacher (N=31) and principal (N=5) questionnaires (open-ended questions), coach focus groups (N=16, 81% Male) and weekly reflections. Data was analysed thematically following Braun and Clarke (2006) guidelines on using thematic analysis.

Results: Five key themes, with subsequent sub-themes, were identified: 1) Implementation of the Moving Well-Being Well model, 2) Outcomes from the intervention, 3) Fidelity of

implementation, 4) Key components of favourite games and 5) Challenges faced and areas to develop.

Conclusions: Findings would suggest that the MWBW intervention is suited to the Irish primary school environment and its model of implementation can provide benefits to both children participants and teachers. Findings also show that the intervention has largely been delivered as intended showing potentially significant increases in participants overall FMS. Future research should examine the contextual impacts on the overall FMS improvement and how it varies from site to site. Evidence from this study also suggests that in order to produce similar or improved results in future as part of a wider-scale roll-out of the intervention in schools, researchers should look to further assist teachers (possibly through added resources and/or training) to assist fidelity of implementation as well as looking at other factors that may influence intervention outcomes such as weather, seasonality, access to indoor facilities and environmental factors.

Key words: physical literacy, fundamental movement skills, intervention, process evaluation, primary school

Introduction

Physical Literacy (PL) is defined by Whitehead as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life” (Whitehead, 2013). Therefore, in the broadest sense, a physically literate child is confident, active and can maintain health enhancing physical activity (PA) for life (Belton et al., 2019). In an Irish context many children do not meet these criteria as recent research has alluded to (Belton et al., 2019; Behan et al., 2019; Peers et al., 2020). The most recent CSPPA (The Children’s Sport Participation and Physical Activity study) report shows that only 17% of primary children and 10% of post-primary children are meeting the recommended PA guidelines of 60 minutes moderate to vigorous physical activity each day (Woods et al., 2018). These figures pose great concern as numerous studies highlight the direct relationship between inactivity and negative health outcomes (World Health Organization 2014; Ding et al., 2016; González, Fuentes, and Márquez 2017; Cairney et al., 2019). One plausible reason for the high percentage of Irish children failing to participate in regular PA may simply be that they fail to possess the key physical skills necessary for play (O’Brien, Belton and Issartel, 2016).

Fundamental Movement Skills (FMS) are described as the building blocks of more advanced, complex movements required to participate in games, sports and other context specific PA (Logan et al., 2018). These FMS are purported to have a significant impact on PA participation, with increased proficiency associated with increased PA participation in children (Barnett et al., 2009; Cliff et al., 2009; Logan et al., 2015). Research also highlights that a lack of proficiency can lead to reduced levels of PA participation (Jaakkola et al., 2016). Early childhood has been identified as a critical period for FMS development (Hardy et al., 2013), with Stodden et al. (2012), stating that early mastery of FMS can lead to a more active lifestyle over time (Stodden et al., 2012). A recent Irish study from Behan et al. (2019) has pointed to a distinct lack of proficiency across all FMS components in Irish primary school children (N=2098, age range 5-12 years, 47% female). This study showed that only 60.6% of primary school children achieve Mastery/Near Mastery (MNM) in balance skills, whilst just over half achieve MNM in locomotor (52.8%) and object control skills

(54.8%) (Behan et al., 2019). This research highlights the need for effective intervention strategies to develop children's FMS, thus developing their PL and ultimately increasing their PA participation (Cairney et al., 2019).

The school environment has been highlighted as a key environment for which to implement PL interventions (Morgan, Barnett and Cliff, 2013; Lundvall, 2015; Edwards et al., 2018). To date, numerous initiatives and interventions have aimed at increasing children's PL (Chen, Hammond-Bennett and Hypnar, 2017; Demetriou et al., 2018; Johnstone et al., 2019). These interventions range from using a multifaceted approach or by targeting one component of PL, such as FMS (Liu and Chen, 2020). Results from these studies however, showed mixed findings from which no consistent conclusion can be made (Liu and Chen, 2020). A range of factors can impact the outcomes of complex interventions, therefore, exploring the mechanisms through which these outcomes occurred is crucial if the desire is to replicate or improve its implementation in the future (Moore et al., 2015; Ma et al., 2021).

There is growing research focusing on qualitative evaluation with core emphasis on intervention studies to aid the development of acceptable, attractive, effective and sustainable interventions (Cathain et al., 2013). This qualitative evaluation provides policy makers and practitioners with vital information about how the intervention was delivered, issues arising or how it might be replicated (Grant et al., 2013; Moore et al., 2015). This can be particularly evident in a school setting, which is a much more complex setting than most with no two schools being the same and where teachers, principals and coaches individual preferences and opinions towards the intervention, as well as other factors such as time constraints can influence the implementation process (van Sluijs and Kriemler 2016). Bolger et al. (2018), highlighted a dearth of published data relating to the implementation or process evaluation of such interventions in the school setting, emphasising the need for potentially effective interventions to be evaluated (Bolger et al., 2018).

The UK Medical Research Council (MRC) framework recommends a feasibility and piloting phase after an intervention has been developed (Craig et al., 2008). Findings from this phase have suggested that the MWBW intervention could be a suitable model of intervention in the Irish primary

school setting and deliver positive results (Behan, 2018). The next phase is to provide a deeper understanding of the interventions effectiveness, by assessing the quantity and quality of what was delivered, and by assessing the generalisability of its effectiveness by understanding the role of context (Moore et al., 2015). Building on the work from Behan et al. (2018) and Bolger et al. (2018) it would be expected that implementation level and quality would vary somewhat from site to site, with suitability for implementation being dependent upon a range of factors. The aim of this study was to evaluate the implementation process of the MWBW intervention in the primary school setting, allowing the research team to assess quality of the intervention's implementation. Objectives included assessing whether the intervention is suitable for the primary school environment, and to inform for future, mainstream implementation through a comprehensive process evaluation.

Materials and Methods

The Intervention

The intervention is underpinned by both the theory of constraints (TOC) and self-determination theory (SDT) (Deci and Ryan, 2010), and is designed using the comprehensive framework outlined by the behaviour change wheel (Michie, Stralen and West, 2011). Multicomponent interventions that are underpinned by relevant theoretical frameworks have proven the most successful in previous research (Craig et al., 2008; Kriemler et al., 2011). The MWBW intervention contains several components, including family, community, active classroom, teacher training, and external provider components, all of which contain a strong focus on developing each component of PL. The content of the intervention was derived from the Move Well, Move Often resource, a programme developed by the Professional Development Service for Teachers (PDST) seeking to develop PL through FMS, and one which is aligned with the Irish primary school curriculum. The intervention was delivered over an eight-week period and consisted of three main components: (i) Two 30-minute FMS-based PE classes per week. (ii) 5–10-minute Active Classroom activities performed at least once daily. (iii) Home Activity Sheets completed once per week (see Table 3.1).

The tailored, FMS specific lessons were delivered by an expert coach who completed the MWBW Continuous Professional Development (CPD) module, for six weeks. The expert coaches are local, community-based coaches who have contact with the children both in school on a regular basis, and in the local GAA club where many participate in Gaelic games. Classes were delivered in a holistic manner, with a focus on creating a mastery environment. While providing these lessons, the coach upskilled the teacher in how to deliver an FMS-based class. The teacher then delivered each lesson to their class the same week before the coach returned to deliver the next lesson. After week six, the teacher delivered the last two weeks of the intervention with the coach shadowing and offering support. This acted as an onsite upskilling for class teachers aspiring to develop their confidence and ability to deliver effective PE lessons. The content of these lessons focused on just three locomotor (Hop, Skip & Jump) and three object control skills (Kick, Catch & Throw). These skills emerged as weak from the national cross-sectional study carried out by Behan et al. (2019) and

were therefore deemed most appropriate to focus on in the immediacy (Behan et al., 2019). Active classrooms have been shown to be an important component to effective, multicomponent interventions in a school setting (Martin and Murtagh, 2017). The content was designed to supplement that covered in each weeks PE class and was delivered through PowerPoint by the class teacher each day. The Homework Activity worksheets were sent home with the children once each week to be completed with someone at home. All students within the classes participated in the sessions (regardless of whether or not they consented to participate in the research evaluation), unless unable to due to injury or illness.

Week	Component	Delivery responsibility	Frequency (Days per week)	Duration (minutes)	Focus of the Core Activities	
1	PE class	Coach	1	30	Hopping, Throwing	Catching,
1	PE class	Teacher	1	30	Hopping, Throwing	Catching,
1	Classroom Activities	Teacher	5	5-10	Vertical Jump & Catch	
1	Home Activity Worksheet	Parent/Guardian	1	10-15	Jumping	
2	PE class	Coach	1	30	Hopping, Throwing	Catching,
2	PE class	Teacher	1	30	Hopping, Throwing	Catching,
2	Classroom Activities	Teacher	5	5-10	Hop & Kick	
2	Home Activity Worksheet	Parent/Guardian	1	10-15	Jumping	
3	PE class	Coach	1	30	Hopping, Throwing	Catching,
3	PE class	Teacher	1	30	Hopping, Throwing	Catching,
3	Classroom Activities	Teacher	5	5-10	Skip & Stride	
3	Home Activity Worksheet	Parent/Guardian	1	10-15	Skipping	
4	PE class	Coach	1	30	Skipping, Throwing	Catching,
4	PE class	Teacher	1	30	Skipping, Throwing	Catching,
4	Classroom Activities	Teacher	5	5-10	Horizontal Jump & Throw	
4	Home Activity Worksheet	Parent/Guardian	1	10-15	Hopping	

5	PE class	Coach	1	30	Skiping, Throwing	Catching,
5	PE class	Teacher	1	30	Skiping, Throwing	Catching,
5	Classroom Activities	Teacher	5	5-10	Vertical Jump & Catch	
5	Home Activity Worksheet	Parent/Guardian	1	10-15	Catching	
6	PE class	Coach	1	30	Skiping, Kicking, Jumping	
6	PE class	Teacher	1	30	Skiping, Kicking, Jumping	
6	Classroom Activities	Teacher	5	5-10	Hop & Kick 2	
6	Home Activity Worksheet	Parent/Guardian	1	10-15	Throwing	
7	PE class	Teacher	1	30	Jumping, Kicking	
7	PE class	Teacher	1	30	Jumping, Kicking	
7	Classroom Activities	Teacher	5	5-10	Skip & Stride 2	
7	Home Activity Worksheet	Parent/Guardian	1	10-15	Striking with the hand	
8	PE class	Teacher	1	30	Jumping, Kicking	
8	PE class	Teacher	1	30	Jumping, Kicking	
8	Classroom Activities	Teacher	5	5-10	Horizontal Jump & Throw 2	
8	Home Activity Worksheet	Parent/Guardian	1	10-15	Kicking	

Table 3.1: Moving Well-Being Well Intervention Delivery Components

CPD training for coaches and school recruitment

Eighteen Games Promotion Officers (GPOs) (coaches) were selected to participate in the study by Dublin GAA. The selected GPOs attended a training module specifically designed for and delivered to them by the three leading authors along with two other experts on the project. Training consisted of two full contact days in January 2019 before schools were recruited, one full contact day mid-intervention and one full contact day post intervention. Total training time amounted to 24 hours with a mixture of theoretical and practical elements conducted in Dublin City University's School of Health and Human Performance. Some of the modules included in this training were: An overview of the MWBW project, Physical Literacy (Coach Ireland Certified), Motor Control (Theory and Practical), Motor Development, Assessing FMS, Self-Determination Theory, Lesson Delivery practical etc. In addition to these modules GPOs also had to undergo a consistency assessment to ensure good quality data was collected. To do this, coaches had to achieve a 95% inter-observer

agreement on a set of data that was pre-coded by one of the researchers on the team. Training did not include content on how to upskill the classroom teachers as this is something that they regularly do with other coaches and teachers as part of their jobs, and so they already possessed the necessary skillset for this.

Following preliminary training days GPOs contacted principals within schools that they coach in to participate in the study. On agreement from principals one first and one second class (age range 6 – 10 years, mean 7.55) within each school was selected to participate in the intervention. Parental consent and participant assent were obtained (age-appropriate child assent forms were supplied to participants). In total 18 schools (22% DEIS) were approached to participate in the study, all accepted. Irish primary schools in areas classed as “socioeconomically disadvantaged” qualify for the Delivery of Equality and Opportunity in Schools (DEIS) programme (The Department of Education and Science, 2005). In Ireland, 19.7% of schools fall into this category which is consistent with the demographic of this study.

Children

Qualitative data were collected from a sample of children (n=32) who participated in the study through the form of focus groups. The aim of the focus groups was to identify outcomes of the intervention and assess the quality to which it was implemented. Focus groups were led by the lead author who is a qualified teacher as well as having previous experience in conducting focus groups with a similarly aged cohort. All sessions took place in a resource classroom within each school with the lead author and a research assistant present. These were conducted in four selected schools (50% DEIS), with eight students in each (n=32, 62% male), post intervention. In order to have a varied sample of participants, students were shortlisted based on their FMS results from pre-intervention testing. Students were divided into quartiles. This shortlist was then given to the class teacher who selected two students from each quartile who they thought would offer the most to the discussion. Each focus group lasted between 53 minutes – 1hr 15 minutes. All focus groups were recorded using a digital recorder, were transcribed verbatim and anonymised for thematic analysis. Focus groups guiding questions were semi-structured in nature, with questions having been reviewed by an expert

in qualitative research and pilot tested prior to the commencement of the study. Each focus group also incorporated a Write, Draw, Show & Tell (WDST) component to act as an ice-breaker activity. This methodology has also been used in other research projects examining health of children (McWhirter, 2014).

Teachers

Teachers were asked to complete a short online questionnaire consisting of closed and open-ended questions. This was completed on a tablet supplied by the lead researcher. The aim of this was to provide the research team with feedback from the teacher's point of view on the quality of the intervention and its various components, how easy it was to implement, their perceptions of student enjoyment, elements they liked/disliked and also its inclusivity for all students. In total, 31 teachers responded (out of total sample of 36), with the non-respondents absent due to illness or attending Continuous Professional Development (CPD) training.

Coaches

Following their PE lessons each week, GPOs completed a short weekly reflection in written, audio or video format which they uploaded to their own individual online folder assigned to them by the research team (100% completion rate). This platform allowed the research team to receive real-time updates and feedback on specific classes, challenges faced, or the quality to which the GPOs delivered the lessons. This acted as a way for the research team to monitor the fidelity of the coaches delivering the intervention.

Data was also collected from the GPOs via focus groups. These took place during the final CPD session post intervention. Of the 18 GPOs, 16 were in attendance (81% Male). Two focus groups were carried out, led by the lead researcher and another member of the research team who has extensive experience in coach education and carrying out similar focus groups. Each focus group had eight GPOs participating and guiding questions were semi-structured in nature. Questions were piloted prior to data collection. Both focus group sessions lasted for forty-five minutes and were aimed at gathering the GPOs opinion of the quality of the intervention components, the model for

upskilling the teachers, student and teacher engagement levels, challenges they faced, suggested improvements and their overall opinions on the process.

Principals

Following post-intervention testing Principals were asked to complete an online questionnaire, consisting of closed and open-ended questions, which aimed to gain their perspectives on the intervention, their views on physical education, its importance to the school, and also their perspectives on this model of upskilling teachers. Of the 18 Principals, five completed the questionnaire.

Data Analysis

Due to having data from a multitude of sources with varied perspectives, a mixed analysis approach was taken which meant that the researcher did not consider how the variety of data would relate until the interpretation stage. From this, data was triangulated to ensure credibility (Nowell et al., 2017). This approach was taken for complementary purposes, meaning that each separate data source could expand, enhance and clarify the others (Noonan et al., 2016). The multitude of sources collected allows for cross-data validity checks between the children, teachers, GPOs, principals, and the researcher.

Data was analysed thematically following Braun & Clarke (2006) guidelines on using reflexive thematic analysis. This process involves several phases (i.e. familiarisation with the data, data coding, searching for and reviewing themes, defining and naming themes, reflexive and thoughtful engagement with the analytic process and production of a final report). In this study data were gathered from children focus groups, GPO focus groups, GPOs reflections and open-ended questions from teacher questionnaires. Data from focus groups as well as any audio clips from reflections were transcribed verbatim by the lead author in preparation for thematic analysis. The transcribed data was analysed inductively after the first author was familiar with the data from reading and re-reading of the transcription text. Thematic analysis requires the researcher to produce

initial codes following multiple revisions of the data (Savage, 2000) and then identify initial themes from the dataset. Throughout this process, initial codes and themes were discussed by all members of the research team, as well as with an expert in thematic analysis, ensuring trustworthiness in the data. Themes were identified at a semantic level and examined within a realist/essentialist paradigm (Potter and Wetherell, 1987; Widdicombe and Wooffitt, 1995). Identified themes were then reviewed and refined to form a more coherent pattern which accurately reflects the meanings within the data (Braun and Clarke, 2006). Responses from the teacher questionnaire's open-ended questions were also transcribed verbatim and thematically analysed. As suggested by Lincoln & Guba (1985), peer debriefing and review of coded transcripts with experienced members of the research team were conducted throughout the process to ensure trustworthiness (Lincoln and Guba, 1985).

Results

Five key themes, with subsequent sub-themes, were identified from the qualitative data sources (Figure 3.1): 1) Implementation of the Moving Well-Being Well model, 2) Outcomes from the intervention, 3) Fidelity of implementation, 4) Key components of favourite games and 5) Challenges faced and areas to develop.

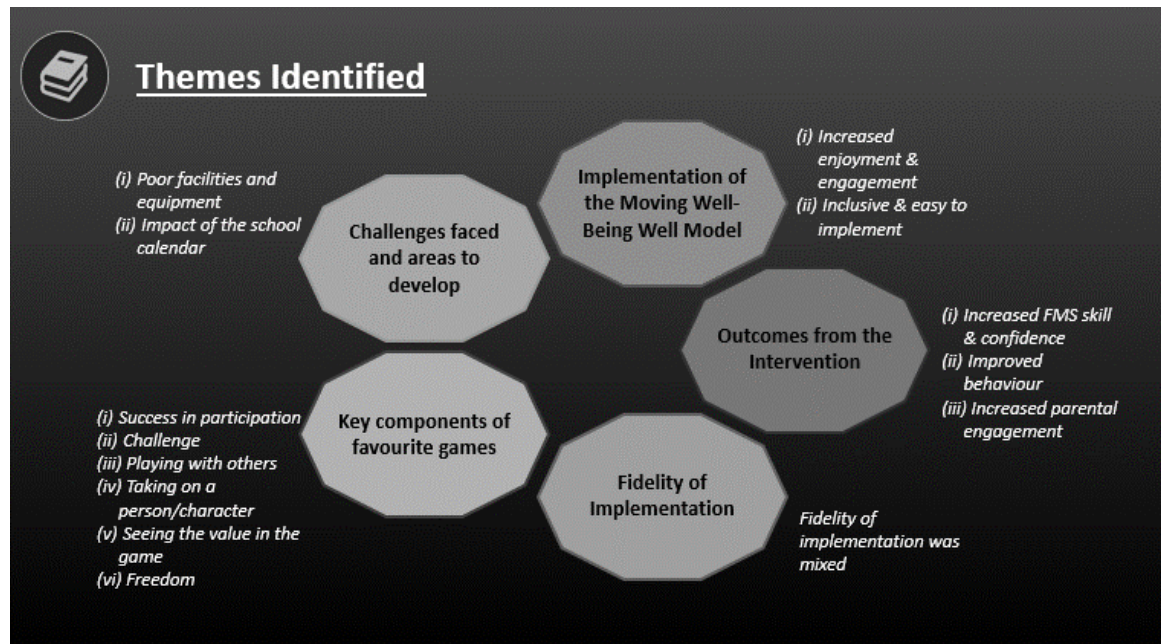


Figure 3.1: Identified themes and sub-themes from thematic analysis

Theme 1: Implementation of the Moving Well-Being Well model

Two sub-themes related to the implementation of the MWBW model were identified: (i) Increased enjoyment & engagement and (ii) Inclusive & easy to implement. Increased enjoyment & engagement was identified from all data sources apart from Principals, as they were not directly involved in the implementation of the intervention. Participating children reported to have enjoyed all elements of the intervention and to have enjoyed the intervention PE classes much more than their regular PE classes.

“I liked all of the games” – (Child, focus group 4)

“I like PE, but it’s funer when the Moving Well-Being Well thing came” – (Child, focus group 1)

Teachers also reported that all students enjoyed the intervention, with most enjoying it “much more” than their regular PE lessons. Within the questionnaire, teachers rated the student’s perceived enjoyment of the intervention at 9.77/10. In addition, 100% of teachers stated that they enjoyed delivering the programme.

“I found it all to be a very positive experience. Great benefit to all the children and I could definitely see a huge improvement in the children’s physical literacy & fundamental movement skills by the end of the intervention. I also now feel more confident in teaching lessons targeting specific FMS”. – (Teacher questionnaire)

Along with this increase in enjoyment both teachers and coaches reported an increase in engagement in class compared to their regular PE lessons.

“The level of engagement was much higher with the games and activities in this than going in like I said and trying to do GAA with them, it definitely engaged them more and it absolutely engaged the less active kids more” – (Coach, focus group 1)

For the kids on the outskirts as it doesn’t have a specific sport focus, it benefits them in a big way, they’re just as involved as each other” – (Coach, focus group 2)

Another identified sub-theme in relation to the implementation of the MWBW model was that coaches and teachers found it inclusive & easy to implement. Both groups felt that all elements of the intervention were inclusive for all students regardless of ability. As a result, both parties found it easy to implement within their daily routines and environments.

“Children with gross motor difficulties were still able to fully partake, we have a little girl in our class who is in a wheelchair and there weren’t any activities she could not partake in” – (Teacher, questionnaire)

“I had quite a few children with dyspraxia and special needs and everything was matched for their ability and you can progress it then, even the teacher would be sitting looking at the kids like being

able to do it and just think it was so good to be able to cater for them and be so inclusive for everyone without taking anything away from the games is great”. - (Coach, focus group 1)

“Teachers came back saying that they were very good, very structured and easy to do” – (Coach, focus group 2)

“The sessions have been handy to run so far. I’m not really using anything equipment-wise that I wouldn’t have before....more balls and smaller groups is probably the biggest change” – (Coach, weekly reflection)

“All pupils were able to take part and the range of activities appealed to all” – (Teacher questionnaire)

Theme 2: Outcomes from the intervention

Three sub-themes were identified as outcomes from the intervention: (i) Increased FMS skill & confidence, (ii) Improved behaviour and (iii) Increased parental engagement. Increased FMS skill & confidence were identified from data provided by the children, coaches and teachers. Improved behaviour was identified based on data from coaches and teachers and increased parental engagement was identified from data provided by children and coaches.

The improvement in children’s FMS from pre to post intervention was identified from data provided by children and coaches focus groups and weekly reflections where all participants felt that their skills increased over the course of the intervention.

“When I was on the beam thing the second time I didn’t wobble at all and I couldn’t do it the first time” – (Child, focus group 4)

“You can definitely see the benefit of it like and see an awfully big improvement in the kids”- (Coach, focus group 1)

“We’re halfway through the programme now and you can already see the technique getting better”

– (Coach, weekly reflection)

Along with the increase in skill, teachers and coaches also reported that the children’s confidence in their ability and to participate increased as the intervention progressed.

“You could see the less confident kids growing each week, I enjoyed the weaker kids stepping up, they were actually stepping up when you’re trying to show everyone the skills or what to be doing

like “Can I do it? Can I do it? I got a great buzz from that” – (Coach, focus group 2)

GPO focus groups also provided evidence that the participating teachers confidence in delivering the PE classes increased as the intervention progressed.

“I was just blown away, his [the teacher] confidence just shot up as it went on” – (Coach, focus group 2)

“I think maybe the fact I was going in, doing a session at the start of the week and she just had to mirror that during the week maybe she gained her confidence from that as the one that had the

least confidence was flying around by the end of it” – (Coach, focus group 1)

In relation to the sub-theme improved behaviour, teachers reported the classroom activities had a positive effect on classroom behaviour throughout the school day.

“It was a good break from the regular class work which helped the children focus on written and oral tasks after” – (Teacher Questionnaire)

Children who partook in the focus groups also reported an increase in PA time at home with their parents/family members as a result of the Home Activity component of the intervention.

“I got to play more, I also liked getting to play with my Dad” – (Child, focus group 3)

A number of coaches also reported a significant increase in engagement and volunteerism among parents at their local GAA clubs under-age training sessions following the introduction of some of the intervention components as part of their nurseries.

“I took quite a few of the games and would use them in the nursery all of the time....it actually helped get a few parents involved that would normally just stand and watch but I think it was familiar and they knew it was easy to do” – (Coach, focus group 1)

“I see a huge benefit now for the club in terms of nurseries” – (Coach, focus group 1)

Theme 3: Fidelity of Implementation

Self-reported teacher fidelity scores and data from child and GPO focus groups would suggest that the fidelity to which the intervention was delivered was mixed across schools and between classes within schools. Data outlining this was provided by coaches, teachers and children. It is evident that not all intervention components were delivered with the quality or frequency that they were intended to by all coaches and teachers.

“We didn’t play any games, but we had to hop” – (Child, focus group 2 in relation to a PE class with a focus on hopping)

“We done them [classroom activities] in like the first two weeks then not until the last week” – (Child, focus group 1)

Reasons given for this were:

“Teacher forgot to do them” and “The board [electronic whiteboard] stopped working one day too” – (Child, focus group 1)

“We just missed sometimes” – (Child, focus group 4)

When asked following the above quote whether they got to do the PE classes twice every week the child responded:

“Not all of the time but I don’t know how many times” – (Child, focus group 4)

Theme 4: Key components of favourite games

This theme was identified following analysis of the children's focus group data. There were several common games in which most children identified as their favourite games to play during the intervention, these were: Partner Catch, Litterbug, Beanbag Flick and Foxes & Rabbits. Analysis of children's reasons for why they enjoyed those particular games the most identified that there were certain key components which were common in nearly all of the participants favourite games. These components were: success in participation, challenge, playing with others, being able to take on a person/character, seeing the value in the game and freedom.

"I used to only be able to kick to the line but now I can kick to the other side of the hall" - Success

"I wasn't really that good at cops and robbers, but I still liked it.....because it was challenging" -

Challenge

"Because I get to play with other people and I feel stronger" – Playing with others

"I liked pretending to be a litterbug throwing the paper" – Taking on a person/character

"I liked that it helped get me better at catching" "It increases my leg strength" – Value

"I like the bit where we get our own time to make up a game and play around and stuff" - Freedom

Theme 5: Challenges faced and areas to develop

Two sub-themes were identified within the theme challenges faced and areas to develop: (i) Poor facilities and equipment and (ii) impact of the school calendar. Both sub-themes were identified from GPO and teacher data sources as they were involved in implementing the intervention. A number of schools reported having poor indoor PE facilities and equipment which meant in the event of poor weather, classes were either cancelled or could not be delivered as the coach or teacher would have liked.

"...if it rains you need to call it off" (Coach, focus group 1)

“It was raining and we couldn’t get the hall today. I’ll try take them again on Thursday instead.” –

(Coach, weekly reflection)

The annually changing school calendar also meant that the period required for testing and the intervention to be completed could not be accommodated within a single school term without being broken up by a school holiday. Several GPOs and teachers felt this broke the momentum of the intervention slightly as well as introducing added challenges around planning.

“I found it was disruptive because the way the weeks fell in the year like we were doing it and then you’d hit midterm, then Easter for two weeks and things like active schools were on and you were coming in and the school was away somewhere else” (Coach, focus group 1)

“It would be great if you could run it in 8/10 consecutive weeks” (Coach, focus group 2)

Discussion

The aim of this study was to evaluate the implementation process of the MWBW intervention (Exploratory trial) in the Irish primary school setting allowing the research team to assess the level and quality of the intervention's implementation. Objectives included, assessing whether the intervention was suitable for the Irish primary school environment, and to inform for future mainstream implementation through a comprehensive process evaluation. Previous research has highlighted that multicomponent interventions that are underpinned by relevant theoretical frameworks have been the most successful (Craig et al., 2008; Kriemler et al., 2011). The MWBW intervention contains several components, including family, community, active classroom, teacher training, and external provider components, all of which contain a strong focus on developing each component of PL.

The first of these components which significantly contributed to the implementation process is the external provider and community element. External providers are often used in Irish primary schools to support the delivery of PE. Ireland has seen an upsurge towards the use of external providers in the primary school PE landscape (Mangione et al., 2020), with the GAA being one of the largest providers. The GAA is Ireland's largest sporting organisation and promotes indigenous Gaelic games such as Gaelic football, hurling, camogie, handball, and rounders. Recent research has recommended increased communication and involvement with external providers in Ireland to change the existing dynamic in which the teacher views the external provider as the expert (Ní Chróinín and O'Brien, 2019). MWBW seeks to act on these recommendations and utilise the existing infrastructure of community-based coaches, potentially providing a new avenue of professional development in primary school PE. Considering that these community-based GAA coaches already spend significant time in schools and have contact with many of the children through the local GAA club also, this model of professional development and intervention has the potential to be a low-cost and sustainable model for the Irish context going forward. This relationship has the potential to be mutually beneficial for each party involved and could result in larger, community-wide benefits. In the case of the coaches, a number participating in the study adapted their nurse training programmes

to incorporate more of an FMS focus. Some transitioned to more of a PL ideology looking at personal development rather than a traditional winning and losing mentality which many sports have developed (Lundvall, 2015). This change has resulted in more parents helping and participating in the running of these sessions, linking to the community branch of this intervention. If children can develop a positive association between the GAA coach and fun PE classes, it is also plausible to consider they may wish to participate in such activities outside of the school environment. This is something which future research could explore, but it is clear that many children receive insufficient amounts of PE each week (Woods et al., 2018). One hour of PE each week is inadequate to develop PL and sufficiently active children. Therefore, school cannot be the only answer to PL and working with an external provider such as the GAA which is in every community nationally could be an enticement for children to uptake extra-curricular PA if they develop a positive association of it through their PE classes.

As previously alluded to, the importance of the coach's contribution to this study is not only in the delivering of the PE classes or in the community, but in the teacher training element of this intervention also. In Dublin, GPOs typically spend one school term or a 6-week block delivering PE in a school. They then have to move on to another batch of schools. In other counties this period may be even shorter or not as regular. It is then the responsibility of the class teacher to deliver PE for the remainder of the school year. This is challenging considering Irish primary school teachers are non-specialised and are expected to cover 12 curriculum subjects. Previous research has already shown that primary school teachers feel poorly prepared to teach effective PE classes (Fletcher and Mandigo, 2012). While the generalist teacher is unquestionably best placed to deliver curricular content to their students in a child centred and integrated manner (Coulter et al., 2009), it is difficult when insufficient time for PE is available on an overcrowded initial teacher training curriculum that would allow all primary teachers to develop the necessary confidence and competence to deliver good quality PE. Implementing new strategies to help improve generalist classroom teacher's confidence and competence in teaching PE is recommended as a feasible avenue for improving the quality of PE experiences at primary level (Fletcher and Mandigo, 2012). Findings from this study

would suggest this model of implementation may be an effective strategy to do so. Anecdotal evidence provided by their shadowing coaches point to a distinct increase in teacher confidence in delivering the PE classes as the weeks progressed. In their questionnaire, all teachers reported feeling confident in delivering the classes following the intervention with the majority of teachers finding it easy to implement.

Results highlight that the delivery of the intervention varies amongst teachers which is reflected in their self-reported fidelity scores (see Table 3.2). Nevertheless, students were still reported to have improved their FMS scores, even for teachers reporting a low level of fidelity. This relationship will be explored further in future research, but one would assume these findings could be due to the initial impact of the 1st lesson each week with the GPO. If proven to be true, although effective, it seems crucial to further assist teachers in continuing to improve their fidelity of implementation. It is also important to note that the fidelity of this implementation is not solely down to the teacher. The coaches played a large part in this. The role and impact of the coaches could have been even better understood if video recording of sessions or live observations would have been possible. To gain further insights into the fidelity and to improve future GPO training elements or teacher uptake, a more comprehensive examination would be beneficial for future research also.

Teacher self-reported fidelity score	Frequency
6	5
7	4
8	12
9	7
10	5
Average	8.09

Table 3.2: Self-reported teacher fidelity scores

Along with fidelity, this study also highlighted several challenges affecting the implementation of the intervention. The first of these was the school calendar. Including pre- and post-testing the intervention ideally requires a consecutive ten-week period to be completed. This

was interrupted by school holidays which coaches, and teachers felt broke the momentum and continuity of the classes. Future implementation should look to take part in the first half of the school year with longer school terms available allowing for complete intervention implementation. Another challenge faced to the intervention's delivery were facilities. All GPOs and teachers reported having adequate outdoor facilities to deliver classes, however, in the event of bad weather a number did not feel they had proper indoor PE facilities, with one school having none. This can result in classes being missed and the fidelity of a programmes implementation to be affected. This scenario is unfortunately not uncommon in Ireland. Fahey et al. (2005), found that two-thirds of primary school principals stated that the facilities they had for PE and sport in their schools were not at all adequate and many of their PE programmes were dependant on weather conditions arising from the lack of access to indoor facilities and equipment (Fahey, Delaney and Gannon, 2005).

Despite the challenges faced, this intervention yielded a substantial number of positive elements. The first of these being the apparent increases in children's FMS. This is a vitally important element of the intervention and one which future research will explore in detail to understand how the context, which varies so much from school to school, impacts the overall FMS increase. Evidence suggests that students enjoyed participating in the lessons throughout the intervention. Teachers and coaches also reported to have enjoyed delivering these lessons. This kind of enjoyment can lead to the development of more autonomous forms of motivation (Owen et al., 2014) and result in more permanent changes in health behaviour (Bardid et al., 2016). Stakeholder perceptions also suggests that this intervention fosters an inclusive environment for all students, including those with disabilities and special educational needs which also meets PE policy implementation, however further research is required to examine the specific effects on various cohorts. The intervention has shown to increase the engagement of students in PE lessons, particularly those who tend to "shy-away" from traditional PE. These students are those for whom increased participation could be most beneficial. These outcomes would appear to satisfy the calls from policy makers both in Ireland and internationally to increase the provision of fun physically active experiences in schools (The Department of Education and Skills, 2012; Sollars, 2020). Creating a programme which is easy to

implement for teachers is also welcome, and as a result, all teachers and principals participating in the study would recommend other teachers and schools to introduce MWBW into their classes and schools further highlighting its suitability for the Irish primary school environment.

Another positive outcome identified from the active classroom component of this intervention is an increase in classroom behaviour. This finding has also been corroborated by other studies suggesting that short active breaks throughout the day can result in reduced off-task behaviour during class time, benefitting both children and teacher (Ma, Mare and Gurd, 2014; Watson et al., 2019; Myrto et al., 2020). The final identified outcome was made from the family branch of this intervention, which was an increase in parental engagement. There is substantial evidence within the literature to suggest the inclusion of a community or family-based component to an intervention can result in more positive outcomes (De Meij et al., 2010; Murillo Pardo et al., 2013; Belton et al., 2014) and an increase in PA participation (van Sluijs and Kriemler 2016) which is consistent with this study's findings. The inclusion of FMS-based games by some GPOs to the local GAA club has helped to generate more inclusion and co-operation from parents and children further developing that community spirit the GAA holds.

Some of the findings from this study would suggest that there were key elements within these games which may have promoted this inclusion and the level of enjoyment that we have seen. These components were identified during the child focus groups and may offer some guidance or insight into future intervention game design/implementation. Firstly, children enjoyed games where they were able to experience some level of success. This level of success did not have to be winning a game, but personal success, such as being able to catch more or kick further than the previous lesson. Many of the games within the intervention gave the children a certain level of autonomy to choose how far away they stand for example when throwing and catching. This allows each child to both achieve a desired level of success, but also progress and develop at their own rate (Weiller and Richardson 1993).

Another desirable component was challenge. Dovetailing with success, children enjoyed games which provided them with a suitable challenge. Games which challenged them to improve

their skills, where they could set personal targets to improve week-to-week and which still afforded them enough success on a regular enough basis to keep them motivated to play more. The same findings are also reiterated by Morgan et al. (2013), who found that effective interventions incorporated a mastery climate approach focussing on success, challenge and autonomy (Morgan et al., 2013).

Along with challenge, understanding or seeing the value in a game was another key component found. Children identified games as helping to improve their skills or helping to make them healthier and so, they valued them. Seeing the value in something increases their engagement and provides the motivation they need (Chen 2013). Helping children to value PA through knowledge and understanding of its benefits also helps develop them into more physically literate young people (Whitehead, 2001).

Playing with other children was another key component identified from the research. Each child acknowledged that they would rather play games with other children than to play by themselves. Children enjoyed these games more for several reasons; being able to celebrate with others, to feeling stronger, having people to help them or just by making it more entertaining. Many of these social aspects of play are crucial to children of this age, the majority of which cannot be learned in the classroom (Smith and Parr 2007).

Another element children enjoyed was taking on a person or character in certain games. During the school years a child's imagination undergoes a revolutionary shift that profoundly impacts their development in many ways (Vygotsky 1990; Cody and Todaro-Franceschi 2001). Therefore, especially in a subject such as PE where children can afford to have that freedom, it should be encouraged. Allowing children the freedom to immerse themselves more in the game through their imagination can not only enhance their development, but hugely enhance the overall engagement and quality of the lesson from the teachers perspective also.

It is this freedom which feeds into the final identified component which is giving children the freedom or autonomy to shape how they play. Allowing children to play games in their own way,

use adaptive tactics and allowing them to individualise the way they play could lead to an increase in engagement from them (Perlman and Webster 2013; Sanders et al., 2016). This could be giving students the autonomy to develop their own rules, adapt playing spaces or create their own games within certain parameters provided by the teacher.

Conclusion

The aim of this study was to evaluate the implementation process of the MWBW intervention in an Irish primary school setting allowing the research team to assess the quality of the intervention's implementation. Objectives were also to assess whether the intervention is suitable for the Irish primary school environment and to inform for future mainstream implementation through a comprehensive process evaluation. Findings would suggest that the MWBW intervention is suited to the Irish primary school environment and its model of implementation can provide benefits to both participating children and teachers. Findings also show that the intervention has largely been delivered as intended, with children, coaches and teachers perceiving meaningful increases in participants' overall FMS. A finding which will be examined in detail in future research. A larger scale intervention and a controlled trial would allow future research to evaluate in depth how much each element of the intervention contributed to the increase in FMS, as well as allowing a rigorous evaluation of the intervention. Evidence from this study also suggests that in order to produce similar or improved results in future as part of a wider-scale roll-out of the intervention in schools, researchers should look to further assist teachers (possibly through added resources and/or training) to assist fidelity of implementation as well as looking at other factors that may influence intervention outcomes such as weather, seasonality, access to indoor facilities and environmental factors.

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Linking Chapter 3 to Chapter 4

Chapter 3 addressed a notable gap in the literature by investigating the implementation process of the MWBW intervention in the Irish primary school setting. These types of evaluations can provide in-depth and necessary information regarding the quality of an intervention's delivery. They can also provide an accurate interpretation of either positive or negative outcomes, allowing researchers to examine each intervention component, its delivery, and how effective they were (Craig et al., 2008). To the authors knowledge, this was the first study to complete such an evaluation following the implementation of a PL-based intervention in Irish primary schools.

The findings of this study concluded that the MWBW intervention was suitable for the Irish primary school environment, and it may be effective at enhancing the FMS proficiency of participating children. Findings from this study also found that the fidelity in which classroom teachers implemented the intervention was mixed across schools and between classes within schools, which may have impacted the overall FMS improvement of the participating children.

Chapter 4 will examine how effective the MWBW intervention was at improving children's FMS proficiency as well as examining the associated role of teacher fidelity on said improvement. Although previous iterations of the MWBW intervention have suggested that the intervention can significantly improve children's FMS proficiency (Behan, 2020), research has shown that the effectiveness of interventions can diminish as they are scaled up (Lane et al., 2021). This chapter will therefore examine whether the MWBW intervention can elicit similar levels of improvement to the original findings reported by Behan et al. (2020) when implemented on a larger scale.

**Chapter 4: Moving Well-Being Well:
Evaluating the efficacy, impact on gender,
and role of teacher fidelity of a physical
literacy-based intervention on Irish primary
school children**

Moving Well-Being Well: Evaluating the efficacy, impact on gender, and role of teacher fidelity of a physical literacy-based intervention on Irish primary school children

Abstract

Background: Competence in fundamental movement skills (FMS) are purported to be linked with increased PA participation. Research has highlighted a low level of proficiency in children's FMS, underlining the need for potentially suitable intervention strategies (such as MWBW) to be further evaluated. The aim of this study is to evaluate the effectiveness of the intervention in improving children's FMS in comparison to previous iterations. A secondary purpose was to determine whether the intervention had differential effects on gender and examine how fidelity of implementation affected the FMS improvement of the participating children.

Method: The intervention was delivered in 18 primary schools (n=925, mean 7.55 years). Data were gathered on 6 FMS and two balance skills pre- and post-intervention using the TGMD-3 and BOT-2. A two-way ANCOVA was conducted to examine the effectiveness of the intervention in improving the FMS proficiency of both males and females and to investigate the impact that teacher fidelity had on the overall FMS improvement whilst controlling for the differences in pre-test levels.

Results: Overall, the mean post-intervention FMS score was higher than pre-intervention, with a mean increase of 7.85 (23%). After adjusting for FMS scores pre-intervention, there was not a significant interaction effect ($p = .23$). Of the main effects, gender was not statistically significant ($p = .74$), however, teacher fidelity was statistically significant ($p = .000$).

Conclusions: Findings suggest the MWBW intervention had a significant impact in improving primary school children's FMS, and that the intervention produces similar positive outcomes for both males and females. Teacher fidelity when delivering the intervention components has a significant impact on the overall FMS increase, highlighting the need to provide further resources and support to teachers to maintain a high level of fidelity.

Key Words: Physical Literacy, Fundamental Movement Skills, Primary School, Intervention, Physical Education

Introduction

Research has sought to improve the physical activity (PA) levels of children and adolescents in an effort to promote health and wellbeing (Fletcher 2009). Evidence in this area suggests that developing a strong foundation of movement competence (MC) may be critical to promoting and sustaining positive trajectories of PA and health-related fitness (HRF) (Stodden et al., 2008; Robinson et al., 2015; Jaakkola et al., 2019). One important aspect of MC is the level of proficiency in fundamental movement skills (FMS) (Stodden et al., 2008). Fundamental movement skills are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018). These skills are typically classified into three areas: locomotor (running, jumping etc.), object manipulation (kicking, catching etc.) and stability skills (balance) (Gallahue, Ozmun and Goodway, 2012). Children are thought to have the potential to master most of these movement skills by six years of age (Goodway, Ozmun and Gallahue, 2019), with mastery of all FMS achievable by nine or ten years of age (Hardy et al., 2010). Consequently, a proficient level of FMS mastery is purported to be linked with increased PA participation (Barnett et al., 2009; Cliff et al., 2009; Lubans et al., 2010; Logan et al., 2015).

Mastery of a skill is attained, when a maximum score for a skill is achieved (i.e. all skill criteria are met for both trials) (Behan et al., 2019; Kelly et al., 2021). Thus, near-mastery is defined as when all but one skill criteria was performed over the two trials (Behan et al., 2019; Kelly et al., 2021). Although children have the capabilities to master most FMS at a young age, research has shown that largely this is not happening (Van Beurden et al., 2002; Erwin and Castelli, 2008; Cliff et al., 2012; O'Brien, Belton and Issartel, 2016). Behan et al. (2019), highlighted a lack of proficiency across all FMS components in primary school children, with only 52.8% achieving mastery/near-mastery (MNM) in locomotor, 54.8% achieving MNM in object manipulation skills, and 60.6% achieving MNM in balance skills (Behan et al., 2019). These figures are cause for concern, as children who are below the expected levels of FMS for their age may have increased difficulty in developing more complex, sports specific skills as they get older (Goodway, Ozmun and Gallahue, 2019), resulting in a decrease in participation in PA or sport (O'Brien, Belton and Issartel, 2016;

Peers et al., 2020), and an increase in sedentary behaviours (Cairney et al., 2006). This concern was validated by the most recent iteration of the Children's Sport Participation and Physical Activity (CSPPA) study, which found that the number of children meeting the recommended guidelines for PA was steadily decreasing (Woods et al., 2018). This study also highlighted that a significant gender imbalance exists, with fewer females (9%) meeting the PA guidelines than males (17%) (Woods et al., 2018).

The gender imbalance in PA participation may be partly attributed to differences in FMS proficiency (Hardy et al., 2013). Recent findings from studies assessing gender differences in FMS proficiency report males scoring significantly higher in overall FMS than their female counterparts (Barnett et al., 2009; O'Brien, Belton and Issartel, 2016; Behan et al., 2019). A significant contributor to this gender disparity in overall FMS appears to be object manipulation skills, with research consistently showing that males are more proficient than females in these skills (Van Beurden et al., 2002; Okely and Booth, 2004; Barnett et al., 2009; Bardid et al., 2016; Behan et al., 2019; Kelly et al., 2019). Gender differences in locomotor skills are less definitive, with some studies reporting that there are no gender differences in locomotor skill proficiency level (Barnett et al., 2010), while other studies report females as more proficient (Hardy et al., 2010; Cliff et al., 2012; Behan et al., 2019). The underlying reason for this gender disparity in FMS proficiency may be attributed to males generally favouring object manipulation based activities (e.g. football or rugby), whilst females generally prefer locomotor based activities (e.g. dance or gymnastics) (Van Beurden et al., 2002).

A common misconception surrounding FMS is that they are developed naturally through free play (Stodden et al., 2008). Whilst children may naturally develop a rudimentary form of fundamental movement pattern through free play (Lubans et al., 2010), a more mature form of FMS proficiency is likely to be achieved with appropriate practice, encouragement, feedback and instruction (Lubans et al., 2010) in both educational and free play settings (Clark 2007; Haywood and Getchell 2019). The school environment has been highlighted as a key environment in which to improve these skills (Okely and Booth, 2004; Morgan et al., 2013). The Irish primary school PE curriculum cites FMS development as a core element, stating that a "*child's holistic development,*

stressing personal and social development, physical growth and motor development” should be a core focus while teaching primary school PE (Department of Education and Skills 1999, p.9). Evidence would suggest however, that schools are falling short of this target, with recent studies indicating that children are entering second level schools lacking in basic FMS proficiency (O’ Brien, Belton and Issartel, 2016; Britton et al., 2020). The reason for this remains unclear. It could be that many teachers feel poorly prepared to develop children’s FMS within their PE classes, and that many lack the confidence and competence to do so (Fletcher and Mandigo 2012). It could also be due to a lack of general consideration for the subject, such as the lack of time, resources, facilities or assessment afforded to it (Fahey, Delaney and Gannon, 2005; Woods et al., 2018). In fact, less than a decade ago, Ireland, along with Malta and Norway were the only three countries in Europe who did not have a formal PE assessment in primary school (Eurydice, 2012). Since then, there is little evidence to suggest that assessment strategies are widely used in primary school PE in Ireland to assist teachers in enhancing children’s FMS proficiency (Chróinín and Cosgrave, 2013; Macken, Macphail and Calderon, 2020).

The multitude of barriers mentioned, places a significant burden on primary school teachers, who remain arguably the key pillar in developing young children’s FMS (Coulter et al., 2009; Fletcher and Mandigo 2012). Despite calls for policymakers to either introduce or increase the number of specialist PE teachers (Marshall and Hardman, 2000), it is also argued that *‘the generalist teacher is best placed to teach the child-centred, integrated curriculum in primary schools, and hence is best placed to teach PE as one element of that curriculum’* (Coulter et al., 2009). Considering this, it is imperative that generalist teachers garner more support in their delivery of both PE and school-based intervention programmes, in order to achieve higher levels of fidelity, and thus, greater overall impact. The value of having a high level of teacher fidelity is clearly outlined by Brian et al. (2017), who identified that every 1% increase in teacher fidelity was predicted to increase post-test FMS scores by .13 when using the TGMD-2 (Brian et al., 2017).

The elements presented above underlines the need for suitable intervention strategies to improve children’s FMS proficiency within the primary school environment. Evidence would also

suggest that in order to maximise the uptake, enjoyment and outcome, any school-based intervention should consist of more generalist FMS-based games as opposed to sports specific ones. Moving Well-Being Well (MWBW) is an intervention model which has demonstrated positive outcomes (Behan et al., 2018; Behan, 2020). During Phase I implementation of the intervention, involving 417 children aged 7-8 years (52% female, mean age 7.6 ± 0.66 years), the intervention group significantly increased FMS proficiency from baseline (74.43), to post-intervention (86.36) and retention (91.98), in comparison to the control group (baseline – 77.67, post-intervention – 75.47, retention – 81.93) (Behan et al., 2018). In line with the MRC framework, the next phase of evaluation should provide a deeper understanding of the intervention's effectiveness (Moore et al., 2015). As part of this phase, research examining the implementation process of the intervention suggests that MWBW is suitable for the Irish primary school environment and can provide benefits to both students and teachers (Gavigan et al., 2021). The aim of this study is to evaluate to what extent this iteration of the intervention improves children's FMS in comparison to the previous iteration (as interventions typically diminish in impact as they are scaled up (Lane et al., (2021))). A secondary purpose was to determine whether the intervention had differential effects on gender and examine how fidelity of implementation affected the FMS improvement of the participating children.

Materials and Methods

Ethical approval for this study was granted by the Dublin City University Research Ethics Committee (REC/20/00).

The Moving Well-Being Well Intervention

The MWBW intervention is underpinned by both the theory of constraints (TOC) (Newell, 1986) and self-determination theory (SDT) (Deci and Ryan, 2010), and was designed using the comprehensive framework outlined by the behaviour change wheel (Michie, Stralen and West, 2011). Moving Well-Being Well is a multi-component intervention that includes family, community, active classroom, teacher training, and external provider components. Multicomponent interventions that are underpinned by relevant theoretical frameworks have proven the most successful in previous research (Craig et al., 2008; Kriemler et al., 2011).

The intervention was designed to be delivered over an eight-week period through three main elements: (i) two 30-minute FMS-based PE classes per week, (ii) 5–10-minute active classroom activities performed at least once daily, (iii) home activity sheets completed once per week. The lesson content of the PE classes was derived from the Move Well, Move Often resource, a programme developed by the Professional Development Service for Teachers ([PDST](#)) seeking to develop PL through FMS, and one which is aligned with the Irish primary school curriculum (Department of Education and Skills, 1999). The skill content of these lessons focused on just three locomotor (Hop, Skip & Jump) and three object control skills (Kick, Catch & Throw) based on the findings of Behan et al. (2019) (Behan et al., 2019). The content for the active classroom and home activity elements were developed by the research team to supplement the content developed in the PE lessons each week.

The intervention was co-delivered by an expert coach and class teacher. Prior to the commencement of the intervention, coaches completed the MWBW Continuous Professional Development (CPD) module (see below). The coaches were responsible for delivering the first PE lesson each week for the first six weeks. Whilst delivering these lessons, the coaches were also

responsible for upskilling the class teachers who shadowed them, on how to deliver the lessons. The class teachers were then responsible for delivering the same lesson as the one that they shadowed, to the class, before the coach returned the following week to deliver the next lesson. Following the first six weeks, the class teacher was responsible for delivering both PE lessons for the final two weeks with the coach now shadowing and offering a supportive role. This process acted as an onsite upskilling for class teachers aspiring to develop their confidence and ability to deliver fun, active, FMS-based lessons. Class teachers were also responsible for the delivery of the active classroom components. These were delivered at least once each day through PowerPoint and could be completed at the teacher's discretion. The homework activity worksheets were sent home with the children once each week to be completed with someone at home.

CPD training for coaches and school recruitment

Eighteen Games Promotion Officers (coaches) were invited to participate in the study by Dublin GAA. The selected coaches attended a training module specifically designed for, and delivered to them, by the three leading authors along with two other experts on the project. Training consisted of two full contact days in January 2019 before schools were recruited, one full contact day mid-intervention and one full contact day post-intervention. Total training time amounted to 24 hours with a mixture of theoretical and practical elements. As part of the study, coaches aided one another with data collection. Thus, coaches were divided into four regional groups (with four or five coaches in each group) based on school location. To ensure good quality data was collected, coaches had to undergo a consistency assessment, in which they had to achieve a 95% inter-observer agreement on a data set of fundamental movement skills that were pre-coded by one of the researchers on the team.

Following pre-intervention training days, coaches contacted principals within schools that they coached in to participate in the study. On agreement from principals one first and one second class (age range 6 – 10 years, mean 7.55) within each school was nominated to participate in the intervention. Parental consent and participant assent were obtained (age-appropriate child assent

forms were supplied to participants). In total 18 schools were approached to participate in the study, all accepted. Irish primary schools in areas classed as “socioeconomically disadvantaged” qualify for the Delivery of Equality and Opportunity in Schools (DEIS) programme (The Department of Education and Science, 2005). In Ireland, 19.7% of schools fall into this category which is consistent with the demographic of this study.

Data Collection

Fundamental movement skill data were collected from 925 first- and second-class children (47% female, age range 6 – 10 years, mean 7.55). Data were collected by the lead author and a group of coaches (depending on the region) <1 week pre- and post-intervention. Hop, skip, horizontal jump, kick, catch and throw were assessed using the Test of Gross Motor Development - 3rd Edition (TGMD-3). The TGMD has been widely used in other studies reporting strong reliability, validity and interrater reliability (Wagner, Webster and Ulrich, 2015; Wagner, Kipling Webster and Ulrich, 2017; Webster and Ulrich, 2017). The step and beam balance skills were assessed using a subset of the Bruininks-Oseretsky Test of Motor proficiency 2 (BOT-2) Short form (Bruininks, Bruininks and Case, 2013) as the TGMD does not contain a balance component, an important component of FMS (Rudd et al., 2015). Much like the TGMD-3, the BOT-2 has been widely used in research and has been shown to demonstrate strong reliability (Wilson et al., 2013) and validity (Fransen et al., 2014).

Self-reported teacher fidelity was recorded via questionnaire (using a tablet supplied by the research team) during post-intervention testing. Teachers self-reported their fidelity of implementation using a 0-10 scale, a measure commonly used for fidelity in school-based research (Domitrovich et al., 2008). Although methods such as teacher observation may offer a more robust measure, self-reported measures have been used primarily due to their practicality (Ransford et al. (2009). Despite some literature suggesting that this measure has the potential to have a positivity bias among teachers (Adams et al. 1999), research by Koziol et al., (1986) found that teacher (n=9) self-report scores correlated highly to expert observations (considerable agreement: 0.74, exact agreement

0.72, kappa: 016). Further research by Khoury et al., (2019) (n=736) found a moderate-strong correlation (0.61 - 0.77) between self-reported teacher fidelity and that of an expertly trained coach when delivering a school-wide intervention, with the findings suggesting self-reported measures of fidelity are a potentially viable tool that may actually increase in accuracy over time.

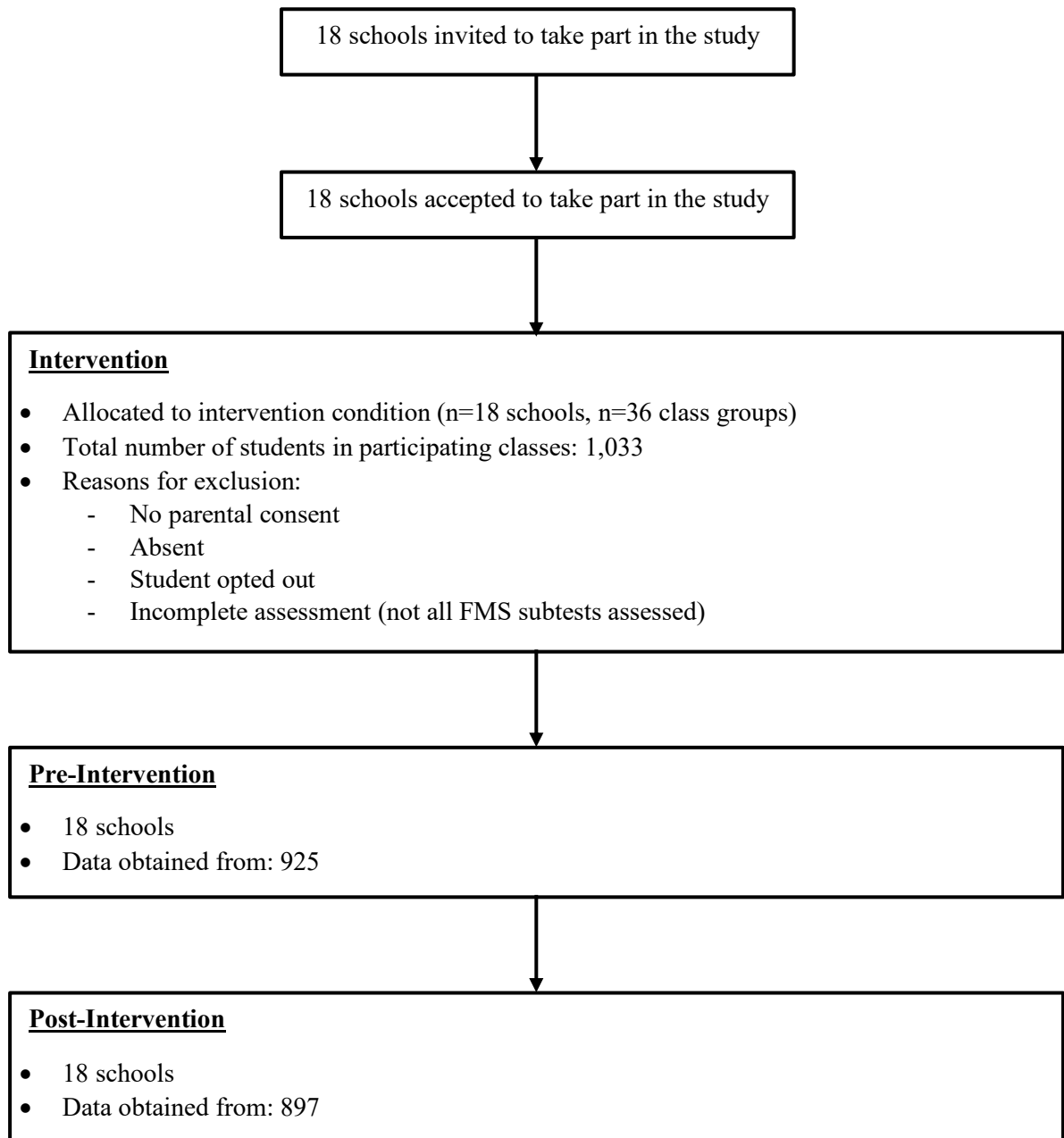


Figure 4.1: Flow chart of participants through the study

Data Analysis

Data were analysed using SPSS version 27 for Mac. Descriptive statistics and frequencies were calculated for FMS pre- and post-intervention, teacher fidelity, and gender. To allow the research team to understand the teacher's delivery and development over the course of the intervention, teachers were grouped based on their self-reported fidelity scores. A two-way ANCOVA was conducted to examine the effectiveness of the intervention in improving the FMS proficiency of both males and females and to investigate the impact that teacher fidelity had on the overall FMS improvement whilst controlling for the differences in pre-test levels.

Assumptions

There were fourteen outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box; and six outliers, as assessed by examination of studentized residuals for values greater than ± 3 . Outliers were assessed for data entry and measurement errors and deemed genuinely unusual values (Field, 2013); none were removed from the analysis. While the Shapiro-Wilk test indicated a deviation from a normal distribution ($p < .05$), the Normal Q-Q plots suggested these deviations were relatively minor. There was not homogeneity of variances for pre-intervention ($p < .05$), but there was for post-intervention ($p = .95$), as assessed by Levene's test of homogeneity of variance ($p > .005$). There was homogeneity of covariances, as assessed by Box's test of equality of covariance matrices ($p = .027$).

Results

A two-way ANCOVA was conducted to examine the effectiveness of the intervention in improving the FMS proficiency of both males and females and to investigate the impact that teacher fidelity had on the overall FMS improvement whilst controlling for the differences in pre-test levels. The independent variables were teacher fidelity and gender. The dependant variable was the children's FMS proficiency following the intervention. FMS proficiency level pre-intervention was used as a covariate to control for the differences in pre-test levels.

After adjusting for FMS scores pre-intervention, there was not a significant interaction effect; $F(4, 636) = 1.42, p = .23$, with a small effect size (partial eta squared = .009). Of the main effects, gender was not statistically significant, $F(1, 636) = .11, p = .74$, however, teacher fidelity was statistically significant, $F(4, 636) = 6.27, p = .000$, with a moderate effect size (partial eta squared = .038). These results suggest that the intervention has similar effects on both males and females. They also suggest that teacher fidelity has a significant impact on the overall FMS improvement of the children, and this improvement was not due to the FMS scores pre-intervention.

							Percentiles		
	n	M	Median	SD	Min	Max	25	50	75
Pre- Intervention	897	34.45	35	6.766	12	52	30	35	39
Post- Intervention	897	42.29	43	5.689	21	54	39	43	47

Table 4.1: Descriptive Statistics for Pre- and Post-Intervention FMS scores

Intervention Fidelity

FMS	Pre-Intervention					Post-Intervention				
	6	7	8	9	10	6	7	8	9	10
<i>M</i>	36.73	37.00	31.63	37.94	33.40	41.49	42.91	41.22	43.47	41.43
<i>(CI)</i>	[35.3 - 38.2]	[35.8 - 38.2]	[30.7 - 32.5]	[36.8 - 39.1]	[32.1 - 34.7]	[39.9 - 42.2]	[41.6 - 43.7]	[40.3 - 41.9]	[41.9 - 43.9]	[40.4 - 42.5]
<i>SD</i>	6.806	5.653	6.449	6.422	6.531	5.404	5.053	5.674	5.424	5.247

Table 4.2: Means and Standard Error for Pre- and Post-Intervention FMS scores between Teacher Fidelity Groups

	Males			Females		
	n	M	SD	n	M	SD
Pre-intervention	490	33.89	7.315	435	35.05	6.065
Post-intervention	479	42.33	5.893	418	42.23	5.439

Table 4.3: Means and Standard Deviations for Pre- and Post-Intervention FMS scores for each Gender

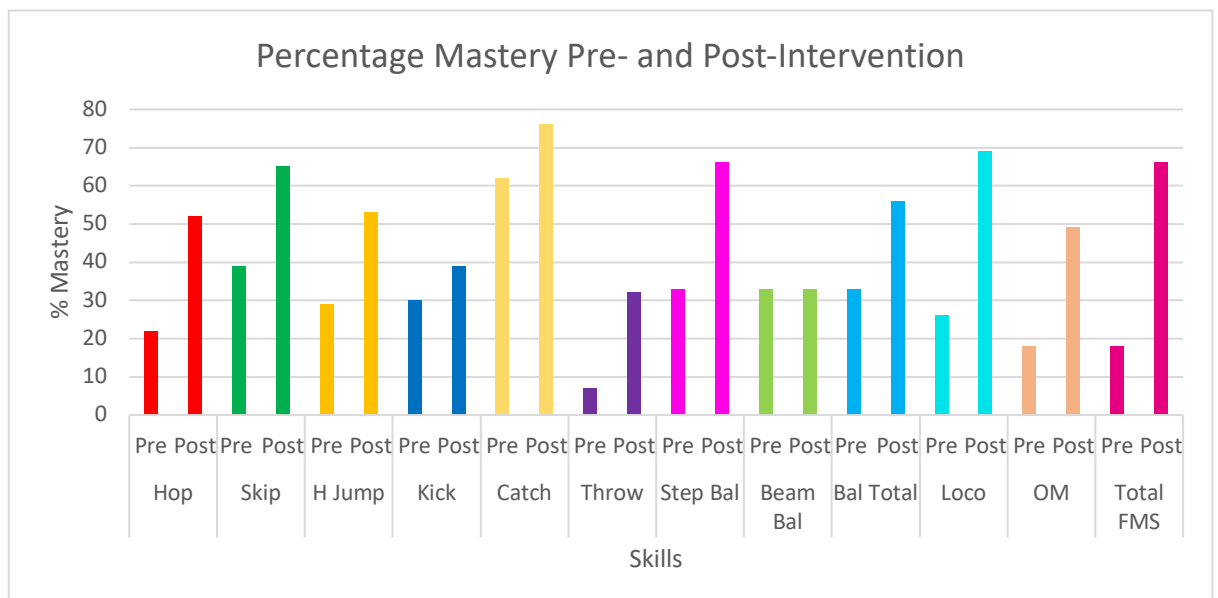


Figure 4.2: Percentage of children achieving Mastery pre- and post-intervention

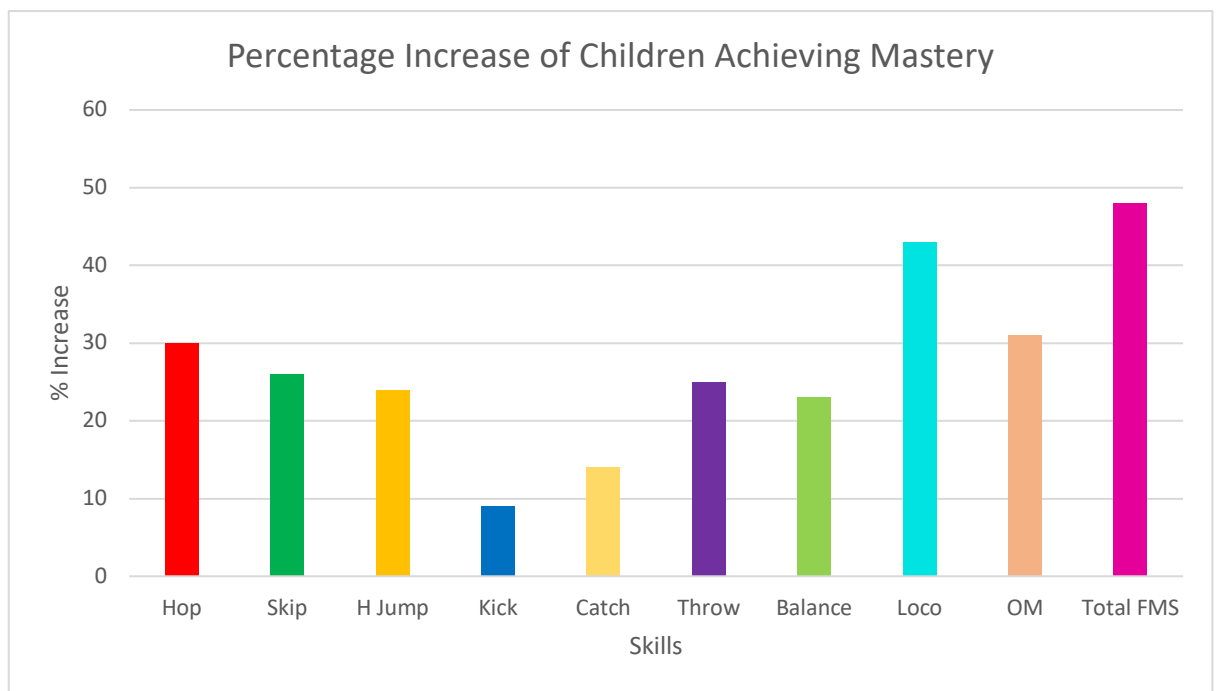


Figure 4.3: Percentage increase of children achieving Mastery per skill

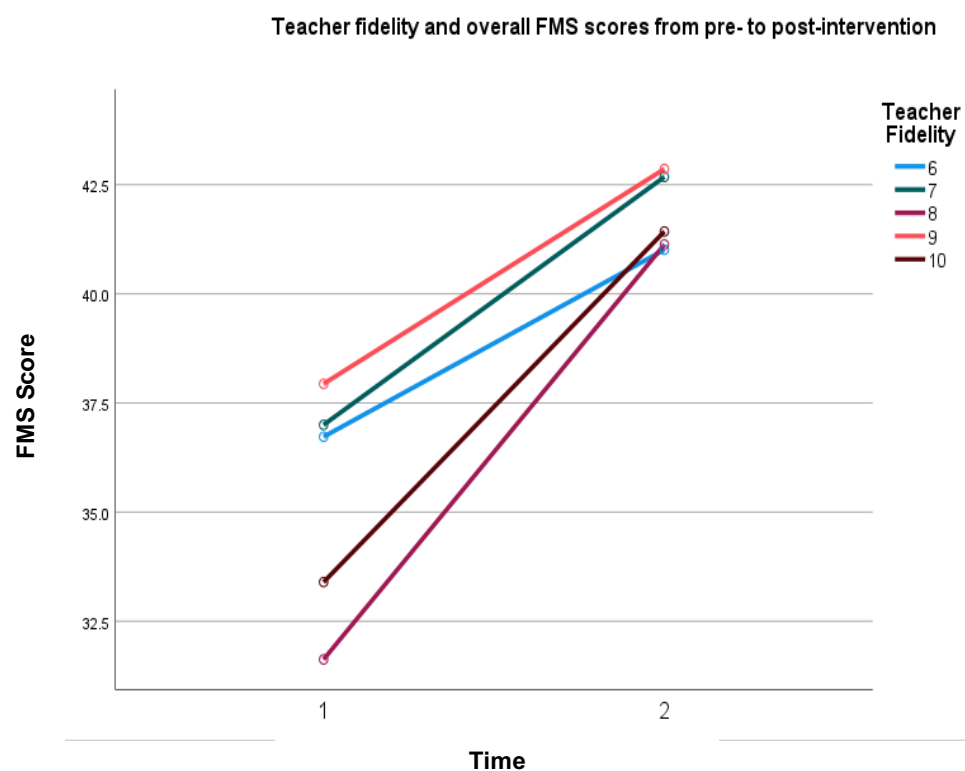


Figure 4.4: The impact of teacher fidelity on overall FMS scores from pre- to post-intervention

Discussion

The findings presented in this study suggest that the MWBW intervention is an effective programme at improving the FMS proficiency of 1st and 2nd class primary school children. Findings also indicate that the intervention does not have a significant effect on gender, however, fidelity of implementation by the teachers has a significant impact on the overall FMS improvement of the participating children.

Previous research suggests that children have the potential to master most FMS by six years of age (Gallahue and Ozmun, 2006), with mastery of all FMS achievable by nine or ten years of age (Hardy et al., 2010). Considering this, it would be expected that a significant number of children within this sample would be achieving mastery prior to the intervention. Yet, the results of baseline testing at pre-intervention indicate that the FMS proficiency of the children in this sample were below the expected proficiency levels for children of this age (See Table 4.1). Moreover, Figure 4.2 shows that the percentage of children achieving mastery in all skills was low, a finding that aligns with the low levels of FMS proficiency reported in other studies both nationally (Behan et al., 2019; Belton et al., 2019; Kelly et al., 2019) and internationally (Van Beurden et al., 2002; Erwin and Castelli, 2008; Cliff et al., 2012; Mukherjee, Ting Jamie and Fong, 2017), and provides further evidence to support the call for policy makers to increase the provision of fun physically active experiences in schools (The Department of Education and Skills, 2012; Sollars, 2020).

To date, the MWBW intervention has shown to be a suitable programme for the Irish primary school environment (Gavigan et al., 2021), as well as being effective in improving children's FMS proficiency during Phase I of its implementation (16% increase) (Behan, 2020). Despite the positive outcomes displayed by this programme, research has suggested that as interventions are scaled up, they regularly diminish in impact (Lane et al., 2021), in fact, typically by 50-60% (Yohros et al., 2019). The results of this study demonstrated that the MWBW intervention substantially increased the overall FMS proficiency of children from pre- to post-intervention, with a mean difference of 7.8 (23% increase), significantly greater than the 16% increase found in Phase I of the interventions implementation. This finding comes in contrast to that of previous research and perhaps provides

evidence supporting the changes made to the intervention following Phase I of the interventions implementation (i.e. the number of games in each weeks PE lesson were reduced from four to three – reducing transition time and having more time spent in games, and classroom activities were revamped to greater supplement each weeks PE lesson and be more child friendly).

Moreover, prior to the intervention, only 18% of children were achieving mastery in their overall FMS (See Figure 4.2). Following the intervention, 65% of children were achieving mastery in their overall FMS (See Figure 4.3). It is well documented that at present, many children receive insufficient time for PE each week to develop their FMS (Woods et al. 2018), many schools lack adequate PE facilities (Fahey, Delaney and Gannon, 2005), there are a lack of meaningful assessment for learning strategies in PE (Chan, Ha and Ng, 2016; Ní Chrónín and Cosgrave, 2013), and many primary school teachers lack the training (Marshall and Hardman, 2000), confidence and competence (Fletcher and Mandigo, 2012) to deliver effective PE that facilitates children developing their FMS to a desired level of proficiency. Yet, the findings from this study demonstrate that when provided with the right support, guidance and programme, generalists classroom teachers can significantly improve the FMS proficiency of children.

Previous research has identified that females do not develop FMS at the same rate as males, who are frequently reported as superior in object manipulation skills (Van Beurden et al., 2002; Okely and Booth, 2004; Barnett et al., 2010; Bardid et al., 2016; Behan et al., 2019; Kelly et al., 2019), and overall FMS proficiency (Cantell, Crawford and Tish Doyle-Baker, 2008; Barnett et al., 2009; Lopes et al., 2011; Breslin et al., 2012; O' Brien, Belton and Issartel, 2015). Failure to achieve a sufficient level of FMS proficiency in childhood has contributed to a much steeper decline in PA participation in females during early adolescence (Woods et al., 2010, 2018; Bradley et al., 2011), resulting in females being identified as a high priority population for intervention (Biddle, Braithwaite and Pearson, 2014). The findings in this study demonstrate that the intervention had similar effects on both males and females, with males exhibiting a mean difference of 8.4 (24.9% increase) in overall FMS score between pre- and post-intervention, whilst females displayed a mean difference of 7.2 (20.5% increase) in overall FMS score between pre- and post-intervention (Table

4.2). This similar level of improvement between gender groups may support the theory that non-sports specific, FMS-based games may provide a suitable template for primary school PE programmes going forward in order to help children achieve a desirable level of FMS proficiency.

In addition to having a suitable programme, the fidelity to which it is implemented plays a critical role in the outcomes observed. At present, there is a dearth of literature that quantifies the role that teacher fidelity contributes to an interventions' outcomes. A significant finding in this study was that teacher fidelity had a significant impact on the overall FMS improvement of the children, accounting for 38% of the variance (See Table 4.2 and Figure 4.4). The findings of this study further emphasise the importance that sufficient supports are put in place in school-based interventions to ensure that teachers have the necessary supports to deliver a programme as it is intended, and is a factor that future programmes must strongly consider. Hence, future iterations of the MWBW intervention should further consult with teachers to establish suitable and individualised strategies and routines to aid them in the successful delivery of the programme.

Limitations

Although the methods used within this study allowed the research team to successfully achieve the aim of this study, there are a number of limitations which would have enhanced the findings of the work further. Firstly, despite self-reported teacher fidelity being a common measure used in school-based research (Domitrovich et al., 2008), and the reasons for this choice of measure being discussed previously, it must still be acknowledged that a more robust measure such as observation by a member of the research team or peer observation (by coach) would have provided a clearer picture of the interventions fidelity. In addition, the fidelity of implementation by the coach could also have been measured, given the coach was responsible for the training of the teachers. Future research should explore this.

Another limitation to this study is the lack of a control group. Although the aim of this study was to compare its effectiveness to the previous iteration of the intervention in Phase I, the absence of a control group constitutes as a limitation to this study's findings. Thus, as the intervention is scaled up further, future iterations should include a control group, to ensure that the intervention is still developing the children's FMS proficiency at a consistent rate to previous iterations, as well as allowing for comparisons to their regular PE lessons.

Conclusion

This study highlights the low levels of FMS proficiency in primary school children, with participants mirroring similarly poor levels to those previously reported in the literature (Behan et al., 2019; Kelly et al., 2019). Such findings are worrying considering that FMS proficiency is so closely linked with future PA participation (Barnett et al., 2009; Cliff et al., 2009; Logan et al., 2015), emphasising the need for FMS development to be made a priority in primary schools. The findings presented in this study support the notion that the MWBW intervention could potentially be an effective strategy to improve primary school children's FMS proficiency. Findings also indicate that the intervention can produce similarly positive outcomes for both males and females, who have been identified as a high priority population for intervention (Biddle, Braithwaite and Pearson, 2014). Additionally, this study demonstrates that teacher fidelity when delivering the intervention components has a significant impact on the overall outcome, highlighting the need to gather further data and provide further resources to teachers to maintain a high level of fidelity. Considering the positive outcomes identified in this iteration of the MWBW intervention study, a larger randomised controlled trial is the logical next step to ascertain its efficacy and scalability to a wider cohort of children.

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Linking Chapters 4 to 5

Chapters 3 and 4 examined the suitability and effectiveness of the MWBW intervention in Irish primary schools. The results of these studies suggest that the MWBW intervention may satisfy calls from policy makers to increase the number of FMS-based programmes and fun physically active experiences in Irish schools (Sollars, 2020; The Department of Education and Skills, 2012; Woods et al., 2018).

Despite the fact that the school setting is considered the optimum setting to develop FMS (McKenzie and Lounsbery 2009), many schools do not afford enough time to PE or PA in order to make a significant enough impact (Woods et al., 2018), nor do many teachers possess the necessary confidence and competence to deliver a high-quality PE programme (Ní Chróinín 2017). Hence, this change should be the collective goal of academics and practitioners from multiple environments. At present however, there are a number of limitations to this collective strategy.

Firstly, until recently, academics and practitioners from different environments (i.e. education and clinical) have focussed on developing different constructs of MC (Basman, 2019). For example, teachers have mainly tried to develop children's FMS, whereas athletic therapists have focussed on developing functional movement skills in children. Only recently has research emerged highlighting the interconnected relationship between these two skill constructs, and their shared contribution to a more holistic view of a child's MC (Lester et al., 2017; O'Brien et al., 2021; Wu, Eungpinichpong, Ruan, Zhang, & Dong, 2021). Consequently, no assessment tool exists that examines both fundamental and functional movement skills together. Secondly, although there is a plethora of existing tools that examine both constructs separately (Hulteen et al., 2020), it is widely reported in the literature that these tools have significant limitations (Bardid, Vannozzi, Logan, Hardy, & Barnett, 2019; Eddy et al., 2020; Klingberg et al., 2019; Mauntel et al., 2017; Moran, Schneiders, Major, & Sullivan, 2016).

Chapter 5 of this thesis looks to address the gap in the literature, by designing a new tool to assess the fundamental and functional movement skills of children aged 8-12. A number of studies

have cited numerous limitations to the use of existing tools in practical settings. This study seeks to address these limitations by working with expert academics and practitioners from education, sport, and clinical settings to reach consensus on the key design features of the tool using a method of research known as a Delphi method.

Chapter 5: Design of a new movement competence assessment for children aged 8- 12: A Delphi poll study

Design of a new movement competence assessment for children aged 8-12: A Delphi poll study

Abstract

Assessing children's movement competence (MC) offers numerous benefits for academics, practitioners, clinicians and children, allowing individuals to meet children's developmental needs and improve their MC. Yet, there is concern that currently available assessment tools only provide a single plane (fundamental movement skills) perspective of a child's MC. The aim of this study was to elicit the expert opinion of a mixture of academics and practitioners from a variety of fields (research, education, sport, physiotherapy, athletic therapy) to design a tool to measure both the fundamental and functional movement skills of children aged 8-12. A three round Delphi poll with an international panel of 17 academics (n=8) and practitioners (n=9) was conducted. Consensus was that the assessment should assess (1) object manipulation, (2) locomotor, and (3) stability MC and the assessment layout should be dynamic, incorporating a hybrid model of stations and a circuit. Expert consensus was that most skills were to be performed using the dominant and non-dominant side, with object manipulation skills assessed using process and product criteria. Consensus was also that the assessment should have varied "layers" of marking criteria to cater for varying assessor expertise and have a series of "add-on" elements to provide a more detailed evaluation, should it be needed. These findings present the foundation and content validity for an assessment which takes a dualistic view of children's movement skill, that could be used across several environments (schools, sports clubs, clinical settings etc.) and could be suitable for use with a large group of children.

Keywords: movement competence, physical literacy, fundamental movement skills, functional movement skills, movement assessment, injury screening

Introduction

Movement Competence (MC) is defined as the development of skill proficiency to ensure successful performance in a range of physical activities (Bisi et al., 2017). Developing appropriate levels of MC is critical in developing physical literacy (PL), mediating physical activity (PA) and other positive health trajectories across the lifespan (Robinson et al., 2015; Stodden et al., 2008). Physical literacy can be defined as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life” (Whitehead, 2013: p.29). In children and adolescents, PL research has primarily focused on the development and assessment of fundamental movement skills (FMS) (Barnett et al., 2016). FMS are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018). FMS are typically classified into three areas: locomotor (running, jumping etc.), object control (also termed object manipulation such as kicking, catching etc.), and stability skills (balance) (Gallahue et al., 2012). Children are thought to have the potential to master most of these movement skills by six or seven years of age (Gallahue and Ozmun, 2006), after which they enter a transition phase whereby they combine these FMS into more complex skills (Gimenez et al., 2012). Children refine and combine FMS as they acquire more advanced or specialised movement skills, that are used in a range of sports and/or PA (Clark and Metcalfe, 2002), with increased MC proficiency leading to increased PA participation in children (Barnett et al., 2009; Cliff et al., 2009; Logan et al., 2015). Research also highlights that a lack of MC proficiency can lead to reduced levels of PA participation (Jaakkola et al., 2016). Such findings are cause for concern as inadequate levels of PA are reported to contribute to an estimated 6–10% of the major non-communicable diseases of coronary heart disease, type 2 diabetes, breast and colon cancers worldwide (Lee et al., 2012).

Functional movement competence relates to the body’s use of multi-planar and multi-joint movements, specifically those activating the core musculature region (e.g. bodyweight squat, lunge, push/pull exercises) (Abraham et al., 2015). Similar to FMS, functional movement has been shown to have a positive relationship with PA as well as having a significant negative correlation with

weight status (body mass index) in children (Duncan and Stanley, 2012; Duncan, Stanley and Wright, 2013), however, it must be acknowledged that within the literature, only a few studies have examined this relationship, all with varied sample sizes, highlighting the need for further research in this area. There is also concern that low levels of functional movement competence in children have the potential to lead to orthopaedic conditions (e.g. arthritis, low back pain, osteoporosis) in later life, resulting in difficulty completing tasks of daily living, in turn, decreasing an individual's quality of life (Duncan, Stanley and Wright, 2013). Cliff et al. (2012) previously compared the mastery of 12 FMS and skill components between a treatment-seeking sample of overweight/obese children and a reference sample from the United States. They found that, as well as the prevalence of mastery being lower across all FMS in the sample of overweight/obese children, many of the movement patterns in which this sample exhibited the greatest deficiency in mastery were functional movement components (e.g. difficulties in bending the knees to lower the body), suggesting that a proficient level of functional movement is required in order for children to perform FMS well (Cliff et al., 2012).

Consequently, the meaning of MC is broadening to reflect the diversity of movement skills utilised in all PA pursuits (O'Brien et al., 2021), and research is emerging that examines the relationship between both fundamental and functional movement skills (Lester et al., 2017; O'Brien et al., 2021). This broader view of MC is warranted, considering that both fundamental and functional movement competence has previously been used to define MC (Basman, 2019), and viewing a child's development through one lens presents a single plane perspective of MC, whereas a dualistic mode of assessment (examining functional and fundamental movement skills together) has the potential to provide a richer, more extensive source of a child's MC status to inform subsequent intervention. It is clear that the assessment of children's MC is beneficial, and can allow individuals who work with children to better meet children's developmental needs (Platvoet et al., 2018), identify children with low MC and allow for early intervention (Lopes et al., 2021).

There is a strong concern that currently available assessment tools only provide a single plane perspective of a child's MC and do not consider the risk of injury in their protocols (Miller et al.,

2020). For example, a disadvantage of product-based (e.g. Körperkoordinationstest für Kinder (KTK)) (Kiphard and Schilling, 2007; Schilling and Kiphard, 1974) MC assessments is the inability to identify movement or technique errors and high-risk movements, such as knee valgus (when the knee collapses inwards, a risk factor in knee injuries), associated with musculoskeletal injury (Hulteen, True and Pfeiffer, 2020; Miller et al., 2020). Opposed to product-based assessments, process-based assessments describe the quality of the movement patterns (Logan et al., 2017). Despite capturing movement quality, few process-based tools consider functional movement patterns or injury (Miller et al., 2020). This is potentially due to the range of specific purposes such tools are designed for, or indeed the environment in which they are designed for (i.e. physical education, athletic therapy etc.). Regardless, failure to consider injury in current MC assessments can result in children adopting compensatory movement patterns which can occur when limitations in mobility, stability, motor control or functional movement patterns prevent proper motion from occurring which may result in an increased risk of injury over time (Coker and Herrick, 2020). These compensatory movements may inhibit FMS mastery and negatively influence perceived MC impeding PL development (Coker and Herrick, 2020).

The strength of association between process and product-based assessments appears to vary depending upon the skill and the assessment, suggesting that each mode can provide unique information relating to a child's MC. Several MC assessments (both fundamental and functional movement based) are currently available and designed for a range of environments (schools, sports clubs, clinical settings etc.) (Bardid et al., 2019). Each of these tools have been designed for a range of purposes (e.g. mass surveillance, talent identification, evaluation of programmes, injury prevention etc.) and have varied functions (Bardid et al., 2019), making it increasingly difficult for users to identify which assessment is best suited for them (Klingberg et al., 2019). These tools also have varied amounts of empirical evidence supporting their use in terms of feasibility, validity and reliability (Bardid et al., 2019; Eddy et al., 2020; Klingberg et al., 2019). Eddy et al. (2020) recently conducted a systematic review to evaluate the suitability of current FMS assessment tools with a particular focus on the school environment. This research highlighted a range of determinants and

barriers that prevent such assessments from being used, such as feasibility (Bardid et al., 2019; Klingberg et al., 2019), not measuring all FMS components (typically balance) (Rudd et al., 2015) or a lack of reliability/validity research conducted as outlined in the COSMIN guidelines (Bardid et al., 2019; Mokkink and Terwee, 2010). They concluded that there is a need to develop low cost, reliable and valid assessment tools that are suitable for testing children at scale (Eddy et al., 2020; Morley et al., 2021). Furthermore, the literature has outlined a number of additional barriers around the feasibility of current tools for use in many ‘real-world’ settings (e.g. schools or sports clubs) (Lander et al., 2017), such as complex marking criteria, time/cost involved (Cools et al., 2009; Hoeboer et al., 2018; Wiart and Darrah, 2001) and a lack of fun for participating children (Lander et al., 2015), likely due to the static nature of many assessments (e.g. Test of Gross Motor Development (TGMD)). In response to the aforementioned limitations, more practical (i.e. FUNMOVES) (Eddy et al., 2021) and dynamic modes of assessment have been developed in recent times (i.e. The Canadian Agility and Movement Skill Assessment (CAMSA), The Dragon Challenge) (Longmuir et al., 2017; Tyler et al., 2018), creating a more ecologically valid form of assessment. Nevertheless, these tools are also not without their limitations (e.g. lacking stability components and having an imbalanced scoring system) (Tyler et al., 2018), highlighting the need to build on and further progress MC assessment tools. It has been proposed that rather than develop new assessments, researchers should seek to investigate and adapt existing tools (Hulteen et al., 2020); however, in order to maintain consistency in layout, performance and scoring of skills, there remains a strong argument for developing complete tools.

Thus, despite the fact that there is a proliferation of MC assessment tools available, it is evident that the majority are not suitable for use in many settings (Bardid et al., 2019; Eddy et al., 2020; Klingberg et al., 2019), many only provide a narrow view of MC (e.g. some just measure FMS/a component of FMS or do not consider injury) (Miller et al., 2020; Rudd et al., 2015) and many are designed specifically for 4-7 years of age and therefore do not have the complexity to effectively challenge children as they exhibit more specialised and complex movement skill patterns (Gimenez et al., 2012). These findings suggest that although plentiful, current MC assessment tools fail to

satisfy the variety of needs that academics, practitioners and clinicians have for them. It is also evident that having one tool that could assess MC in multiple environments (including education, sport, clinical and research) and that meets the needs of assessors in each would have wide reaching benefits both nationally and globally (Bardid et al., 2015).

In recognition of these inadequacies in the field, the aim of this study was to elicit the expert opinion of a mixture of academics and practitioners from a variety of fields (including research, education, sport, physiotherapy, athletic therapy) to design a new movement assessment tool to measure both the fundamental and functional movement skills of children aged 8-12. Drawing upon the extant literature, a key focus within this design would need to be on practicality for use with a large group of children, transferability across multiple environments (schools, sports clubs, clinical etc.) and implementation by users of varied levels of experience and expertise.

Methods

This study involved two main phases: i) Pre-Delphi Questionnaire, and ii) Delphi Poll, as explained below. Ethical approval was granted by the Dublin City University Research Ethics Committee (REC/2020/003).

Pre-Delphi questionnaire

An important aspect of MC assessment tool development is content validity, defined as ‘the degree to which the content of an instrument is an adequate reflection of the construct to be measured’ (Mokkink et al., 2010: p.743). To establish content validity, it is recommended that assessments are developed with input from experts in the field, alongside literature reviews and importantly, with the involvement of the target population (i.e. the assessment users) (Mokkink and Terwee, 2010). Therefore, the first stage of the tool’s development was to gauge the desire for its development, identify the main barriers preventing individuals from using existing assessments and identify key features that users desired to be included in the new tool. This data was gathered via online questionnaire.

Content.

Questionnaires consisted of 21 open and closed-ended questions with an estimated completion time of 6-10 minutes. All items were reviewed by the research team and piloted prior to dissemination. The research team consisted of a PhD candidate, and four senior members of the university, with on average 12+ years’ experience supervising postgraduate students, writing grants and extensively publishing in top tier journals. Questionnaires looked to examine the following: i) how important it is for children to develop fundamental and functional movement skills (both were clearly defined for participants) within each respective environment (e.g. schools, sports clubs, clinical, research), ii) whether assessing these skills is important in the course of the participant’s professional work with children, iii) what currently available movement assessments are individuals familiar with, iv) what barriers are preventing them from using currently available assessments, v) what characteristics (i.e.

time efficient, space efficient, cost effective etc.) would they like a new movement assessment tool to have, and vi) demand (i.e. if one was made available for them would they use it?).

Recruitment and participants.

Questionnaires were disseminated via email invitation to primary school teachers with a specialism in PE, post primary PE teachers, sports coaches (coaching 8-12-year-olds or responsible for youth development at a sport club) from all sports recognised by Sport Ireland who have a national governing body (Sport Ireland - NGBs), researchers/academics with expertise in the relevant fields, athletic therapists and physiotherapists from selected domains. The questionnaire garnered 370 responses. Respondents who wished to be eligible for selection to the Delphi panel were given the opportunity to express this interest at the end of the survey.

Delphi poll

Recruitment and participants.

Participants were identified as experts and invited to the study if they were: (i) an academic with expertise in developing and/or assessing children's FMS or functional movement skills, (ii) a coach with experience in children's movement development, (iii) a primary school teacher with experience in developing movement-based resources, (iv) a physiotherapist with experience developing children's movement, movement assessments and/or expertise in working with children, or (v) an athletic therapist with experience developing children's movement, movement assessments and/or expertise in working with children.

A search of electronic databases (PubMed and MEDLINE) was conducted to identify academics who: (i) authored peer-reviewed papers, and/or (ii) authored textbooks, or chapters within textbooks. The search was directed with the keywords "fundamental movement skills," "functional movement skills," "movement competence," "motor proficiency," "injury screening," and "movement

assessment". Due to teachers, coaches, physiotherapists and athletic therapists not being detectable through this search strategy, potential experts in these areas were identified through existing professional and research networks as well as those who expressed an interest through the pre-Delphi questionnaire. Shortlisted experts were identified by fulfilling the recommended criteria outlined by Alarabiat and Ramos (2019), in that experts should: 1) have first-hand background knowledge and experience in the topic under investigation, 2) provide useful contributions, 3) be willing to allocate a substantial amount of time to participate and 4) be respected and well known in the respective fields (Alarabiat and Ramos, 2019). Potential panel members (N = 20) were invited from Ireland, Northern Ireland, England, Japan, the United States and Australia via email. This correspondence also contained an information package detailing the project as well as a timetable outlining when rounds (questionnaires) would be sent out and expected to be completed by.

Delphi process

The Delphi method is a group facilitation technique that seeks to achieve consensus on the opinions of "experts" through a series of structured questionnaires (commonly referred to as rounds) (Hasson, 2000). The questionnaires are completed by the group of experts anonymously to one another (Day and Bobeva, 2005). As a part of the process, the responses from each questionnaire are fed back in summarised form to the expert panel (Jünger et al., 2017). The responses from one round then influence the questions posed in the next (Jünger et al., 2017). This continues for a number of rounds until consensus is achieved.

Within this study, three rounds of questions were deemed appropriate over a relatively short period of time in order to maximise respondent retention and reduce potential fatigue (Trevelyan and Robinson, 2015). Rounds one and two were designed to take no more than 30 minutes with round three taking around 45 minutes to complete. Panellists had one week to complete each round. Results of each round were distributed to the panel one week after responses were collected, with the following round being distributed three weeks later. Surveys were developed and distributed to

panellists via a commercial survey provider (SurveyMonkey Inc, CA, USA). The use of an online poll with a combination of qualitative and quantitative questions has the potential to make this poll a more rigorous validation than more traditional Delphi techniques (Colton and Hatcher, 2004).

Prior to the commencement of polling, it was determined that for Likert-scale type questions, consensus would be achieved if 67% of panellists rated the question as “Strongly Agree” or “Agree” or if over 67% of panellists selected the inclusion of an item (e.g. a skill) in a multiple choice style question. This value of consensus was chosen as it was the median reached in other similar studies (Francis et al., 2016; Morley et al., 2019; Okoli and Pawlowski, 2004; Robertson et al., 2017; van Rossum et al., 2021).

Each round of questions consisted of four main areas: (i) “The Skills” looked to establish the movement skills (i.e. the tasks that the children will perform within the assessment, for example, run, catch etc.) which the experts felt should make up the assessment, how the selected movement skills would be performed, and the order that they should be performed in, (ii) “Assessors Experience” aimed to establish how the assessment could be developed to cater for the different environments (schools, sports clubs, clinical, research) it could be used in, as well as the varying levels of experience users/assessors would have in order to make the tool as practical as possible to use, whilst still achieving the goals in which each environment would demand from it, (iii) “Practicalities of the Assessment” looked to establish the layout and how the skills would be marked, (iv) “Settings” examined the needs each group of assessors would have for this assessment and looked to find solutions on how to design a tool that works for all. Summaries of each round were also coupled with several short Likert-style questions to confirm the group’s opinions on findings from each round. These questions were designed to take 1-5 minutes to answer.

Round one.

Consisting of 21 questions, the aims of round one were to: (i) begin to establish which skills should be included in the assessment, (ii) establish whether children should be assessed on both their

dominant and non-dominant sides, (iii) establish what elements of the assessment should be adapted to cater for the varied levels of assessor, (iv) begin to develop the layout of the assessment, and (v) establish whether the assessment should be product-based, process-based or a mixture of both. To begin, panel members were presented with a list of movement skills drawn from a review of existing movement assessments (TGMD (Ulrich, 2004, 2016), Athletics Skills Track (AST) (Hoeboer et al., 2016), Bruininks-Oseretsky Test of Motor Proficiency (BOT) (Bruininks, 2005), CAMSA (Longmuir et al., 2017), Canadian Assessment of Physical Literacy (CAPL) (Longmuir et al., 2018), Get Skilled Get Active (Ryde, 2000), KTK (Kiphard and Schilling, 2007), Movement Assessment Battery for Children (MABC) (Henderson et al., 2007), Functional Movement Screen™ (Cook et al., 2014)) and suggestions from the research team. With this, they were asked to select which skills they felt were the most important to include in an assessment for 8–12-year-old children. Due to the developmental stage of skill acquisition children of this age should be at (Gimenez et al., 2012), the panel were then asked whether they felt that some skills should be combined to form more complex movement tasks. They then provided their feedback on which skills they felt should be combined, if any. The remainder of the round consisted of a range of open and closed-ended questions looking to establish the panels views on whether the assessment should i) be designed with the aim of being suitable in a range of environments, ii) be adapted in some way to cater for varied levels of assessor experience and expertise across the environments, and how they would do this, iii) have a specific layout or structure (e.g. circuit/stations), iv) follow a specific ordering of skills, v) perform all skills in the same continuous session or not, vi) assess children on both their dominant and non-dominant sides, and finally, vii) be assessed using process-orientated criteria, product, or a combination of both (see Figure 5.1).

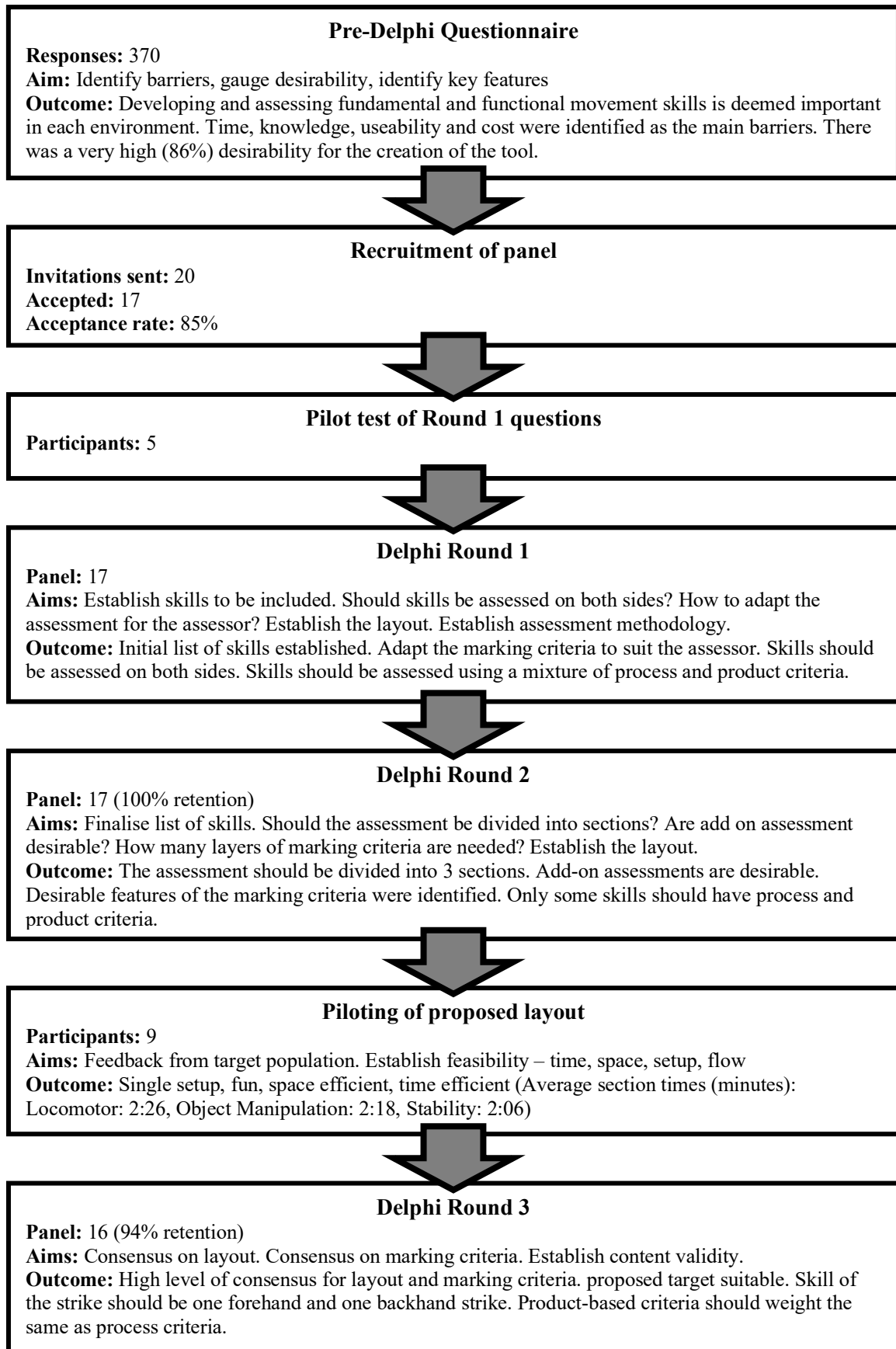


Figure 5.1: Flow chart outlining the stages of development of the tool

Round two.

Consisting of 45 questions, the aims of round two were to: (i) establish whether the list of skills reaching consensus from round one were a complete list of the skills needed to capture the MC of an 8-12 year old child, (ii) determine whether the assessment should be divided into subsections or independent parts, (iii) establish whether developing a series of optional “add-on” assessments was desirable, (iv) develop the number of “layers” and features of the adapted marking criteria, and (v) establish the layout of the assessment. Based on the opinions provided in round one, as well as taking practicality (time taken, ease of use etc.) into account, the research team summarised that the assessment should consist of three main categories as described by Gallahue et al. (2012): locomotor, object manipulation and stability. It was also important that categories could be examined independently to one another if the assessor so wished. This rationale was presented back to the panel to allow them the opportunity to consider these deductions at the commencement of round two. Considering that the assessment would be sub-divided into three sections (locomotor, object manipulation and stability), the panel were then asked whether the list of skills established for each of these sections in round one would adequately capture a child’s MC or whether they would add to this list.

It was also evident from round one that users from each environment (schools, sports clubs, clinical, research) desired different levels of detail or have different goals for the assessment. To accommodate this, the research team proposed developing several “add-on” assessments. These would be optional functional movement tests that an assessor might use to attempt to diagnose the source of a child’s movement deficiencies more accurately. For example, if a child performs poorly in several skills or in a certain combination of skill criteria, the assessment tool would ask the assessor to use a certain “add-on” assessment which may identify the source of the problem. This rationale was again presented to the panel for their expert opinion. Round one also established that the assessment should be adapted to cater for the varied levels of experience/expertise assessors may have, and by adapting the marking criteria was the best way to do so. Panellists were subsequently asked how many “layers” (versions of the marking criteria with different “layer” of detail) of marking

criteria would be desirable, as well as what features each layer should have. To do so, panellists were presented with a range of examples of marking criteria from existing functional and fundamental movement skill assessments. They rated each, provided comments and expressed which features of each should be considered in the design of this assessment tool (see Table 5.1). The remainder of the round sought to establish consensus on i) the layout/structure of the assessment, ii) whether all or some skills should have both process and product-orientated criteria, and iii) establishing other key features of the marking criteria.

Assessment	Average score (Max 5)	Feedback
Gallahue & Ozmun's (1998) Three stage model	2	• Clear pictures were good • Words accompanying the pictures would be better • Pictures from different angles should be included when necessary • Real pictures rather than silhouettes would be better
Landing Error Scoring System	1	• Definition and common errors are good there are just far too many • Absent/Present marking style is easy to use
Functional Movement Screen	4	• Frontal and Sagittal views good • Should highlight key differences between a score of 1/2/3 • Simple and clear criteria – not too many • Combination of images and simple criteria • What happens if you fall between the stages?
TGMD-3	3	• Pictures would be much more helpful • Pretty clear criteria • Present/Absent is easy to mark
MABC	2	• Images and description of how to set it up good • Simple scoring • Simple criteria • Too basic
BOT-2	3	• Seems user friendly • Simple graphic • Good instructions for the assessor • Administration guidelines good for less experienced users

Table 5.1: Panel feedback on existing assessment marking criteria

Round three.

Consisting of 36 questions, the aims of round three were to: (i) finalise the layout of the assessment, (ii) finalise both layers of marking criteria, (iii) finalise how all skills should be performed and in what order, and to (iv) establish the weighting product criteria would have in comparison to process criteria. From the first two rounds there was no consensus as the preferred layout/structure of the assessment. Consequently, based on the information gathered in the first two rounds, the research team developed a proposed layout. For the object manipulation section, this layout consists of a simple, square layout where participants travel to the corners, gather equipment and travel back into a central zone where all the skills are performed. As for the locomotor and stability sections, they also consist of a simple square layout, where participants travel around the outskirts and into the middle of the zone performing various skills at each section. This was then presented back to the expert panel to review. Two layers of marking criteria were also developed based on the information gathered from the previous two rounds. These were also presented to the panel to review. The remainder of the round aimed to clarify matters surrounding how the skills are performed, and the weighting of process vs product criteria within the proposed scoring system. To establish content validity (Robertson et al., 2014), follow up questions accompanied round three with the aim to further clarify the content (skills) and the assessment criteria for each of the skills. These follow-up questions were Likert-scale type questions with answers ranging from “Strongly agree” to “Strongly disagree”.

Results

Pre-Delphi questionnaire

In total, the questionnaire gathered 370 responses (50.55% female). Respondents felt that it was important that all children develop good functional and fundamental movement skills, rating that importance at 4.75/5 and 4.8/5 respectively. A significant proportion (85.66%) of respondents said that assessing both fundamental and functional movement skills was important in the course of their professional work with young people; however, only 58% of respondents were familiar with any form of movement assessment. Time constraints, not understanding how to use them and feeling they do not have the expertise to use them were the main barriers found to prevent people using assessment tools in their work. If a new tool could be created 86.7% of respondents said that they would like to use it; however, ease of use (3.91/5), time efficiency (3.51/5), low cost (2.92/5) and not using much equipment (2.74/5) would have to be key considerations in its design.

Delphi poll

Participants.

A total of 20 experts (academics n=10 and practitioners n=10) were invited to take part in the study, with 17 participating in round one (academics n=8 and practitioners n=9), a sample size considered appropriate based on previous research (Day and Bobeva, 2005; Okoli and Pawlowski, 2004). Of the 17 panellists completing round one, 17 completed round two, a 100% retention rate from the previous round. Of the 17 panellists who responded in round two, 16 completed round three (94% response rate, 94% retention rate from round one). This overall retention was significantly higher than the threshold of 70% described by Walker and Selfe (1996) for the findings to be valid.

Round one.

The run, catch, overarm throw, kick, skip, landing technique, hop and strike (with a bat or implement) as well as skill combinations of the catch and throw, run and dodge/cut, run and kick, vertical jump and land, and catch and strike all reached the level of consensus needed to be included in the assessment (see Figure 5.2). A large percentage (94%) of panel members felt that it was important to design a tool that could be used across multiple environments. A high level of consensus was achieved (81%) in relation to the assessment being adapted to cater for the different levels of expertise assessors will have across these environments and that adapting the marking criteria (69%) was the most suitable way of doing this. Consensus was not achieved on the layout the assessment should take (56% Stations, 19% Circuit, 25% Combination). Consensus was also not achieved on whether the ordering of skills mattered (56% does matter, 44% does not matter) or whether all skills should be performed in the same session (50%) or over more than one session (50%). Panel members reached a high level of consensus (81%) stating that children should be assessed on both their dominant and non-dominant sides as part of the assessment. Finally, consensus was also reached (75%) that the assessment should use a mixture of process and product-orientated assessment criteria.

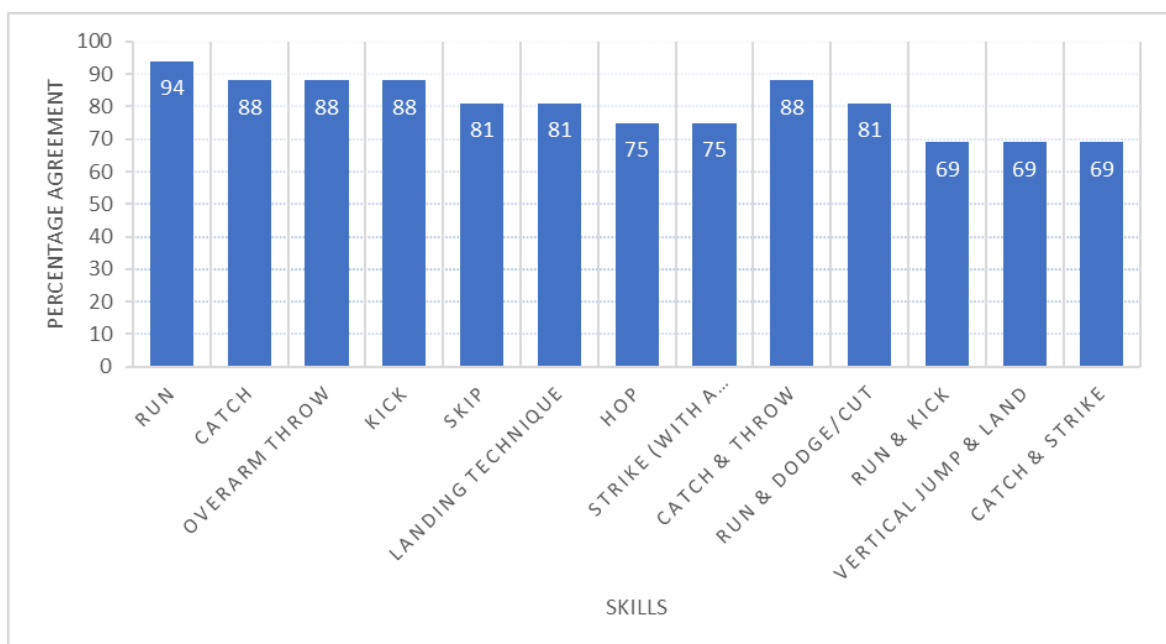


Figure 5.2: Skills reaching consensus for inclusion in round 1

Round two.

All panellists felt that the assessment should be divided into three independent sections as presented to them based on the findings from round one (locomotor, object manipulation and stability). There was a high level of consensus (85%) regarding the development of a series of optional “add-on” assessments which would provide more detail to the assessment should the assessor wish to gather that information. Consensus was not reached on how many layers of marking criteria should be developed, subsequent to round one’s findings (14% 2, 50% 3, 7% 4, 29% Other). For the most basic layer of marking criteria the panel preferred a traffic light system with illustrations or videos with three simply worded, clear criteria (67%). The marking scheme for the Functional Movement Screen™ received the highest average score from the panel (see Table 5.1). Once again, when presented with the three sections for the assessment, the expert panel could not reach consensus on whether it should be implemented using stations (58%) or a hybrid of stations and a circuit style (42%). Consensus was reached (67%) that only some skills should be assessed using both process and product criteria. Skills reaching the required 67% for this were the kick (83%), throw (75%), strike (75%) and catch (67%).

Round three.

Prior to the commencement of round three, feedback from the expert panel regarding the number of layers of marking criteria was analysed by the research team. Some opinions suggested that two layers may be the most suitable to ease comparisons between studies, whilst still having something easy to use in a practical setting and detailed enough for other environments. Considering this, the research team proposed two layers of marking criteria for round three. All panellists felt the design of the two layers of marking criteria were suitable and that they should meet the needs of any level of assessor in each environment (schools, sports clubs, clinical, research). A high degree of consensus (93%) suggested that the proposed layout presented was a suitable solution across the environments. All of the panel also felt that the proposed size of the area required (10x10 metre square) for the

assessment was appropriate. Consensus (71%) also established that the proposed target was a suitable measure of product for the agreed skills (kick, throw and strike). Panellists reached consensus (71%) that for the skill of the strike, children should strike a ball once with the forehand and once with the backhand to assess both sides; however, consensus was not reached on whether the ball should be on a tee (21%), self-bounced (36%) or other (43%). To increase the complexity of the beam balance, panel members also agreed (71%) that participants should perform a 360 degree turn on the balance beam. A high level of consensus (93%) among the expert panel selected Option A (single leg balance similar to the one in the BOT-2 assessment) as the most appropriate single leg balance to include. The panel could not reach consensus on the ceiling time that participants should hold the balance for during the assessment (10s 43%, 15s 14%, 20s 29%, Other 14%). Finally, the panel agreed (71%) that a product skill criterion should carry the same weight of marks as a process criterion.

Object Manipulation	Locomotor	Stability
2-Handed Catch	Run	Beam Balance (with 360 turn)
Throw (right and left) (shoulder and trunk rotation)	Cut/Dodge (Body position, knee valgus)	Single Leg Balance
Kick (right and left)	Deceleration (body control)	Core Stability (Bear Crawl and Crab walk)
Strike (forehand and backhand) (shoulder and hip rotation)	Vertical Jump and Land	Single Leg Vestibular Functioning (tennis ball throw)
	Horizontal Jump and Land	Vestibular Functioning Test on a Line (turning head)
	Diagonal Hop (knee valgus)	
	Skip	

Table 5.2: Final list of assessment components

Discussion

The aim of this study was to elicit the expert opinion of a mixture of academics and practitioners from a variety of fields (including research, education, sport, physiotherapy, athletic therapy) to design a new movement assessment tool to measure both the fundamental and functional movement skills of children aged 8-12. Key foci for this design were (a) practicality of use with a large group of children, (b) transferability across multiple environments (schools, sports clubs, clinical, research) and (c) implementation by users of varied levels of experience and expertise. Following this three-round Delphi poll with a panel of international expert academics and practitioners, the findings highlight that a novel tool could be created. According to consensus reached within the study, the tool would assess the three movement types of locomotor, object manipulation and stability, use a simple, dynamic layout and assess children bilaterally. The tool would also have unique features such as various “layers” of marking criteria as well as optional “add-on” assessment elements to afford differentiated access for users in multiple environments.

The first novel aspect of this tool are the skills included. It was established that the assessment should contain skills from each FMS construct: locomotor ($n=7$), object manipulation ($n=4$) and stability ($n=6$) (see Table 5.2). This emphasises the importance of assessing each FMS construct in order to provide a more comprehensive measurement of MC that is not currently quantified in other established MC assessment tools (e.g. TGMD does not assess stability) (van Rossum et al., 2021). This is also in line with research that indicates that stability should be assessed independently from locomotor and object manipulation skills (Rudd et al., 2015). The selection of such a range of static and dynamic stability exercises by the expert panel makes this tool unique, as stability has shown to have a significant relationship to functional movement patterns (Yıldız, 2018), sporting performance (Hrysomallis, 2011), lower body asymmetry (Sannicandro et al., 2014) and injuries (Hrysomallis, 2007). These findings also correspond to a number of selected locomotor movements which are associated with injury and performance, namely: running (Kelly, Farris and Lichtwark, 2018), cutting technique (Fox, 2018), jumping (Fort-Vanmeerhaeghe et al., 2020; Ozmen, 2016) and hopping (Butler et al., 2003). In contrast to other tools (e.g. TGMD), this tool includes only four object

manipulation skills. These skills are the most commonly assessed object manipulation skills across a range of assessments (Eddy et al., 2020), as well as being some of the most commonly used skills in many physical activities and sports.

Asymmetry is a factor which has been linked to increased musculature and non-contact related injuries when partaking in sports and other physical activities (Abraham et al., 2015). For example, Chalmers (2017) demonstrated that the presence of ≥ 2 asymmetrical subtests of the Functional Movement ScreenTM was associated with a threefold increase in the risk of injury that caused a missed game in 237 elite junior male Australian football players (Chalmers et al., 2017). It has also been linked to physical performance in a range of sports (Fort-vanmeerhaeghe et al., 2016; Fousekis, Elias and Vagenas, 2010). The ability to perform skills using both sides of the body is a desirable feature for many activities which can significantly aid performance (McLean and Mpe, 1993). To the best of the researchers' knowledge, the fact this assessment will measure children's skill performance on both their dominant and non-dominant sides is a unique feature to this proposed assessment tool. This advancement should significantly improve the identification of asymmetries and facilitate subsequent targeted corrective intervention.

Whether to examine the movement pattern and/or outcome of a skill is a key consideration in the methodology of any movement assessment. Currently available MC assessments can be categorised as either using a "process" or "product-oriented" methodology (Logan et al., 2017). Product-oriented assessments evaluate the outcome of a movement or skill (how fast/how many). This offers an objective evaluation of the outcome of a task, but not on how it was achieved (Bisi et al., 2017). These forms of assessment are feasible as assessors do not require an extensive understanding of MC to administer the test (Hands and Larkin, 1998) and the test can be performed with a large group of children quite quickly (Hands, 2002). Alternatively, process-oriented assessments analyse how a movement or skill is performed, but do not examine outcome (Logan et al., 2017). Although more time consuming and often deemed quite static, process-based forms of assessment provide users with specific information on children's MC, which can be useful when providing feedback or for the design of interventions. The expert panel in this study established that

all skills should be measured using process-oriented criteria. Consensus also established that object manipulation skills should be measured using both process and product-oriented criteria. Robinson et al. (2015) concur with this notion, reporting that a combined use of process and product-oriented measures can provide a more comprehensive assessment of MC (Robinson et al., 2015). The product measure deemed most appropriate to use for this assessment by the expert panel was accuracy. Other possible product outputs such as speed, velocity or distance have been used in other assessments; however, given the age range under scrutiny, such product outputs could be influenced by maturation (Sheehan and Lienhard, 2018). For example, force-producing capacities are lower in younger children when compared to older children or adolescents, due to the structure (O'Brien et al., 2010), size (Dotan et al., 2012), activation patterns (Dotan et al., 2013) and function (Waugh et al., 2013) of a child's muscle. Of all product measures, maturation has the most limited influence on accuracy and precision, resulting in those outcomes being the most objective measure for inclusion in this assessment tool.

Although a combined use of process and product-oriented measures can provide a more comprehensive assessment of MC (Robinson et al., 2015), it can also make an assessment more time consuming and less feasible for assessors. The expert panel in this study sought to mitigate these concerns by dividing the assessment into three sections: locomotor, object manipulation and stability. This feature gives assessors more control over the testing, meaning less confident assessors must only focus on a limited number of skills at a time, whilst also making it more time efficient to use with a larger group. This feature also allows for assessors to use a certain component of the test, focus their intervention to improve said components for a certain time, then move on to another component. The dynamic layout of this assessment (whereby children are constantly in motion or performing skills when moving from one part of the assessment to the other) also contributes to its time efficiency, as well as the ecological validity of the skills being performed. Many assessment methods used can be considered static, where skills are performed following an iterative sequence of instruction and performance (Bardid et al., 2019). Circuit-based assessments (e.g. CAMSA (Lander et al., 2017) or the Dragon Challenge (Tyler et al., 2018)) have recently emerged as a dynamic

method to assess MC using a sequence of different motor tasks, which children have to complete without interruption (Bardid et al., 2019). The expert panel in this study decided that a hybrid model was the best fit, whereby children move through the assessment performing the required skills with breaks after each skill performance where participants are moving to another area, regathering equipment or performing other skills to allow the assessor sufficient time to score the performance before the next skill is performed and assessed. This design has shown promising early signs of being suitable and time efficient. When trialled during the Delphi with two groups of children (Group 1 – n = 6, age range 8-12 years. Group 2 – n = 3, age range 8-11 years) the time taken to complete each section suggested to be significantly lower than many current assessments (locomotor: 2:26, object manipulation: 2:18, stability: 2:06 (in minutes) (time includes scoring time and was conducted by a field expert)). These preliminary findings show promise in this assessment tool being a feasible option for use with a large group of children within a restricted time; however, further research must be conducted to investigate this.

Another feature which contributes to the feasibility of this tool are the varied “layers” of marking criteria. It is evident that many non-experts such as primary school teachers lack the confidence to measure or deliver effective lessons to develop MC (Fletcher and Mandigo, 2012; Harris, Cale and Musson, 2012; Lynch and Soukup, 2017). The expert panel felt that developing a more basic (See Appendix G) and a more complex level (See Appendix F) of marking criteria for the assessment tool would allow all levels of assessor to use the tool effectively (see Figure 5.3). Future stages of this tool's development will look to examine this feasibility and inter-rater reliability as per the COSMIN guidelines (Mokkink and Terwee, 2010).

Run & Cut/Dodge Criteria – Layer 1
Arms move in opposition to the legs
Outside foot is planted and pushed off in each cut
Trunk is lowered when turning and leans in the direction of each cut
Use's rapid small steps to stop in the square

Run & Cut/Dodge Criteria – Layer 2
Arms move in opposition to the legs (Right arm - Left leg etc)
Outside foot plants outside the cone with toes pointing forward (Not out away from turn)
Knees bend and hips lower entering the cut
Trunk leans in the direction of the turn
Use's rapid, small steps to stop in the square
Trunk remains upright during deceleration (No excessive forward lean)

The Catch Process Criteria – Layer 1
Changes position to put themselves in the flight path of the ball
Brings their hand(s) up and out to meet the ball
Tries to catch the ball using their hands only (Rather than grasping it into the body)

The Catch Product Criteria – Layer 1
Clean catch
Fumbled but caught
Not caught

The Catch Criteria – Layer 2
Eyes track the flight of the ball
Adjusts positions to put themselves in the flight path of the ball
Arms extend up and out to meet the ball
Ball is caught by the hands only (Not grasped to the body)
Successful catch/Not caught

Figure 5.3: Example of marking criteria (Layer 1 and 2 for the Run and Cut/Dodge and the Catch)

Arguably, the most significant feature of this tool is its potential ability to be used in a range of environments (schools, sports clubs, clinical, research). Features that have been mentioned previously (consideration of injury in marking criteria, comprehensive stability section, asymmetry, process & product criteria, time efficiency, space efficiency, minimal equipment, “layered” marking criteria) would significantly contribute to what users in education, coaching and research would require from a MC assessment tool (Bardid et al., 2019). Clinicians however, can require a more detailed screening tool (McCunn et al., 2016; Bennett et al., 2017). Although there are functional movement components included in all skills, the “add-on” functional tests feature of this assessment tool is a feature that, based on a child’s performance in the assessment (e.g. failing to achieve certain criteria from a range of skills), the tool will intuitively recommend that clinicians use a certain “add-on” assessment (e.g. single-leg squat) to identify the source of a child’s movement deficiency more accurately. This feature will be further developed and refined following trialling of the main assessment.

Conclusion

By achieving consensus from a panel of international expert academics and practitioners from a range of environments, these findings provide content validity for a new, innovative, dualistic MC assessment tool for children aged 8-12. These findings also provide the key features that comprise a proposed tool such as the layout, structure, marking criteria, equipment required and additional features such as optional “add-on” assessments. The purpose of this study was to develop a valid, reliable, feasible, practical and user-friendly tool that can be used in a range of environments to act as an assessment for learning tool by teachers, coaches, physiotherapists and athletic therapists to develop children’s MC. Future research should now focus on the consideration of all components of the COSMIN guidelines during the tool’s construction to ensure this is a reliable, feasible and valid tool (Mokkink and Terwee, 2010).

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Linking Chapter 5 to Chapter 6

Chapter 5 outlined the process involved in designing the FMS² assessment tool. The findings from this study provided content validity for a new, innovative, dualistic MC assessment tool for children aged 8-12. The findings also describe the key features that comprise the proposed tool such as the layout, structure, marking criteria, equipment required and additional features such as optional “add-on” assessments. In order to utilise this tool in practical settings, validity and reliability must first be established. Building on the content validity, which was established in chapter 5, chapter 6 will examine the structural and convergent validity of the newly designed FMS² assessment tool.

Naming FMS²

Within the literature, the abbreviation FMS has been used to describe both fundamental and functional movement skills. The aim of this tool is to measure MC more holistically, by capturing both children's fundamental and functional movement skill proficiency. If you consider MC as a mathematical formula then, you multiply FMS x FMS, and you get FMS², which is where the name for this tool emerged.

Chapter 6: The Structural and Convergent Validity of the FMS² Assessment Tool Among 8 to 12-year-old Children

The Structural and Convergent Validity of the FMS² Assessment Tool Among 8 to 12-year-old Children

Abstract

Although there is a plethora of existing tools available to assess children's movement competence, the literature suggests that the majority of tools have significant limitations. The FMS² assessment tool has recently been developed as a targeted solution to many of the existing barriers preventing practitioners from utilising movement competence assessments. The aim of this study was to investigate the structural and convergent validity of this new tool among 8- to 12-year-old primary school children. As part of this study, 102 children (56.8% female, M=9.8 years) were assessed using FMS², the TGMD-3 (short version) and the FMSTM. Structural validity was assessed using confirmatory factor analysis. The convergent validity between FMS², the TGMD-3 (short version) and the FMSTM was investigated using Pearson product-moment correlation coefficient. Results of confirmatory factor analysis for FMS² indicate a good fit model, supporting a three-factor structure (locomotor, object manipulation, and stability). Results also found a moderate, positive correlation between FMS² and the TGMD-3 (short version) ($r = .66$), with a low, positive correlation between FMS² and the FMSTM ($r = .48$). This study presents the first preliminary findings to suggest that FMS² may present as a versatile, time-efficient and ecologically valid tool to measure children's movement competence in multiple settings (e.g. research, education, sport, athletic therapy, physiotherapy). Future research should also seek to continue to implement this solution, consolidate the existing validity findings with a larger and more diverse sample, and further explore the feasibility of the tool in "real-world" settings.

Key Words: Movement Competence, Fundamental Movement Skills, Functional Movement Skills, Assessment, Confirmatory Factor Analysis

Introduction

Movement competence (MC) is a multi-faceted concept, and the terms used to define it have shifted and evolved over time (Basman, 2019). Even in recent times, both proficiency in fundamental movement skills (FMS) and proficiency in functional movement skills have been separately used to define MC within the literature (Basman, 2019). Fundamental movement skills are described as the basic building blocks of more advanced complex movements that support successful engagement in sport and PA (Logan et al., 2018). Fundamental movement skills are typically classified into three areas: locomotor, object manipulation and stability skills (Gallahue and Ozmun, 2006; Goodway, Ozmun and Gallahue, 2019). In children, proficiency in FMS has been positively associated with weight status (Slotte et al., 2015), health-related fitness (Behan et al., 2020), the acquisition of sports specific skills (Koksteijn and Musalek, 2019) and physical activity (PA) participation (Barnett et al., 2009; Lloyd et al., 2014). Functional movement skill can be defined as the ability to produce and maintain an adequate balance of mobility and stability along the kinetic chain while integrating functional movement patterns with accuracy and efficiency (Mills, Taunton and Mills, 2005; Bagherian et al., 2018). It has also been described as movement efficiency that minimises the risk of injury (Cook, Burton and Hoogenboom, 2006; Coker, 2018; Fitton Davies et al., 2022). Similar to FMS, developing these skills in children is also suggested to be important, with research positively linking functional movement proficiency to weight status (Duncan and Stanley, 2012; Duncan, Stanley and Wright, 2013), sport skill acquisition (Yıldız, 2018), athletic performance (Fitton Davies et al., 2022), and injury risk reduction in children (Lloyd et al., 2015; Pfeifer et al., 2019; Wang et al., 2021).

The emerging relationship between fundamental and functional movement skills has been examined in recent literature. O'Brien et al. (2021) found a moderate association between composite scores on the functional movement screen (FMSTM) and the stability and locomotor subsets of the Test of Gross Motor Development (3rd Edition) (TGMD-3). Although limited by a small sample size, Wu et al. (2021) found that children who were classified as scoring high on the FMSTM, also scored highly on the Test of Gross Motor Development (2nd Edition) (TGMD-2), supporting the notion that

good functional movement skill is required in order to perform FMS well (Cliff et al., 2009; O'Brien et al., 2021). A similar idea was posed by Duncan et al. (2013), who described functional movement as the movement pattern that underpins all other movements.

The assessment of movement skills is an essential aspect of MC development (Chan, Ha, and Ng 2016). Although there is a plethora of existing tools available to assess FMS (Hulteen et al., 2020), the literature suggests that existing tools have significant limitations, ranging from varied amounts of empirical evidence supporting reliability and validity (Bardid et al., 2019; Eddy et al., 2020; Klingberg et al., 2019), to not measuring all components of FMS (e.g. stability) (Rudd et al., 2015), to not being feasible to use in many “real-world” settings, such as schools (Eddy et al., 2020), or that they fail to consider movement patterns related to an increased risk of injury in children (Miller et al., 2018). There are also significant concerns as to the validity and feasibility of existing tools used to assess functional movement proficiency, particularly for use with children (Moran et al., 2016; Mauntel et al., 2017).

More recently, tools such as the Motor Competence Assessment (MCA) (Rodrigues et al., 2019), the Körperkoordinationstest für Kinder 3+ (KTK3+) (Coppens et al., 2021), and the Test of Motor Competence (TMC) (Sigmundsson, Lorås and Haga, 2016) have emerged as the first to assess MC more holistically rather than just a particular construct (i.e. FMS), however these tools have significant limitations. For example, the MCA only consists of six tests, the KTK3+ consists of five and the TMC consists of only four, which hardly represent the broad diversity of skills utilised in many physical activities or sports. In addition, all of these tests utilise product-based measures, meaning they evaluate the outcome of a movement or skill (how fast/how many). This offers an objective evaluation of the outcome of a task, but not on how it was achieved (Bisi et al., 2017), limiting practitioners ability to provide adequate feedback or instruction to children to help improve their performance (Lander et al., 2017). Furthermore, none of these assessments measure all key elements of MC whilst also incorporating functional movement skills or musculoskeletal injury screening techniques, a key construct of overall MC. These limitations restrict the ability of academics to further explore the emerging relationship between both constructs of MC and different

indicators of health and performance, as well as limiting the ability of practitioners to enhance these skills in children.

The FMS² assessment tool has recently been developed as a targeted solution to many of the existing barriers preventing practitioners from utilising MC assessments (Gavigan et al., 2022). Informed by a Delphi poll, with consensus from a panel of worldwide experts from a range of environments (research, education, sport, athletic therapy, physiotherapy) (Gavigan et al., 2022), this tool utilises core features which aim to make it time efficient, easy to administer, practical, fun and more dynamic to better represent skill execution during play/PA (Gavigan et al., 2022). To further promote the use of this tool in practical settings, validity and reliability must first be established. The aim of this study was to present the first preliminary findings investigating the structural and convergent validity of the FMS² assessment tool among 8–12-year-old primary school children.

Methods

Participants

As data collection occurred during a period of restricted access to schools due to the COVID-19 pandemic, a convenience sample of two local, socioeconomically diverse, single gender (one all-male, one all-female) primary schools were approached to participate in the study, both accepted. Principals from each school then identified three classes to participate (one 2nd, 4th & 6th class from the male school, one 3rd, 5th & 6th class from the female school). In total, 102 children (56.8% female, age range 8-12 years, $M=9.8$, $SD=\pm 1.287$) participated in the study. Parental consent and participant assent were obtained (age-appropriate child assent forms were supplied to participants). Ethical approval was granted by the Dublin City University Research Ethics Committee (REC/2021/028).

Instruments

FMS²

FMS² is both a process- and product-oriented instrument, consisting of three subtests and 15 test items (Gavigan et al., 2022). Of these, four are devoted to object manipulation (catch, kick, throw, strike), five are devoted to locomotor skills (run/cut, vertical jump, horizontal jump, diagonal hop, skip), and six are devoted to stability skills (beam balance, single-leg balance, bear crawl, crab walk, tennis ball balance, head-turn walk) (Gavigan et al., 2022). FMS² is an assessment tool that requires observational techniques. The assessment has two layers (versions) of marking criteria that can be used based on the level of expertise of the assessor (basic and more complex version). For the more complex layer, each skill includes three to six components that are presented as performance criteria. For the basic layer, each skill includes three to four components that are also presented as performance criteria. For the purpose of this study, the more complex criteria were used. During the test, if a child performs a component correctly, the assessor gives a score of 1, otherwise they score a 0. Participants do not perform a practice trial. Most skills are performed and assessed twice: once on the dominant and once on the non-dominant side. The sum of the observed performance criteria

for each subscale comprises the total raw score (Complex version: 0–119 points; Basic version: 0–53 points).

The Test of Gross Motor Development – 3rd Edition (Short version)

The Test of Gross Motor Development – 3rd Edition (TGMD-3) (Ulrich 2020) is a validated, process-oriented instrument, consisting of two subtests and 13 test items. Of these, six are devoted to locomotor skills (run, gallop, hop, skip, horizontal jump, slide) whilst seven are devoted to object manipulation skills (two-handed strike of a stationary ball, one-hand forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw, underhand throw). Each skill includes three to five components that are presented as performance criteria. If the child performs a component correctly, the assessor gives them a score of 1, otherwise they score a 0. Each participant performs one practice trial followed by two trials that are scored. The sum of the observed criteria for each subscale comprises the total raw score (0–46/54 points) (Webster and Ulrich 2017). At the time of this study, the limited access to schools and the reduced number of assessors allowed on site (due to the COVID-19 pandemic) meant that the full TGMD-3 was not suitable for data collection. For this study, a short version of the TGMD-3 was used which was validated using confirmatory factor analysis (CFA) on a large, separate dataset of Irish primary school children of the ae age cohort (see below). This cross-sectional dataset were collected as part of a national physical literacy study ‘Moving Well- Being Well’ (Behan, 2020). This shorter version of the TGMD-3 consisted of four locomotor (run, hop, skip, horizontal jump) and four object manipulation skills (one-handed forehand strike of a self-bounced ball, kick a stationary ball, two-handed catch and overhand throw), resulting in a combined maximum raw score of 60 points.

The Functional Movement ScreenTM

The Functional Movement ScreenTM (Cook, Burton and Hoogenboom, 2006) is a validated, process-oriented instrument consisting of seven test items. The FMSTM was designed in order to identify

functional movement deficits and asymmetries that may be predictive of general musculoskeletal conditions and injuries, with the ultimate goal of being able to modify the identified movement deficits through individualized exercise prescription (Cook, Burton and Hoogenboom, 2006). The seven movement patterns that are assessed include: the deep squat, in-line lunge, hurdle step, shoulder mobility, active straight leg raise, trunk stability push-up, and quadruped rotary stability (Cook, Burton and Hoogenboom, 2006; Teyhen et al., 2012). The FMSTM is an assessment tool that also requires observational techniques (Beardsley and Contreras, 2014). Each movement skill is scored on a scale ranging from 0 to 3, with the sum creating a composite score ranging from 0 to 21 points (Cook, Burton and Hoogenboom, 2006). The score of 0 is given if pain occurs during a test, the score of 1 is given if the subject is not able to perform the movement, the score of 2 is given if the subject is able to complete the movement but compensates in some way, and the score of 3 is given if the subject performs the movement correctly (Beardsley and Contreras, 2014).

Data Collection

Researchers in this study were divided into two teams for the data collection process. Team 1 consisted of the lead researcher, an academic with expertise and experience in motor competence, a PhD candidate, one third year and three fourth (final) year undergraduate physical education student teachers. Team 2 consisted of three qualified athletic therapists (who were FMSTM certified). Prior to data collection, all data collectors completed an online training module developed by the lead researcher. As part of this training, data collectors had to undergo a consistency assessment to ensure high quality data was collected and recorded. To do this, data collectors had to achieve a 95% inter-observer agreement on a set of data that was pre-coded by the lead researcher.

Data was gathered over the course of two school days in September 2021. On day one, Team 1 measured the children's FMS in the all-male school using the TGMD-3 (short version) and the FMS². The assessment took place outside in the school playground. On average, data collection for each class group took 1 hour and 5 minutes. Data were gathered using a rotatory system whereby the

assessments were divided into six stations: (i) FMS² locomotor, (ii) FMS² object manipulation, (iii) FMS² stability, (iv) TGMD-3 horizontal jump, catch and kick, (v) TGMD-3 run, hop and skip, (vi) TGMD-3 strike and throw, with each station having between two and four children at any one time. Team 2 measured the functional movement skills in the all-female school. Data were also collected outside on the school playground. On average, data collection for each class group took 39 minutes. Assessors strictly adhered to the scripted instructions provided in the FMSTM documentation to guide the children through the testing procedure (Cook et al., 2006; Duncan & Stanley, 2012). On day two, Team 1 measured the children's FMS in the all-female school and Team 2 measured the children's functional movement skills in the all-male school following the same procedure as the previous day.

Data Analysis

Data were analysed using SPSS version 27 and AMOS version 23 for Windows. Descriptive statistics (i.e. means and standard deviations) were computed for the composite scores of FMS², the TGMD-3, the FMSTM (see Table 6.1), as well as the subtest scores of FMS² (i.e. locomotor, object manipulation and stability) (see Table 6.2).

Age (years)	n		TGMD-3		FMS ²		FMS TM							
			Males		Females		Males		Females		Males		Females	
	Males	Females	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
8	12	10	35.08	9.80	35.90	6.00	61.33	18.32	74.43	9.55	8.57	1.34	10.17	1.60
9	13	7	34.38	10.97	33.43	4.86	72.28	20.75	78.00	13.06	9.93	1.44	9.75	2.75
10	8	17	35.00	8.78	37.59	7.03	87.24	6.38	73.90	15.60	9.38	1.06	10.53	2.62
11	9	17	33.67	6.86	39.47	8.67	69.92	9.90	78.88	14.02	9.09	1.14	9.79	1.69
12	4	5	34.75	8.50	43.00	8.86	69.15	16.71	83.13	19.61	10.00	1.00	11.00	2.12
Total	46	56	34.57	9.00	37.82	7.54	71.29	17.66	76.84	14.08	9.28	1.34	10.20	2.12

Table 6.1: TGMD-3 (short version), FMS² and FMSTM composite scores by age and sex

Age (years)	n		Locomotor				Object Manipulation				Stability			
			Males		Females		Males		Females		Males		Females	
	Males	Females	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
8	12	10	26.17	9.68	36.20	5.12	18.16	7.82	19.63	4.11	17.00	6.95	18.60	6.57
9	13	7	31.54	12.15	37.00	4.36	21.28	5.91	19.85	6.73	19.46	5.08	21.14	4.88
10	8	17	38.13	5.89	33.35	7.51	27.12	6.41	19.84	5.12	22.00	4.54	20.71	5.52
11	9	17	29.11	8.05	35.12	7.56	21.25	5.42	20.46	6.49	19.56	4.56	23.29	4.31
12	4	5	22.75	13.72	35.60	10.36	28.15	6.08	23.33	7.68	18.25	3.30	24.20	4.15
Total	46	56	30.04	10.63	35.05	6.99	22.07	7.11	20.30	5.73	19.17	5.40	21.48	5.35

Table 6.2: FMS² subtest scores by age and sex

Reducing the TGMD-3 from 13 skills to 8

To establish the validity of using a shortened 8 skill form of the TGMD-3 in the current study, CFA was performed on an existing dataset of 2,377 children in Irish primary schools (mean age = 9.2 ± 2.04 years). Model fit for the full 13 skill TGMD-3 and the shorter 8 skill version were analysed. Both models were specified as two-factor models containing locomotor and object-control latent variables. The eight-skill shortened version contained four locomotor skills (run, jump, skip, hop) and four object-control skills (catch, kick, throw, one-handed forehand strike of a self-bounced ball).

Gender and Age Differences

Differences in each MC assessment according to gender and age were examined using a two-way between groups analysis of variance (ANOVA).

Structural Validity

To analyse structural validity of FMS², CFA using maximum likelihood estimation methods was conducted using AMOS version 23 (Arbuckle, 2011). Robust maximum likelihood (Satorra and Bentler, 2001) was used to estimate model parameters, because the data exhibited a multivariate non-normal distribution. Model fit was assessed using Standardized Root Mean Square Residual

(SRMR), Root Mean Square of Error Approximation (RMSEA), Comparative Fit Index (CFI) and Normed Fit Index (NFI). The SRMR represents the average discrepancy between the observed sample and hypothesised correlation matrices. In a well-fitting model the value would be small, equal, or less than .05 (Lopes, Saraiva, and Rodrigues 2018). The RMSEA measures the degree of misspecification per model degree of freedom, adjusted to the number of estimated parameters in the model (i.e. the complexity of the model). Values below 0.06 indicate an adequacy of model (Hu and Bentler, 1999). The CFI indicates the degree of fit between the hypothesised and null measurement, adjusted to the sample size. The NFI reflects the proportion of the joint amount of data variance and covariance that can be explained by the measurement model being tested. CFI and NFI values above .95 are considered indicative of a good model fit (Hu and Bentler, 1999).

Convergent Validity

To assess the relationship between FMS², the TGMD-3 (short version) and the FMSTM, Pearson's correlation coefficient was used. The values of the correlation coefficient (r) can be interpreted as follows: negligible: <0.30; low: 0.30–0.50; moderate: 0.50–0.70; high: 0.70–0.90; and very high: 0.90–1.00 (Ling, 2001).

Results

Reducing the TGMD-3 from 13 skills to 8

Model fit statistics for both versions of the TGMD-3 are presented in Table 6.3, showing the acceptable fit of the 8-skill, two-factor TGMD-3 model and confirming that it is a valid measure of fundamental movement skills in this cohort.

Model	Description	χ^2	Df	Prob	NFI	TLI	CFI	RMSEA [95% CI]
Model 1	TGMD-3; 13 skills	609.9	64	.00	.88	.88	.83	.06 [.056-.064]
Model 2	TGMD-3 short version; 8 skills	233.8	19	.00	.91	.84	.92	.07 [.061 - .077]

Table 6.3: Model fit statistics for the full 13-skill TGMD-3 and the shorter 8-skill version

Gender and Age Differences

A two-way between-groups analysis of variance was conducted to explore the impact of sex and age on the composite scores of the TGMD-3 (short version), the FMS² and the FMSTM. The interaction effect between sex and age group was not statistically significant for any of the assessments (TGMD-3 (short version): $F(4, 102) = 0.735$, $p = .57$, FMS²: $F(4, 102) = 2.668$, $p = .37$, FMSTM: $F(4, 102) = 1.575$, $p = .74$). There was not a statistically significant main effect for age among any of the assessments (TGMD-3 (short version): $F(4, 102) = 0.603$, $p = .66$, FMS²: $F(4, 102) = 1.940$, $p = .11$, FMSTM: $F(4, 102) = 0.801$, $p = .53$). There was not a statistically significant main effect for gender for the TGMD-3 (short version) ($F(4, 102) = 3.238$, $p = 0.08$) or the FMS² ($F(4, 102) = 2.904$, $p = 0.09$). There was a statistically significant main effect for gender in the FMSTM, $F(4, 102) = 4.054$, $p = .047$; however, the effect size was small (partial eta squared = .043).

Structural Validity

In a three-factor model, locomotor (run/cut, vertical jump, horizontal jump, diagonal hop, skip), object manipulation (catch, kick, throw, strike) and stability (beam balance, single-leg balance, bear

crawl, crab walk, tennis-ball balance, head-turn walk) skill scores from the FMS² were tested using CFA. The obtained model fit indices based on the robust estimation for FMS² are shown in Figure 6.1.

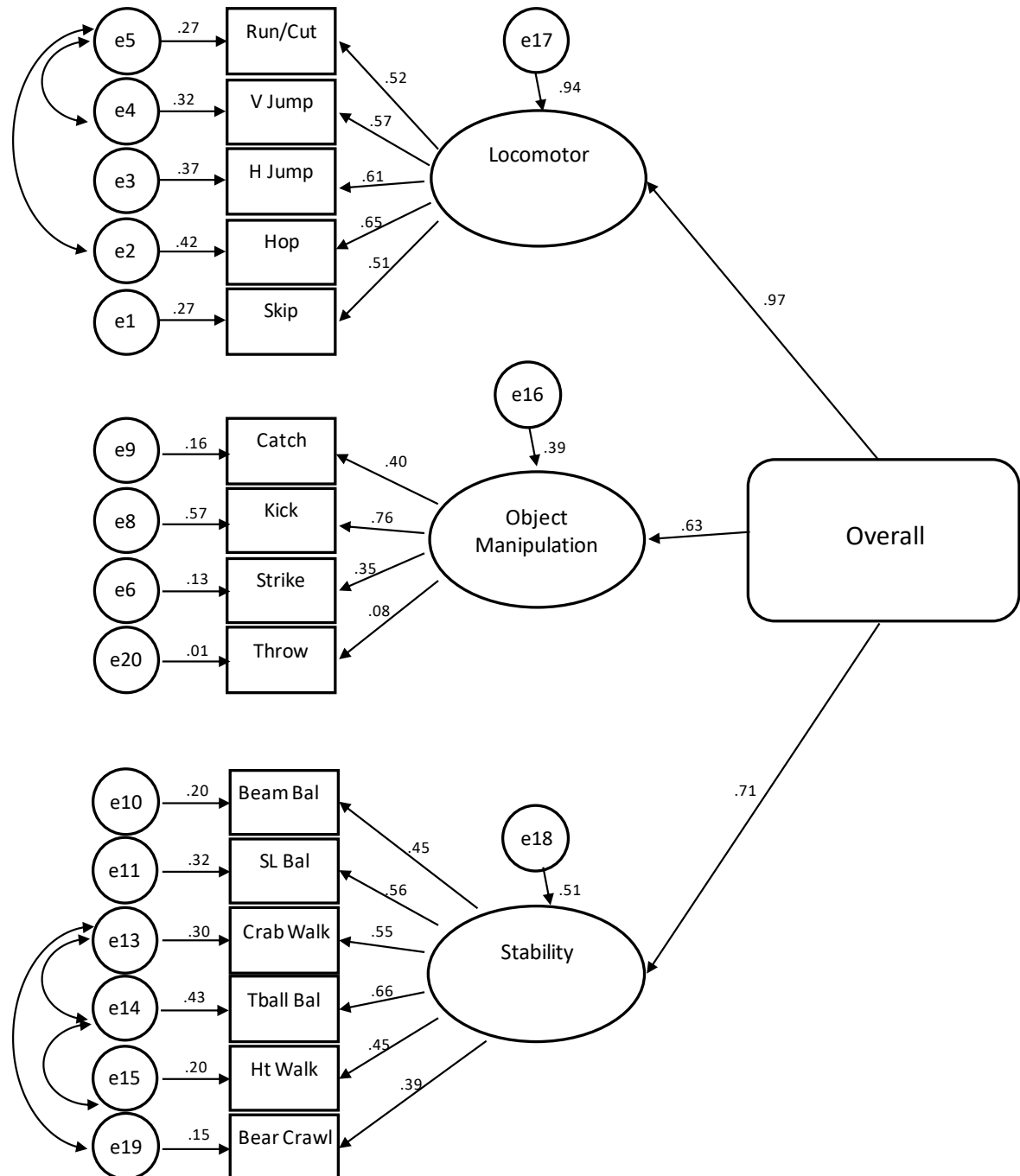


Figure 6.1: CFA Model 1

The values of the goodness-of-fit indices obtained [CFI = .93, NFI = .72, TLI=.94, SRMR=.07, and RMSEA = .047 (90% CI: .00–.08)] suggest a good fit of the model. Indicators within a factor (Loco/Object/Stability) with correlations of >.40 were allowed to covary. Inspection of indicator loadings showed that throw had a low and insignificant loading in the model ($\beta = .08, p > .05$), and was therefore removed from the next model (see Figure 6.2).

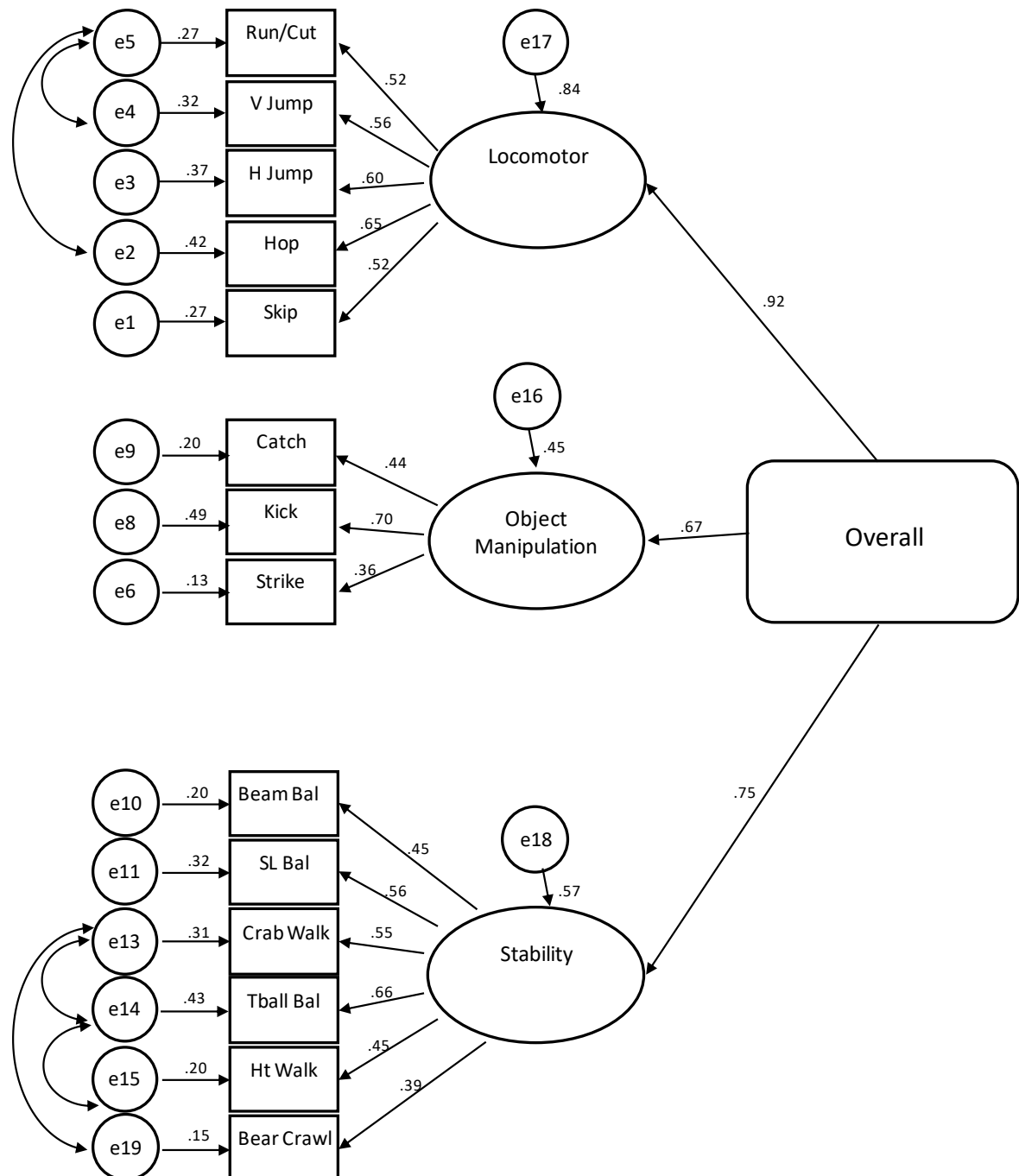


Figure 6.2: CFA Model 2

Goodness-of-fit indices obtained for Model 2 showed acceptable fit [CFI = .92, NFI = .75, TLI=.90, SRMR= .07, and RMSEA = .053 (90% CI: .00–.08)], albeit slightly poorer fit than Model 1. All indicator and factor loading were significant in Model 2.

Overall, locomotor skills had the highest factor loading (Model 2) (.92), followed by stability skills (.76) and then object manipulation skills (.67). In the locomotor domain, all indicators had similar loadings. In the object manipulation domain, kick had a substantially higher indicator loading (0.70 vs .36 and .44). In the stability domain, tennis-ball balance had the highest indicator loading (.66) while bear crawl had the lowest (.38).

The overall FMS concurrent (latent variable) explains 57% of the variance in stability factor, 45% of the variance in object manipulation factor, 84% of the variance in locomotor factor.

Convergent Validity

The relationship between FMS², the TGMD-3 and the FMSTM was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. There was a moderate, positive correlation between FMS² and the TGMD-3 ($r = .66$, $n = 102$, $p < .0005$). There was a low, positive correlation between FMS² and the FMSTM ($r = .48$, $n = 102$, $p < .0005$).

Age	n	TGMD-3		FMS ²		FMS TM	
		CS	%	CS	%	CS	%
8	22	34.05	56.75	67.29	56.54	9.05	43.10
9	20	35.45	59.09	74.28	62.42	9.53	45.40
10	25	36.76	61.27	75.78	63.68	9.89	47.09
11	26	37.46	62.44	76.92	64.64	10.16	48.38
12	9	39.33	65.56	78.17	65.69	10.63	50.60

[CS = composite score, % = percentage of max score]

Table 6.4: TGMD-3 (short version), FMS² and FMSTM average composite scores and percentage of their respective max scores by age

Discussion

The development of children's MC has been deemed important in the professional work of researchers, teachers, sports coaches, athletic therapists, and physiotherapists (Gavigan et al., 2022). The ability to accurately and easily assess these skills significantly contributes to practitioners ability to intervene and develop them (Chan, Ha, Ng, & Lubans, 2019). At present there are several barriers inhibiting practitioners from using MC assessments (Miller et al., 2018; Eddy et al., 2020), highlighting the need for a practical, time-efficient, easy to administer, ecologically valid tool that could assess MC more holistically than existing tools. The FMS² assessment tool was co-designed by an expert panel of academics and practitioners to be a targeted solution to these existing barriers (Gavigan et al., 2022). The aim of this study was to present the first preliminary findings investigating the structural and convergent validity of the FMS² assessment tool among 8–12-year-old primary school children. Overall, findings suggest that FMS² could be an effective tool to use with 8 to 12-year-old children, with CFA suggesting a good fit model, and convergent validity showing moderate, positive correlations with the TGMD-3 and low, positive correlations with the FMSTM.

It is evident from the literature that developing proficiency in all facets of MC is important for children, and can have wide reaching benefits to their overall health and wellbeing (Barnett et al., 2009; Behan et al., 2020; Duncan & Stanley, 2012; Duncan et al., 2013; Fitton Davies et al., 2021; Slotte et al., 2015). Despite this, recent studies have found that both the fundamental and functional movement skill proficiency of children both nationally and internationally is low (Hardy et al., 2013; Lester et al., 2017; Behan et al., 2019; O'Brien et al., 2022). The findings presented in this study appear to align with the low levels of both fundamental and functional movement skill proficiency reported in the literature (see Table 6.1).

Gender differences have been widely observed in the literature relating to both FMS and functional movement skills. It is suggested that males generally outperform females in overall FMS (Barnett et al., 2009; Cantell et al., 2008; O'Brien et al., 2015; Breslin et al., 2012; Lopes et al., 2011), whereas a recent study by O'Brien et al. (2022) suggest that females are slightly more proficient in functional movement skills than their male counterparts. The findings presented in this

study generally conform to that of existing literature. Examination of the FMS² subtests suggest that females generally reported higher mean scores in the locomotor subtest, whereas males recorded slightly higher scores on object manipulation skills. In addition, the FMSTM was the only assessment that recorded statistically significant gender differences with females outperforming males.

It was traditionally believed that FMS develop naturally, however research has shown that these skills must be taught and developed (Clark 2007; Haywood and Getchell 2019; Cools et al., 2009; Stodden et al., 2008). As children progress through the primary school years, you would expect that their FMS proficiency would significantly increase from year to year based on what they learn in their physical education classes. Surprisingly, there was not a statistically significant main effect for age in any of the assessments in this study. Examination of the composite scores (see Table 6.4) would suggest that children's proficiency seems to increase with age. Although, the sample size in this study was low and population-based conclusions cannot be drawn, the fact that there were not statistical differences in the various age groups, coupled with the low overall proficiency, suggest that the rate at which children in this sample are developing their MC is insufficient. It is therefore critical that practitioners, such as teachers, be given sufficient training, support, and resources so that they can make a greater, positive impact on children's FMS proficiency. These findings support those of previous intervention studies, who found that when provided with adequate support and training, generalists classroom teachers were able to significantly improve FMS proficiency amongst other health measures of their students (Sallis, McKenzie and Alcaraz, 1997; Mitchell et al., 2013; Gavigan et al., 2021).

Considering structural validity, the results of CFA support the three-factor structure of FMS² (see Figure 6.1). Examination of the factor loadings within this structure further highlight the critical importance of stability skills as a key component of MC, supporting the work of Rudd et al. (2015). The values of the goodness-of-fit indices obtained suggest a good fit for the overall model. Throw was removed from the second model due to its low factor loading (see Figure 6.2). This came as a surprise considering the frequency in which throw is included in other FMS-based assessment tools, as well as the value placed on it by the expert panel involved in designing the tool (Gavigan et al.,

2022). This finding may stem from a cultural perspective. According to the most recent Children's Sport Participation and Physical Activity (CSPPA) study, rugby was the only sport named among the most popular sports that Irish children participate in that includes a throwing element (Woods et al., 2018). Also, the throwing technique used in rugby is very different from the overhand throwing technique examined in most MC assessments. This raises the questions of whether a more universal skill should be considered to replace the overhand throw in such assessments, whether certain skills should be adapted to be culturally specific, or whether a greater sample would display the same results. Future research should explore these research questions.

Analysis of the factor loadings within Model 2 (see Figure 6.2) suggests that locomotor skills may be the most important contributor to overall MC, with a loading of 0.92. This is then followed by stability skills (0.75) and object manipulation skills (0.67). The value of locomotor skills has been well documented in the literature, with previous research reporting that locomotor skills are the first subset of MC to be associated with sports participation (Henrique et al., 2016), as well as some research showing it to be more strongly associated with PA participation than other MC subcomponents in childhood (Hamstra-Wright et al., 2006). This finding may suggest that locomotor skills should make up a greater percentage of MC interventions, with a suitable ratio then given to stability and object manipulation skills. Should this rationale be implemented, functional movement skills should also be embedded into the locomotor and stability ratios, considering the relationship between them (Harrison et al., 2021; O'Brien et al., 2021).

Convergent validity reflects the extent to which two measures capture a common construct (i.e. are the test's outcomes correlating with another validated testing battery in measuring the same construct) (Carlson and Herdman, 2012). As FMS² is the first tool designed to measure all elements of FMS (locomotor, object manipulation and stability) and consider functional movement skills, there was no one valid and reliable tool that was suitable to pair it with to examine convergent validity. Hence, the TGMD-3 and the FMSTM were considered as the most suitable tools to compare with. The TGMD-3 (short version) was selected because it was practical (the research team did not have the time or human resources to test the full TGMD-3 battery), it contained all of the locomotor

and object manipulation skills examined by the FMS² which would allow for a fair comparison, it has good reliability and validity (Webster and Ulrich, 2017) and it has been previously used in studies to assess the FMS proficiency of children (Mohammadi et al., 2017; Valentini, Zanella and Webster, 2017; Brusseau et al., 2018). The FMSTM was selected as it is the most commonly used assessment of functional movement (Liao, Zheng and Meng, 2017), it has good reliability (Minick et al., 2010; Gulgin and Hoogenboom, 2014; Reid et al., 2015; Stanek, Smith and Petrie, 2019) and it has been previously used to assess the functional movement skill proficiency of children (Duncan & Stanley, 2012; Nauta et al., 2015; O'Brien et al., 2022).

The results of this study found the FMS² to have a moderate ($r = .66$) and low ($r = .48$) correlation to the TGMD-3 (short version) and the FMSTM respectively. Although it may have been hypothesised that a greater correlation would be found, several factors could have contributed to the figures shown. For example, the TGMD-3 (short version) measures FMS, a key construct of MC, the FMS² was designed to assess more facets of MC, hence, the purpose of both tools differs slightly. The variations in the purpose of both tools would contribute to the correlation between the tools being reduced (Cools et al., 2009; Bardid et al., 2019). There are also differences in the skills that are assessed in both tools. Most significantly, FMS² has its own, unique stability section, whereas the TGMD-3 (full battery and sort version) does not contain stability skills, despite it being acknowledged as a key component of FMS (Rudd et al., 2015).

In addition to the skills themselves, the manner in which they are assessed also differs. While both FMS² and the TGMD-3 (shorter version) involve a process-based assessment of the skills, FMS² also uses product-based assessment to assess the object manipulation skills. Some evidence suggests that process and product-oriented assessments capture slightly different constructs (Logan et al., 2014), therefore, an assessment that combines both aspects of product and process assessment is likely to give a more complete picture of a child's MC proficiency (Lander et al., 2017), and may correlate less to the TGMD-3 (short version) that does not capture this.

Furthermore, a common criticism of the TGMD-3 (as well as other assessments) is that skills are assessed in quite a static manner which does not reflect the dynamic way skills are typically

performed by children during play and PA (Longmuir et al., 2015), which can also result in complete test battery's taking 20-60 minutes to administer per child (Lander et al., 2017). This makes them less feasible to use in many practical settings such as schools or sports clubs (Eddy et al., 2020). Interestingly, the average time taken to complete the FMS² assessment within this study was significantly lower at: 6 minutes and 34 seconds per child (Locomotor 2:18, Object manipulation 2:29, Stability 1:47 minutes per child). Although this study provides evidence supporting the use of a shorter version of the TGMD-3, the FMS² assessment may offer a more time-efficient, ecologically valid, and holistic assessment of MC.

In spite of the differences that have been highlighted between the TGMD-3 (short version) and the FMS² assessment tools, the moderate correlation found in this study ($r = .66$), is greater than that found in previous research examining the convergent validity of the full TGMD-3 battery to the Körperkoordinationstest für Kinder (KTK) ($r = .42$), and the Bruininks-Oseretsky Test of Motor Proficiency—2nd edition (BOT-2) ($r = .42$) respectively (Khodaverdi et al., 2020). Hence, these preliminary findings suggest that FMS² may be a more suitable comparative tool to the TGMD-3 than other existing tools, however further research is needed to confirm this hypothesis.

Examination of convergent validity also highlighted a low, positive correlation between FMS² and the FMSTM ($r = .48$). Similarly to the TGMD-3 (short version), the FMS² and FMSTM differ greatly in terms of their purpose, the skills that are assessed and also the manner in which they are assessed. As FMS² aims to capture both fundamental and functional movement skills, functional movement-based criteria are embedded into many of the skills in FMS². Hence, some skills may correlate better than others. Future research should examine the correlations between individual skills in both assessment tools to get a clearer understanding of where the similarities and differences lie between both tools. Moreover, Li et al. (2015) raised concerns as to the internal consistency of the FMSTM, suggesting that each skill in the assessment battery does not assess the same underlying variables (Li et al., 2015). Further research may be warranted to confirm this; however, the findings may further justify the need for future research to examine the correlation between individual skills from both batteries as opposed to composite scores, as well as providing justification for the need for

a new, more valid tool to measure the construct of MC more holistically. More recently, tools like the ChildFIRST have emerged as an alternative tool to measure the functional movement skill proficiency of children, however, at present there is a dearth of empirical evidence supporting this tools validity, reliability or feasibility. Should more evidence emerge in the future, this tool may offer an interesting comparison to FMS² that future research could explore.

Limitations

As previously mentioned, at the time of this study, access to schools was limited due to the COVID-19 pandemic. As a result, the time allowed in schools as well as the number of people allowed on site to collect data was limited. Hence, this study gathered data on a small, convenience sample, that, although adequate to complete the analysis, was not representative of the entire population of young children this age. Thus, further research and analysis should be conducted to compare these results with a larger, more diverse sample. Additionally, data could not be gathered using the entire test battery of the TGMD-3. Although the TGMD-3 (short version) was validated for use with this cohort, results using the full battery may have been different, and is an area that future research should explore. Additionally, although goodness-of-fit indices (NFI, TLI, RMSEA) suggest that the model was a good fit, other values (NFI and SRMR) fell slightly outside the desired range. Future research may seek to formulate this model again by adding/removing items to assess whether it results in a better fit. Finally, it should be acknowledged that other aspects of validity and reliability for this tool remain unverified (i.e. test-retest reliability, cross-cultural validity etc.). To further promote the use of this tool by researchers, teachers, coaches, physiotherapists or athletic therapists in practical settings, further research should be conducted to establish the tools validity and reliability in all areas of the COSMIN guidelines (Mokkink and Terwee, 2010).

Conclusion

The FMS² assessment tool was designed to be a more versatile assessment tool for use across various environments, as well as being the first tool to consider the evolving definition of MC (by considering both fundamental and functional movement skills). This study is the first to investigate the structural and convergent validity of this assessment tool. The findings presented in this study suggest that FMS² may be a unique tool in that it can assess components of both constructs of MC in a more time-efficient and ecologically valid manner than existing methods. Evidence provided also shows the tool has good structural validity supporting the three-factor structure. Further findings suggest that the tool may be a suitable measure of FMS proficiency in time-restricted settings, such as schools, however, further research is required to examine correlations between individual skills and other components (i.e. “add-on” features (Gavigan et al., 2022)) to functional movement assessments. Additional convergent validity research should examine the correlation between this tool and new MC assessments such as the MCA (Rodrigues et al., 2019), KTK3+ (Coppens et al., 2021), or the TMC (Sigmundsson, Lorås and Haga, 2016). Future research should also seek to continue to implement this solution, consolidate the existing validity findings with a larger and more diverse sample, and further explore the feasibility of the tool in “real-world” settings.

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Chapter 7: Conclusions and Future Directions

Overview of the Thesis

It is clear from the literature that many children, both nationally and internationally are falling well short of meeting the recommended minimum daily PA guidelines (Guthold et al., 2016; Aubert et al., 2018; Woods et al., 2018). Although a multitude of factors contribute to this outcome, a lack of proficiency in key movement skills is purported to be significantly linked (D'Hondt et al., 2014; Lloyd et al., 2014). Hence, the overarching aim of this PhD research study has been to enhance children's movement competence through the implementation and evaluation of the MWBW intervention, and the development and validation of the FMS² assessment tool.

Chapter 1 presented an introduction to the thesis. This chapter provided information on the background and significance of the research, as well as the overall aims and objectives of the study.

Chapter 2 critically reviewed the literature in the areas of PA, PL, MC, and functional movement. This chapter summarised, synthesised, and discussed the literature, providing a comprehensive overview of the research in these areas to date.

Chapter 3, the first study in this thesis, describes the process evaluation of the MWBW intervention in Irish primary schools. This was done by gathering a range of quantitative and qualitative data from coaches, teachers, principals, and participating children.

Chapter 4 sought to examine the efficacy of the MWBW intervention at improving children's FMS proficiency. It also investigated whether the intervention had differential effects on gender, and examined the impact that teacher fidelity had on the FMS improvement of the participating children.

Chapter 5 was a particularly novel study that aimed to develop a new, innovative assessment tool to measure the fundamental and functional movement skills of children aged 8-12. This tool was created using a Delphi poll method, gathering the knowledgeable opinion of a panel of worldwide expert academics and practitioners from a range of areas.

Chapter 6, the final study in this thesis, looked to examine the structural and convergent validity of the newly designed assessment tool.

Key Findings, Conclusions and Future Directions

Moving Well-Being Well

In 2000, the Medical Research Council (MRC) published a framework to help researchers and research funders to recognise and adopt appropriate methods of intervention development and evaluation (Medical Research Council, 2000). The framework suggests that interventions should be developed systematically, starting with a series of pilot studies, and moving on to an exploratory and then a definitive evaluation (Craig et al., 2008). As part of this development, process evaluations are identified as having a distinct and vital contribution in the development and evaluation of interventions (Evans, Scourfield, & Murphy, 2015). Despite the clear value of these studies, there are remarkably few examples of them in the literature (Hoddinott, 2015). The study described in chapter 3 of this thesis helps address this gap in the literature and provides what is, to the authors knowledge, the first example of a process evaluation of a PL-based intervention in Irish primary schools. The findings of this study will allow the research team to refine the intervention's content and delivery mechanisms, making the intervention more feasible for both teachers and coaches to deliver and sustain going forward. More broadly, the findings from this study may also inform other researchers who are seeking to design FMS-based games or interventions for children of this age cohort.

As well as ensuring that the delivery mechanism of the intervention is suitable as it is scaled up, ensuring that the outcomes of the intervention are retained is also critical. A recent systematic review by Lane et al. (2021) that examined the effectiveness of PA-based interventions as they are scaled up, found that the majority of interventions remained effective, however their effects were markedly lower than reported in the earlier trials (Lane et al., 2021). Thus, although previous research has suggested that the MWBW intervention can be an effective solution to enhance Irish primary school children's FMS, large-scale implementation and evaluation is a necessary step in proving that its efficacy does not diminish. Chapter 4 in this study examined this effectiveness, by delivering the

intervention to a large group of Irish primary school children. The findings of this study suggest that the MWBW intervention can be an effective solution to increase the FMS proficiency of Irish primary school children, with an average increase of 22.79%, almost a 7% increase from the previous iteration of the intervention carried out by Behan (2020). Given the substantial evidence linking FMS proficiency with future PA participation (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Jaakkola, Yli-Piipari, Huotari, Watt, & Liukkonen, 2016; Stodden et al., 2008) and the associated health benefits, along with the wider physical inactivity pandemic in Ireland and across the world (Hall, Laddu, Phillips, Lavie, & Arena, 2021), evidence supporting this intervention as a viable solution appear even more significant.

Future studies should now seek to consolidate and build on the findings presented in chapters 3 and 4 of this thesis and strengthen the body of evidence supporting MWBW as an effective means of enhancing primary school children's FMS, and upskilling generalist classroom teachers on the delivery of effective FMS-based PE classes. Whilst the data for this study took many demographics into account (i.e. gender, ethos, socioeconomic status etc.), all schools involved in the intervention were located in county Dublin. To ensure that these outcomes translate to similar schools in other counties in Ireland, the next iteration of the intervention should be delivered in a wider array of counties and provinces. Following additional refinement of the intervention based on the findings of this thesis, the next iteration of the intervention should entail the expansion of the intervention to a randomised control trial (RCT), in order to confirm the MWBW intervention as suitable for national dissemination. As all effective intervention programmes should, the MWBW intervention will continue to grow and evolve as new research emerges, so that it can continue to be as effective as possible for participating children, teachers, and coaches. Considering that functional movement skills have emerged as another key construct of overall MC for children to develop proficiency in, future iterations of the MWBW intervention may also evolve to incorporate a focus on developing functional movement skill proficiency in addition to FMS.

Content of an intervention is of course important to consider, however methods of delivery are known to be equally important to examine (James et al., 2017). One of the themes identified in

chapter 3 of this thesis suggested that the fidelity to which the MWBW intervention was delivered by teachers varied from site to site and between classes within schools. Implementation fidelity is described as the degree to which an intervention is delivered as intended, and is critical to the successful translation of evidence-based interventions into practice (Breitenstein et al., 2010). It is purported that diminished fidelity may be why interventions that work well in highly controlled trials may fail to yield similar outcomes when applied in “real life” contexts (Bellg et al., 2004; Breitenstein et al., 2010; Elliott & Mihalic, 2004). Moreover, the school environment can be a more complex environment than most to intervene (van Sluijs & Kriemler, 2016), and the degree to which teachers implement programmes can have a significant effect on the outcome. This effect was demonstrated by Brian et al. (2017), who found that, for every 1% increase in teacher fidelity when implementing an early years motor skill intervention, post-test FMS scores increased by .13 standard score points (Brian et al., 2017). Chapter 4 in this thesis sought to address this critical aspect of intervention delivery by understanding the effect that the teacher’s fidelity of implementation had on the FMS improvement of the participating children. The findings from this study highlights the critical role that teachers play in intervention outcomes and emphasises the fact that if the intervention is to continue to deliver positive outcomes, teachers must be given all the necessary supports and training that they need to implement the programme effectively. Hence, future iterations of the MWBW intervention must seek to further support teachers in their delivery. More broadly, these findings may inform researchers who are developing complex interventions that, as they scale up their interventions, they must also consider methods of supporting those delivering the intervention to ensure that fidelity of implementation can remain at an acceptable level to promote positive outcomes.

As the MWBW programme moves forward, the role of the coach will be critical in upskilling class teachers, supporting their delivery, and ensuring that the fidelity of implementation is consistently maintained at a high level. The MWBW programme is unique from other interventions in that it is partnered with a large national sporting body; the Gaelic Athletic Association (GAA). The GAA are the largest sporting body in the country and have a network of highly trained, capable,

and professional staff throughout Ireland. Building on this relationship is paramount if the MWBW programme is to be implemented nationally. The results from this exploratory trial report positive outcomes, and if a future RCT is successful, the final MWBW intervention could be a practical, scalable, sustainable, and cost-effective solution that can be disseminated nationally, potentially impacting primary school children's health at a societal level.

FMS²

In addition to children developing competence in FMS, recent literature has highlighted a range of positive outcomes associated with proficiency in functional movement skills (Coker & Herrick, 2020; Duncan, Stanley, & Wright, 2013; Fitton Davies, Sacko, Lyons, & Duncan, 2022; Lloyd et al., 2015; Pfeifer et al., 2019; Wang, Lin, Kulmala, Pesola, & Gao, 2021; Wu, Eungpinichpong, Ruan, Zhang, & Dong, 2021; Zalai, 2015). Consequently, the concept of MC has evolved to a more holistic one, identifying that children should seek to develop proficiency in both fundamental and functional movement skills (O'Brien, Duncan, Farmer, & Lester, 2018; O'Brien et al., 2021). In which case, assessment methods must also align with this more holistic viewpoint. At present, examination of the literature would suggest that there is no tool that examines all domains of FMS, that also incorporates functional movement skills, and is practical and feasible to use for practitioners in a range of environments.

Chapter 5 of this thesis sought to address this notable gap in the literature, by designing a new tool to measure both the fundamental and functional movement skills of children aged 8-12. The findings from this study present the content validity for this innovative, dualistic MC assessment tool, as well as outlining the key features that comprise the tool, such as the layout, structure, marking criteria, equipment required and additional features within the tool. In theory, the creation of this tool should make the assessment of MC much more accessible and feasible to many practitioners, allowing them to more accurately identify areas of development, track children's progress over time, and help practitioners give more focussed instruction and feedback (Lander et al. 2017); ultimately

contributing to children achieving a greater level of MC proficiency. In addition, the goal in developing this tool was to produce something that could be implemented across a range of settings. Having a tool that is suitable for use by researchers, teachers, coaches, athletic therapists, and physiotherapists, should facilitate greater collaborations, shared approaches to intervention development and evaluation, and more easily allow for comparisons of studies across various fields of expertise, or across countries, provided that the tool is widely adopted for use. Yet, before this tool can be recommended as a suitable tool for wide scale use, it must first undergo rigorous evaluation on all psychometric properties outlined in the COSMIN guidelines.

Thus, Chapter 6 of this thesis investigates the structural and convergent validity of the FMS² assessment tool. The findings from this study present the first preliminary evidence suggesting that the tool has good structural validity supporting the three-factor structure. Results also suggest that the tool shows moderate and low convergent validity with the most commonly used fundamental and functional movement assessment tools. The findings from this study should inform the research team of adaptations that can be made to the tool going forward, as well as identifying further areas of inquiry that should be followed (e.g. exploring convergent validity with other tools). In addition to validity and reliability, assessment tools that are developed to be used in practical settings (e.g. schools or sports clubs) must also be deemed practical and feasible to use by academics and practitioners who may make use of them in the course of their professional work. Hence, future research must seek to consolidate the preliminary findings outlined in this study as well as look to further validate the tool.

Provided a significant body of high-quality research confirms FMS² as a valid, reliable, and feasible measurement tool, the long-term ambition for this project is for it to become much more than just an assessment tool. The long-term ambition is for this tool to become a readily accessible app which academics, practitioners, clinicians, parents, and children can use as an assessment for learning tool to enhance children's MC. I believe that when fully developed, this concept could significantly transform the way children's MC is developed in a whole range of settings like schools, sports clubs, or even the home. I also believe FMS² could overcome several barriers that inhibit MC

development in children, by offering an educational tool in which to upskill generalist classroom teachers and volunteer youth sports coaches.

Research Strengths

- The MWBW intervention represents a culturally relevant intervention specifically designed and implemented for the Irish primary school cohort. Its method of delivery is unique in the fact that it partnered with the GAA and was able to use the existing infrastructure of community-based coaches to both implement the intervention and upskill the teachers in the school setting. This was achieved through an extensive CPD module that all participating coaches underwent.
- The multitude of sources of data collected in chapter 3 allowed for cross-data validity checks between the coaches, teachers, principals, and children, meaning that each separate data source could expand, enhance and clarify the others (Noonan, Boddy, Fairclough, & Knowles, 2016). This triangulation of the data ensures credibility of the findings (Nowell, Norris, White, & Moules, 2017).
- Whilst there are a number of examples of studies evaluating the effectiveness of FMS-based interventions in Irish primary schools (Bolger et al., 2018; Costello & Warne, 2020; Kelly et al., 2021), to the authors knowledge, the study described in chapter 3 of this thesis is the first process evaluation of a PL or FMS-based intervention in Irish primary schools.
- The studies outlined in chapters 3 and 4 utilise a large sample of 1st and 2nd class primary school children. The varied sample accounts for factors such as gender, school ethos and socioeconomic status. Given the clear links between FMS proficiency and PA participation and the associated health outcomes, the large sample size in this study suggests that the implementation of the MWBW intervention has the potential to make a significant positive difference to the participating children.

- Data collection in chapter 4 was completed using a uniquely designed iPad application (Behan, 2020). The app replaced the pen and paper process traditionally utilised in research of this nature (Ulrich, 2017). The utilisation of this app made data collection much more efficient by cutting down time manually inputting data. This process also reduced potential error through the manual data entry process whilst still complying with GDPR and institutional ethical guidelines.
- The diversity and level of expertise of the Delphi panel involved in chapter 5 was a real strength of this research project. Each area of expertise (research, sport, education, athletic therapy, and physiotherapy) was represented by both expert academics and practitioners. As a result, everyone's expertise was evenly considered in the Delphi process and the research team could be satisfied that each domain equally contributed to the design of the tool.
- Another strength of this study is that chapter 5 and 6 of this thesis target a new and emerging area of research. Only recently has the very definition of MC shifted and evolved to include fundamental and functional movement skills. This evolution has been partly reflected in a recent conceptual model proposed by Hulteen et al. (2018). The findings presented in this study should inform and guide future research in this area.
- Finally, a significant strength of this thesis is the statistical analyses employed throughout. The author believes that the most appropriate and relevant analyses were used for each study presented, and the increasing rigour of analyses utilised as the thesis progresses, also mirrors the authors progression as a researcher.

Research Limitations

- Although self-reported fidelity is a common measure used in school-based research (Domitrovich et al. 2008), the process evaluation study described in chapter 3 could have used a more robust measure for fidelity of implementation, such as observation by a member of the research team or peer observation (by coach). On the same note, the fidelity of implementation by the coach could also have been measured, given that the coach was responsible for the training of the teachers, and their level of guidance would have been reflected in the quality of lessons delivered by the teacher. This is an area that future iterations of the MWBW intervention should explore.
- A general limitation of a Delphi poll is that the results are specific to the panel of experts taking part, and a different group of expert participants may not produce the same responses, reflecting individual experiences and backgrounds.
- As a result of restrictions placed on schools due to the COVID-19 pandemic, the study outlined in chapter 6 consisted of a small, convenience sample, that, although adequate to complete the analysis, was not representative of the entire population of young children that age. Hence, the findings in this section might be considered preliminary, and further research and analysis should be conducted to compare these results with a larger, more diverse sample.
- Although the TGMD-3 (short version) was validated for use with the selected age cohort in chapter 6, results using the full battery may have produced a different result. Thus, future research should examine the construct validity of the FMS² assessment tool with the full TGMD-3 battery.
- As outlined at the beginning of this thesis, I have a specific philosophical position and previous experiences that could influence the interpretations outlined in the thesis. While it must be accepted as a limitation in that this could have had a potential bias on the narrative, I do feel this

was alleviated through implementing strong rigour throughout the research design, particularly through the verification process provided by the supervision of two senior academics.

A Final Word

To summarise, this thesis contributes to the field in several novel areas. Chapters 3 and 4 extend existing literature by evaluating both the effectiveness of the MWBW intervention, as well as examining the processes that contribute to both positive and negative outcomes. The exploratory trial of this intervention has shown encouraging signs, and with refinement, could contribute towards a solution towards addressing physical inactivity in Ireland. Chapters 5 and 6 of this thesis addresses a notable gap in the literature by creating a targeted solution to many of the barriers that prevent academics and practitioners from using MC assessments within their respective working environments. Although it must be acknowledged that the tool remains at an early stage of development, it has the potential to be an effective assessment for learning tool to help develop children's overall MC.

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Appendices

Appendix A: Examples of lesson plans from the Moving Well-Being Well intervention



Lesson 1

Skills Focus

Hopping
Catching
Throwing

This pack contains activities from the PDST Move Well, Move Often Resource.

The other side of this card contains a teacher aid that should accompany this lesson. This aid is aimed at assisting a teacher delivering the lesson.

Equipment required

- Cones
- Beanbags
- Tennis Balls
- Rolled up Newspaper



Insight

This project is being run by the School of Health and Human Performance in Dublin City University, in collaboration with the Insight Centre for Data Analytics

Supported by



DISCOVER-HOP



Description of Activity

Pupils find a space in the playing area. Invite pupils to practise hopping in a variety of different ways, using the following prompts:

- Hop on the spot, forwards, backwards, sideways
- Turn in the air and land with knees bent
- Hop as quietly/noisily/quickly/slowly as possible - alternating hard and soft landings
- Hop over a rope
- Hop on and off a movement spot
- Hop around the cones
- Hop at different levels - as high as you can, with little low hops or at a medium height
- Hop as far as you can for distance
- Practise hopping with a partner, mirroring their hops



Variations

- Arrange pupils in groups or pairs and invite them to explore a range of different hops. Design a hopping sequence and perform it for the rest of the group.
- Scatter PE equipment (cones, hoops, ropes, beanbags etc) around the playing area and invite pupils to hop around the space, hopping over each item they encounter on their way.

Equipment

Ropes, hoops, spot markers, cones,



- Remind pupils to land safely with a bended knee on the landing leg.
- Hopping can be a strenuous activity so pause at intervals to allow pupils to stretch. Remind pupils to alternate the hopping leg when they get tired. Alternatively, intersperse instructions for hopping activities with instructions for other locomotor skills such as running, skipping, jumping etc.
- Pause the activity at intervals to focus on the technique of hopping. Discuss some of the teaching points for hopping, invite a pupil to demonstrate the technique and then return to the activity.



- Practise hopping on one leg. Figure out how many hops you can do on this leg without stopping.



ag tuirlingt • crua • bog • téad • preab ard • preab íseal • ag casadh

DISCOVER HOP

7 MINS

Learning Intention:

Child is learning to to identify the hop pattern, by taking off and landing on the same foot

Key Questions:

Which foot is easier to hop on?

How many hops did you do?

Can you try hop on your other foot?

FMS Differentiation and Success Criteria



Notes:

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CATCH IT IF YOU CAN!



Description of Activity

Invite pupils to find a space in the playing area where they are not in contact with anyone else. Give each pupil a beanbag and invite them to practise throwing it up in the air and catching it while standing still. Include some of the following challenges:

- How many catches can you count before the beanbag drops?
- Can you clap before catching the beanbag?
- Can you clap under your leg before catching the beanbag?
- Can you turn around before catching the beanbag?

Invite pupils to walk around, still throwing the beanbag up in the air and catching it. Pupils count how many catches they complete while walking. Continue to provide instructions for challenges before the catch such as clap hands, click fingers, touch the ground, turn around etc.



Variations

- Use a ball instead of a beanbag.
- Complete the activity only while standing still, or while sitting.
- If the playing area is limited arrange the class in two groups, with one group catching on the move as the other group catches while standing still.

Equipment

An open playing area, beanbags (one per pupil)



- Ensure the playing area is open and free of obstruction.
- Encourage pupils to exercise caution and to look where they are going when walking and catching.
- Ensure pupils have their hands out in front of them in a good catching position.



- Practise this activity at home using a rolled up pair of socks, on your own or with a friend or family member.



an féidir leat í a ghabháil? • gabháil agus caitheamh • málaí pónaire • bualadh bos • Gabh é/i • Comhairigh

CATCH IT IF YOU CAN

9 MINS

Learning Intention:

Child is learning to explore different types of catches, while progressing at their own rate

Key Questions:

What type of catch could we do?

What else can we do instead of running?

FMS Differentiation and Success Criteria



Notes:

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LITTERBUG



ATHLETICS



GAMES



GYMNASTICS

Description of Activity

Arrange pupils in two groups. Place a dividing line using skipping ropes, cones or chalk markings on the ground between the two groups. Give each pupil a piece of old newspaper to scrunch up into a ball. On a given signal both groups begin to throw the paper balls out of their area and into the other groups area. Pupils continue throwing for a set period of time, throwing back the newspaper that lands on their side of the line. The winning group is the group that has fewer paper balls in their area at the end.



Reset the activity again, dividing up the newspaper balls and distributing them evenly to both groups. For the second round, pupils may only use one hand to pick up and throw the paper ball, keeping the other hand behind their back. Alternate the throwing hand to practise on both sides.

Variations

- Use soft balls or beanbags instead of newspaper balls.
- Divide the playing area in half and play two concurrent games.
- Arrange the pupils in four groups. Divide the playing area into four grids, with one group at each corner of the grid. Play four groups against each other.

Equipment

An open playing area, skipping ropes, cones, chalk, newspaper



- Ensure pupils throw the paper balls safely, aiming them for the ground and not at members of the opposing group.
- On the stop signal, pupils must freeze on the spot with their hands on their head to remove the temptation for one more throw.
- Recycle the newspaper after the game has concluded.
- Pause the activity at intervals to focus on the specific teaching points for throwing in the lesson. Invite a pupil to demonstrate correct technique, allow the pupils to practise in pairs with balls of paper, and then return to the activity. Provide feedback to individual pupils as they practise throwing during the activity.



- Draw a picture of you throwing in your PE journal.



roinnte i ndá ghrúpa • líne de cóin, téid scipeála • píosa páipéir • teorainn ama • ag caitheamh • cluiche a imirt

LITTERBUG

9 MINS

Learning Intention:

Child is learning to overhand throw by stepping with opposite foot and throwing a light object multiple times

Key Questions:

How could we improve our throw?

FMS Differentiation and Success Criteria



Notes:

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Lesson Notes:

What went well:

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What didn't work so well:

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Targets for next lesson:

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Appendix B: Examples of classroom activities from the Moving Well-Being Well intervention

Week 1

Vertical Jump & Catch



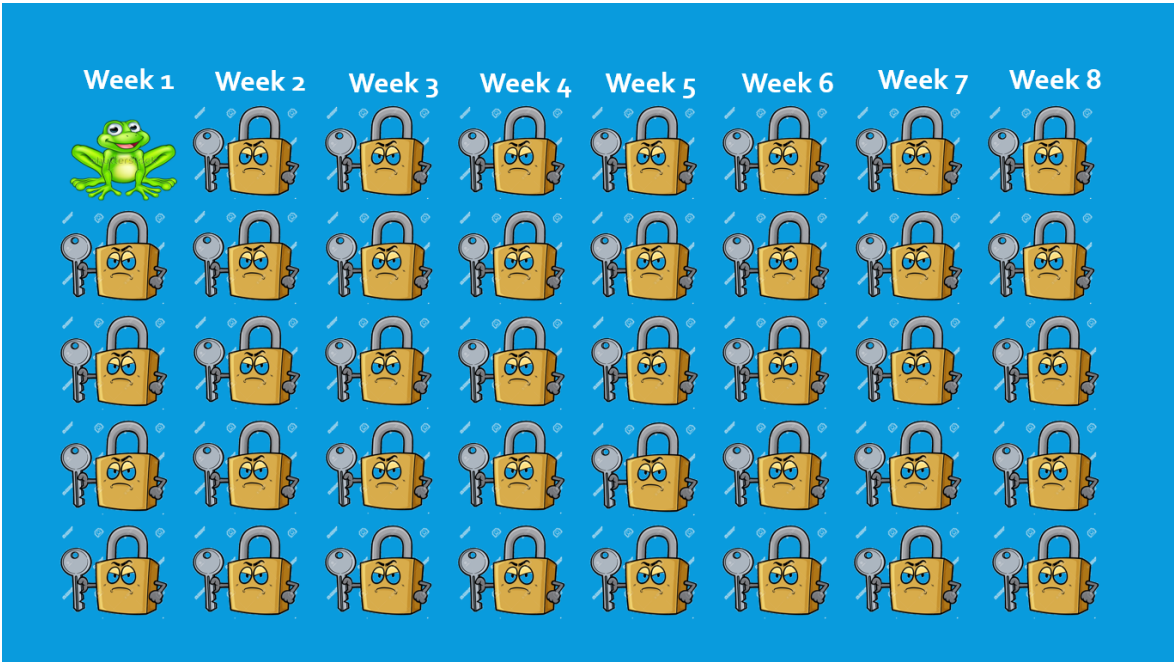
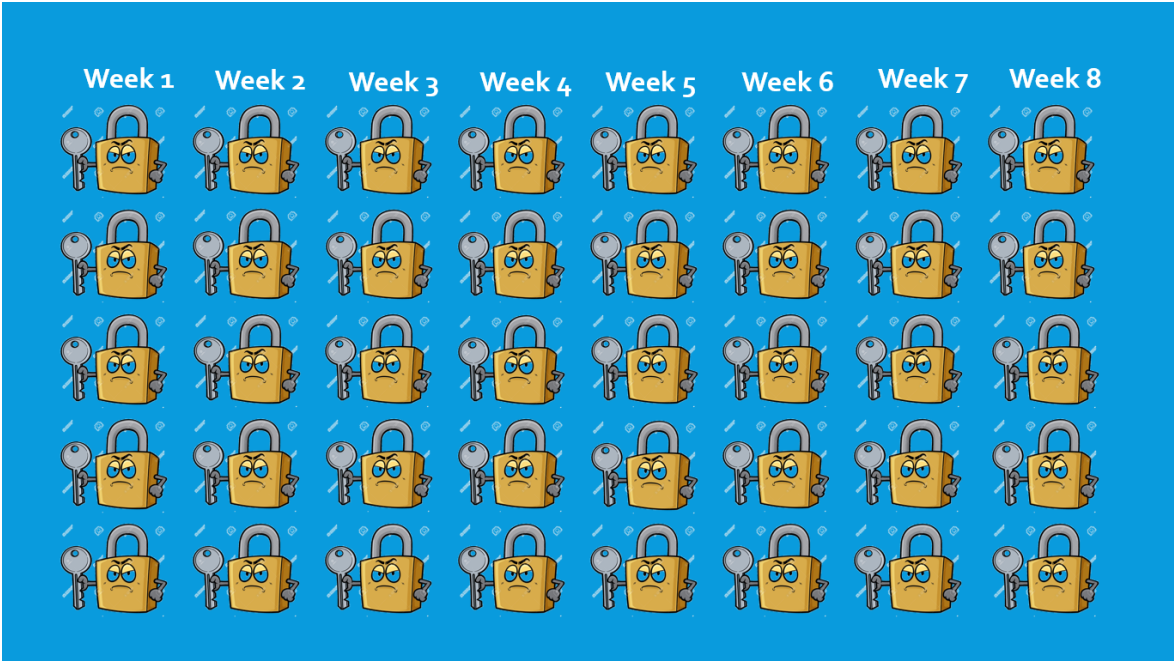
ARE YOU



READY



FOR
ACTIVITY?



IT'S FROG HUNCHES TIME!



Copy my Froggie friends here!

- Start by standing up.
- Stand with your legs a little wider than your shoulders and point your toes out.
- Now hunch down like a frog by bending your knees and touching the floor with your hands.
- Then stand back up.
- Nice work! Lets try and do 10!
- Got that? How about we try bouncing around the room? Make sure not to bump into anyone though!

IT'S FROG



Hey look! You're practically frogs!

How do you feel after that?

When you're able to hunch down nice and low that means your muscles are nice and bendy. Does anyone know what that called?

Flexible!

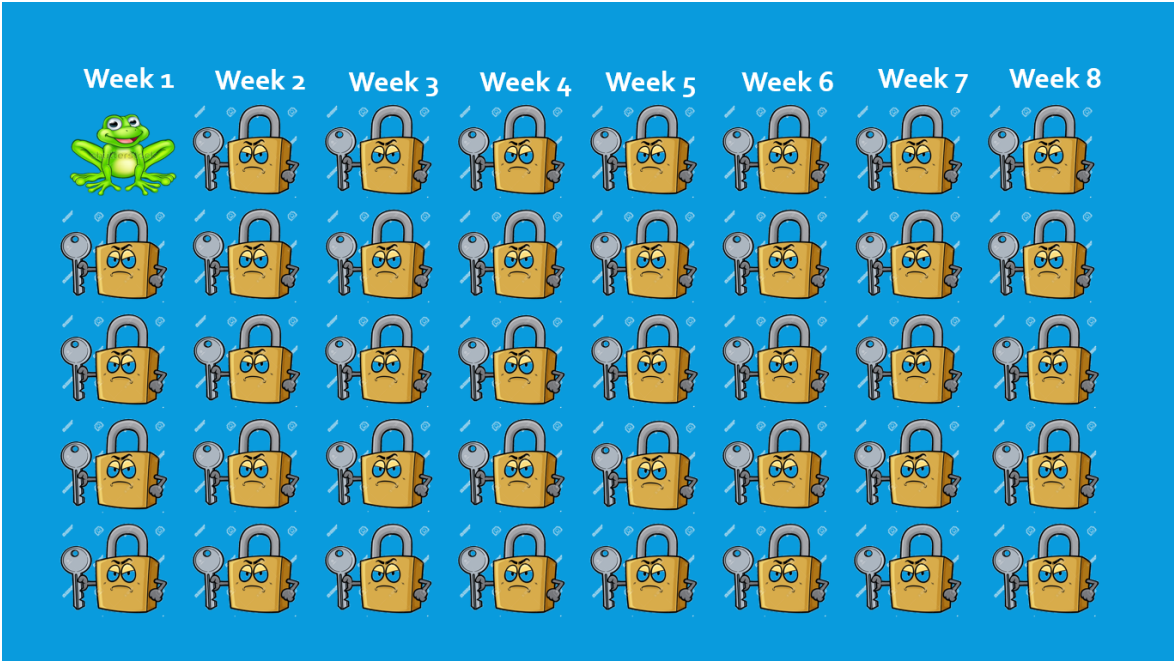


standing up.

der than your
out.

y bending your
with your hands.

bouncing around
ump into



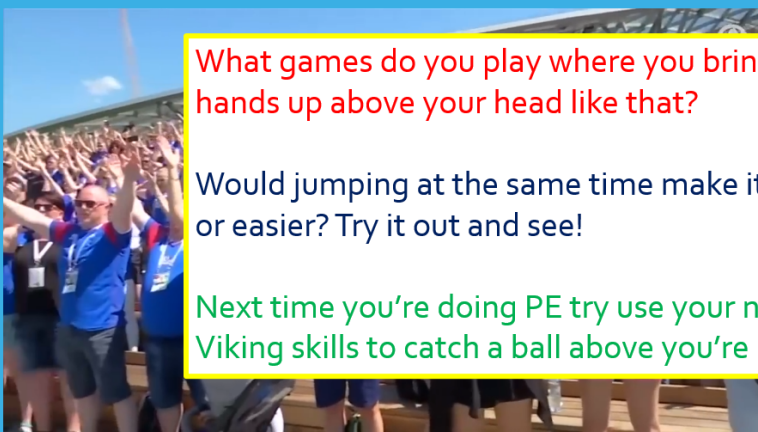
IT'S TIME....FOR THE THUNDER CLAP!



Get ready to show
me your inner
Viking and copy my
Icelandic friends.
Try to do it all
together!



IT'S TIME....FOR THE THUNDER CLAP!



What games do you play where you bring your
hands up above your head like that?

Would jumping at the same time make it harder
or easier? Try it out and see!

Next time you're doing PE try use your new
Viking skills to catch a ball above you're head!

Get ready to show
me your inner
Viking and copy my
Icelandic friends.
Try to do it all
together!



IT'S TIME....FOR THE THUNDER CLAP!

You look just like real Vikings!

Now you have to make up your own Viking handshake with the person beside you!

If you want to be a real Viking it has to include:

- A clap
- You have to be moving whilst doing it
- A high-5
- A Viking roar

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8

THE IMAGINARY CATCH

Let's try
and do 20!



- This movement is going to combine our frog hunch, star jumps and our Viking clap!
- Start with your feet about shoulder width apart.
- Bend your knees, put your bum back and remember: **Keep your head up and looking forward, you can't see the imaginary ball if you don't!**
- Then jump up as high as you can and bring your hands up and clap them. Just like you're catching something!
- **IMPORTANT TIP:** Try not to jump through the roof! Your teacher won't be happy!

THE IMAGINARY CATCH

Let's try
and do



Question time!

What other sports do you do this kind of movement?

Can you think of a game where you go from being in the frog position to jumping and throwing at the same time?



- **IMPORTANT TIP:** Try not to jump through the roof! Your teacher won't be happy!





Appendix C: Examples of home activity worksheets from the Moving Well-Being Well intervention

ACTIVITY - JUMPING



DESCRIPTION OF ACTIVITY

Ask someone at home to join in

1. Stand with your feet together and jump as high as you can. Be sure to land with both of your feet at the same time
2. Does crouching down before you jump help you jump higher?
3. Does using your arms help with your jump?
4. Ask mammy and daddy to do it too, who has the highest jump?
5. Can you think up any high jumping games? Play for 1 minute with someone at home



BRAINY BITS

How many minutes each day should you and other children do physical activities?

This is anything that makes your heart beat faster or makes you breath faster, like walking fast or running.

Use the clock and draw your answer in



Sometimes children watch television, play video games or play on the computer and on a phone.

What is the most time that children should look at a screen each day?

Do not count the time that you have to look at a screen to do your homework.

Use the clock and draw your answer in



ACTIVITY - JUMPING



DESCRIPTION OF ACTIVITY

Ask someone to join in

1. Stand with your feet together and jump as far as you can forward. Be sure to land with both of your feet at the same time and mark where you land.
2. Does crouching down before you jump help you jump further?
3. Does using your arms help with your jump?
4. Ask someone to do it too, who has the biggest jump?
5. Can you think up any high jumping games? Play for 1 minute with someone at home



BRAINY BITS

Physical activity is not just sport. Physical activity is any movement made by the body that uses energy. This includes sports, exercise and other activities such as playing in the playground or walking the dog. Can you find other physical activities in the wordsearch below?

HEALTHY WORD SEARCH:

- CYCLING
- GYMNASTICS
- WALKING
- DANCING
- RUNNING
- SWIMMING
- FOOTBALL
- SCOOTER
- TREE-CLIMBING



S	I	L	G	C	N	Q	G	T	G	Q	A	T	X
O	K	L	L	I	D	N	R	Y	E	R	I	R	R
U	U	A	Q	A	I	R	N	F	U	M	U	E	R
F	Y	O	T	L	B	N	J	N	K	G	Q	E	Q
T	S	P	C	E	A	T	N	N	J	N	D	C	F
A	Q	Y	A	S	B	I	O	M	U	I	A	L	T
L	C	C	T	U	N	O	R	O	K	K	N	I	J
O	Y	I	F	G	K	H	A	E	F	L	C	M	B
J	C	S	C	O	O	T	E	R	E	A	I	B	K
S	G	N	I	M	M	I	W	S	D	W	N	I	E
Z	P	S	W	H	Z	A	X	Q	T	I	G	N	J
A	B	N	G	U	P	O	H	M	I	K	N	G	C
J	B	Y	I	K	Y	N	G	Y	R	L	G	G	W
N	R	U	V	B	U	M	B	T	C	P	V	G	G



ACTIVITY - KICKING



DESCRIPTION OF ACTIVITY

Ask someone at home to join in

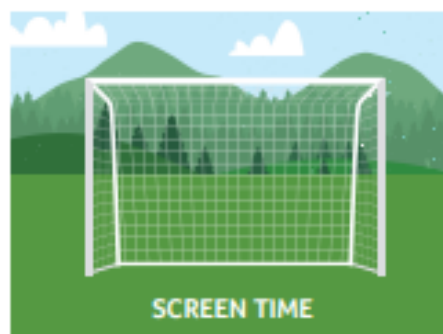
1. Get any ball and place it on the ground. Find a wall or make a target and kick the ball at it.
2. Can you kick with both feet?
3. How do you get a really big kick?
4. Ask someone to try kicking with you. Can they kick with both feet?



BRAINY BITS

Kick the balls that you think belong in each one. Draw an arrow from the ball into the correct goal!

1. Healthy Heart and Lungs
2. Sad
3. Strong
4. Happy



1



2



3



4



Appendix D: Screenshots of the iPad application used to assess children's FMS as part of the Moving Well-Being Well study

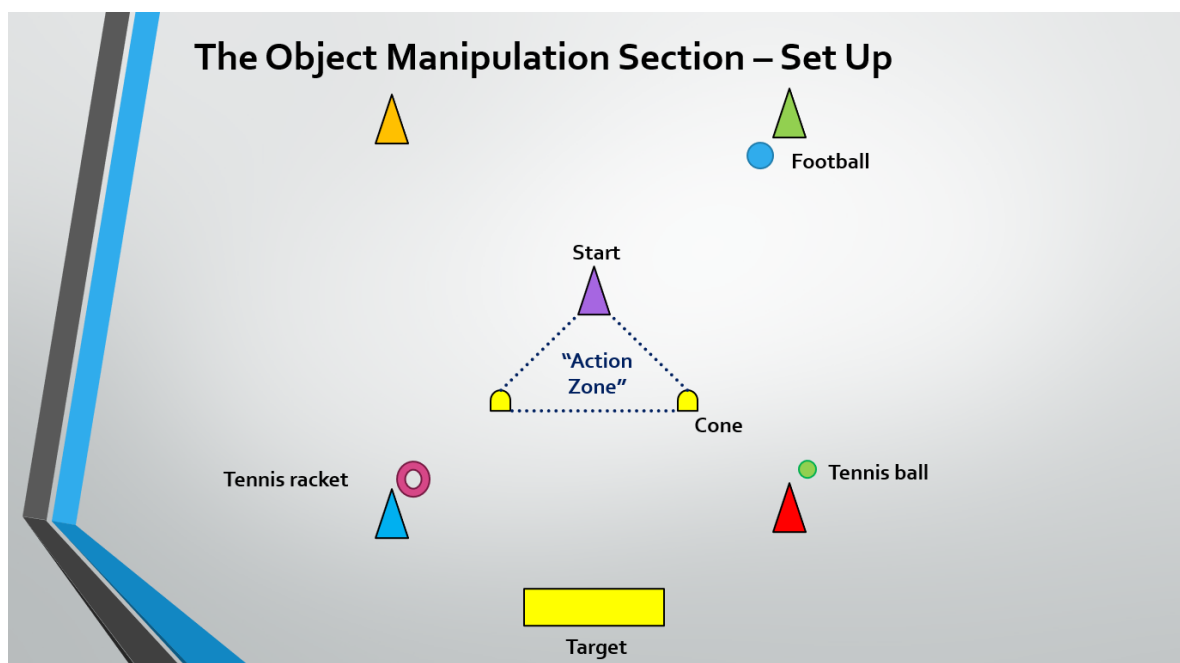
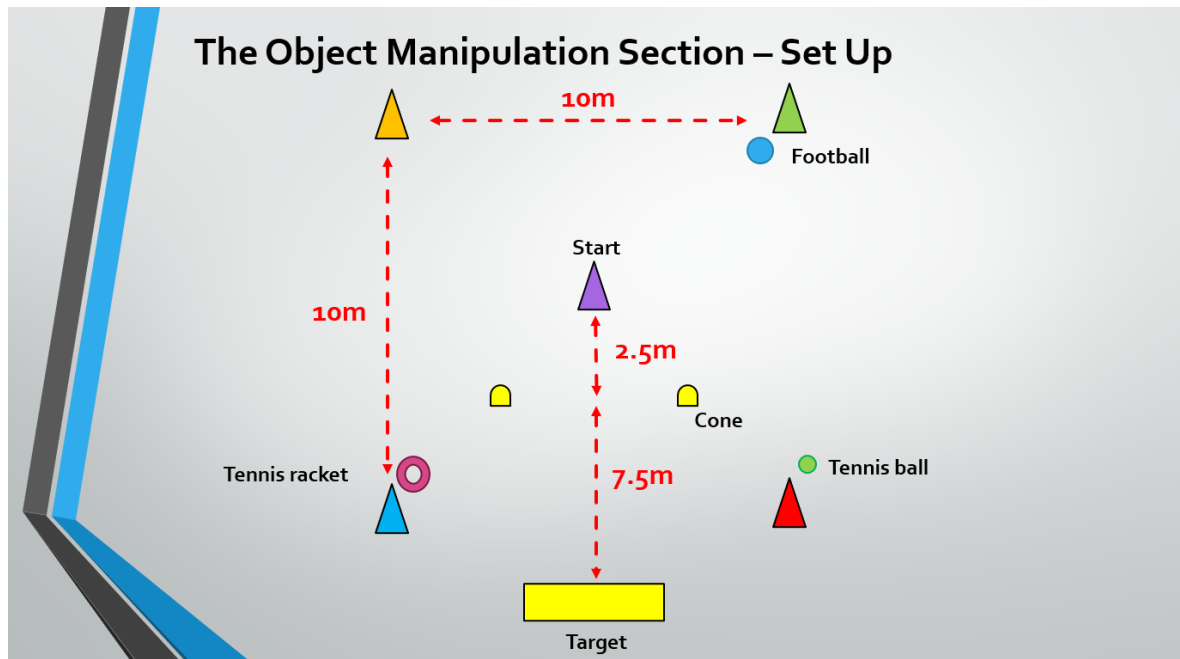
The top screenshot shows the 'Home' screen of the iPad application. It features a logo with two stylized figures and the text 'Moving Well Being Well'. Below the logo, it says 'Group Screen FMS'. There is a 'Choose Skill' button, a 'Candidate No.' field, and an 'ASSESS SKILL' button. A list of candidate numbers is visible on the right side of the screen.

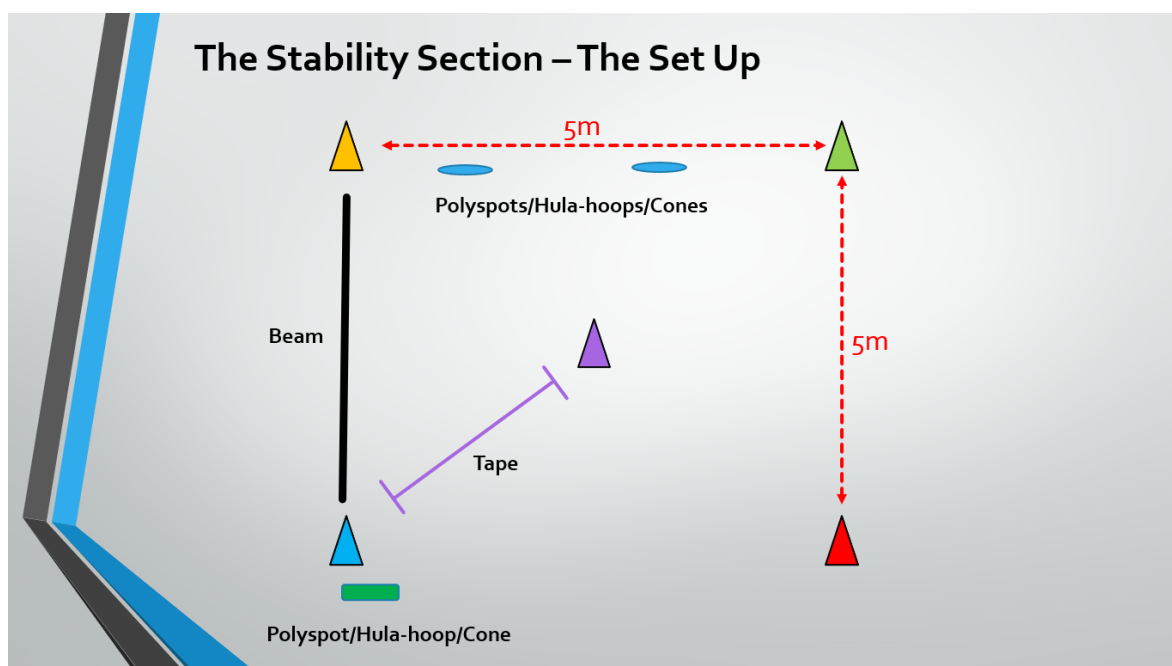
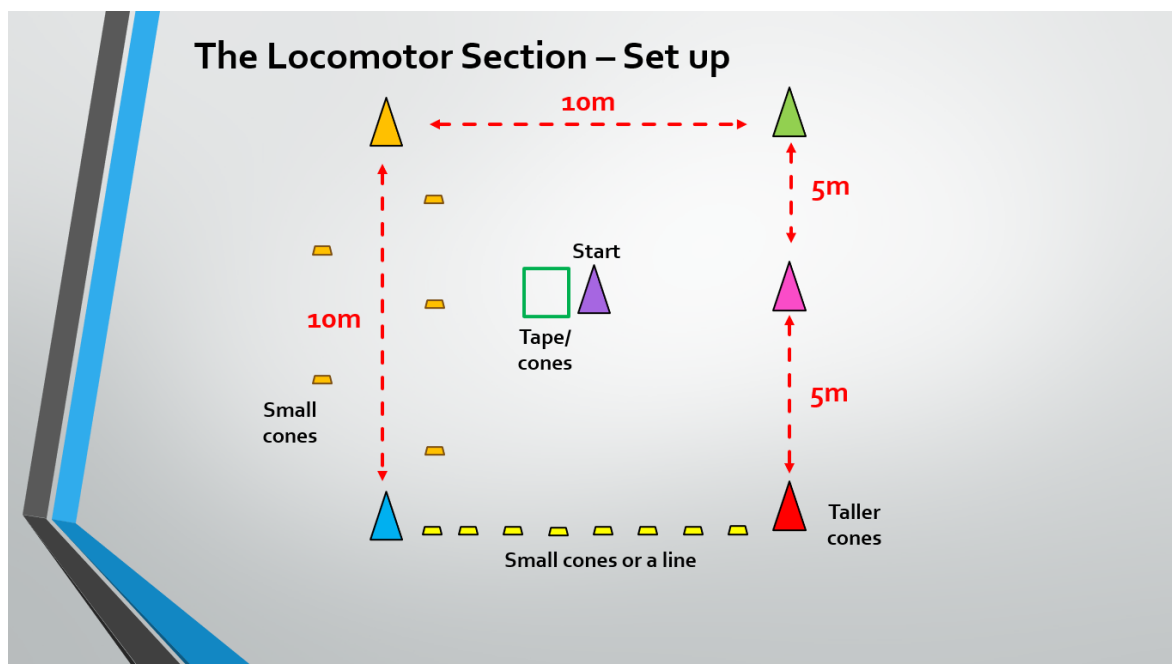
The bottom screenshot shows the 'Skill: Run' assessment screen. It includes a 'Back' button, a 'Skill' dropdown menu, and a 'Counter: 1/30'. The screen displays a table with criteria for running and scores for two trials and a total score.

Criteria	Trial 1	Trial 2	Total Score
Arms move in opposition to legs, elbows bent	☒	☒	2
Brief period where both feet are off the surface	☒	☒	2
Narrow foot placement landing on heels or toes (not flat footed)	☐	☐	0
Non-support leg bent about 90 degrees so foot is close to their buttocks	☒	☒	2
		Total Score	6

At the bottom of the screen, there is a 'Candidate No. = 050_01_01_02' field and a 'Save Score' button.

Appendix E: Diagrams of the layout of the FMS² assessment





Appendix F: The complex version of marking criteria created for the FMS² assessment tool

FMS² Object Manipulation Section

Student number: _____ Class: _____ Time taken: _____

	Catch		
1	Eyes track the flight of the ball		
2	Adjusts positions to put themselves in the flight path of the ball		
3	Arms extend up and out to meet the ball		
4	Ball is caught by the hands only (Not grasped to the body)		
5	Successful catch/Not caught		
	Total		

	Kick	Right	Left
1	Ball is controlled into the action zone prior to kick		
2	Smooth, continuous run-up to the ball		
3	Non-kicking foot is placed beside the ball		
4	Ball is kicked with the laces or inside of the foot (not toes)		
5	Target score (Green/Yellow/Red)		
	Total		

	Throw	Right	Left
1	Following the catch, child adjusts body position so that the non-dominant shoulder is facing the target		
2	Steps forward with the foot opposite the throwing hand, transferring their weight onto the front foot		
3	Arm is brought back behind the head whilst hip and shoulder rotate until the non-throwing side faces the target		
4	Throwing arm follows through pointing in the direction of the target		
5	Target score (Green/Yellow/Red)		
	Total		

	Strike	Forehand	Backhand
1	Steps in to meet the ball with the foot opposite the racket hand		
2	The hip and shoulder of the non-striking side faces the target		
3	Hips and shoulders rotate back to initiate strike with eyes fixed on the ball		
4	Ball is struck with the middle of the racket and follow through extends across the body		
5	Target score (Green/Yellow/Red)		
	Total		

FMS² Locomotor Section

	Run & Cut/Dodge		
1	Arms move in opposition to the legs (E.g. right arm – left leg)		
2	Outside foot plants outside the cone with toes pointing forward (Not out away from turn)		
3	Knees bend and hips lower entering the cut		
4	Trunk leans in the direction of the turn		
5	Use's rapid, small steps to stop in the square		
6	Trunk remains upright during deceleration (No excessive forward lean)		
	Total		

	Vertical Jump		
1	Knees are bent and rear is lowered into a squat position with arms extended down prior to take off		
2	Arms are propelled up over the head at take off		
3	Body extends up by pushing off the toes at the same time		
4	Both feet take-off and land together		
5	Landing is soft finishing in a semi-squat position		
	Total		

	Horizontal Jump		
1	Knees are bent and rear is lowered into a squat position with arms extended down and behind the body prior to take off		
2	Arms extend up and forward to propel the body forward		
3	Take-off pushes off the toes (both feet at the same time)		
4	Both feet take off and land together		
5	Landing is soft finishing in a squat position		
	Total		

	Hop	Right	Left
1	Non-hopping leg swings in an opposite manner to the hopping leg		
2	Arms swing to propel the child forward		
3	Trunk leans in the direction of the hop		
4	Knee remains aligned with the ankle and hip (No knee valgus)		
5	Child hops continuously in a smooth manner from one end to the other		
	Total		

	Skip		
1	Arms move in opposition to the legs		
2	A step is followed fluidly by a hop on the same foot		
3	Trunk remains upright throughout		
4	Skip is maintained smoothly all the way to the end		
	Total		

FMS² Stability Section

	The Beam Balance 360		
1	The body remains upright throughout		
2	Child completes 2 two-footed half turns on the middle section of the beam.		
3	Control is maintained for the duration of the beam		
	Total		

	Single-leg Balance	Right	Left
1	Body remains upright throughout		
2	Non-balancing leg is held above knee throughout		
3	Maintains balance for 10 seconds		
	Total		

	Bear Crawl		
1	Body/Trunk is parallel to the ground		
2	Minimal twisting of the body		
3	Opposite movement of arms and legs		
4	Child crawls continuously in a smooth manner from one end to the other without stopping or using the knee for balance		
	Total		

	Crab Walk		
1	Body/Trunk is parallel to the ground		
2	Minimal twisting of the body		
3	Opposite movement of arms and legs		
4	Child moves continuously in a smooth manner from one end to the other without stopping or using the bum for balance		
	Total		

	Tennis Ball Balance	Right	Left
1	Eyes remain fixed on the ball throughout		
2	Body remains upright throughout		
3	Non-balancing leg is held above knee throughout		
4	Maintains balance for 5 throws and catches		
	Total		

	Head Turning Walk		
1	Head turn movement performed smoothly		
2	Body remains upright throughout		
3	Heel-to-toe movement throughout		
4	Completes test without losing balance/moving off the line		
	Total		

Appendix G: The basic version of marking criteria created for the FMS² assessment tool

The Catch

Process Criteria
Changes position to put themselves in the flight path of the ball
Brings their hand(s) up and out to meet the ball
Tries to catch the ball using their hands only (Rather than grasping it into the body)

Product Criteria
Clean catch
Fumbled but caught
Not caught

The Kick

Process Criteria
Ball kept under control allowing for a smooth, continuous run up to the ball
Non-kicking foot is placed beside the ball when kicking
Ball is kicked with the laces or inside of the foot

Product Criteria
Hits Green target
Hits Yellow target
Hits Red target

The Throw

Process Criteria
Steps forward with the opposite foot to the throwing side prior to throw
Trunk rotates and throwing arm is brought back behind the head
Trunk rotates forwards and throwing arm points towards the target after the ball is released

Product Criteria
Hits Green target
Hits Yellow target
Hits Red target

The Strike

Process Criteria
Non-striking side faces the target
Shoulders and hips rotate to bring the racket back behind the body
Trunk rotates forwards and the racket points towards the target after the ball is struck

Product Criteria
Hits Green target
Hits Yellow target
Hits Red target

The Run & Cut/Dodge

Process Criteria
Arms move in opposition to the legs
Outside foot is planted and pushed off in each cut
Trunk is lowered when turning and leans in the direction of each cut
Use's rapid small steps to stop in the square

The Vertical Jump

Process Criteria
Knees are bent with rear lowered (Squat position) and arms extended down prior to jump
Arms are propelled up over the head and jump pushes off from the toes
Lands softly with hips and knees bent (Semi-squat position)

The Horizontal Jump

Process Criteria
Knees are bent with rear lowered (Squat position) and arms extended down and behind the body prior to jump
Arms are propelled up and forward and jump pushes off from the toes
Lands softly with hips and knees bent in squat position

The Hop

Process Criteria
The non-hopping leg swings in an opposite manner to the hopping leg
Arms swing to propel the child forward
Child hops continuously in a smooth manner from one end to the other

The Skip

Process Criteria
Arms move in opposition to the legs
A step is followed fluidly by a hop on the same foot
Skip is maintained smoothly all the way to the end

The Beam Balance 360

Process Criteria
The body remains upright throughout
Child performs 2, two-footed half-turns in the centre of the beam
Control is maintained for the duration of the beam

The Single-leg Balance

Process Criteria
The body remains upright throughout
Non-balancing leg is held above knee throughout
Control is maintained for Xs

The Bear Crawl

Process Criteria
Body/Trunk is parallel to the ground
Minimal twisting of the body
Opposite movement of arms and legs

The Crab Walk

Process Criteria
Body is kept parallel to the ground throughout
Minimal twisting of the body
Opposite movement of arms and legs

Vestibular Functioning - The tennis ball balance

Process Criteria
Body is kept upright throughout
Non-balancing leg remains higher than the knee throughout
Balance and control of the ball maintained throughout

Vestibular Functioning - The head turning balance

Process Criteria
Performs head turns smoothly without altering speed
Walks heel-to-toe with no separation
Foot remains on the line from start to finish