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University College Cork, Ireland

Investigating the relationship between perceived motor competence and actual motor competence in adolescent youth

Thesis presented by

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for the degree of

Doctor of Philosophy

University College Cork

School of Education

Head of School: Dr. Fiona Chambers

Supervisors: Dr. Wesley O'Brien, Dr. Sarahjane Belton, & Dr. Fiona Chambers

2022

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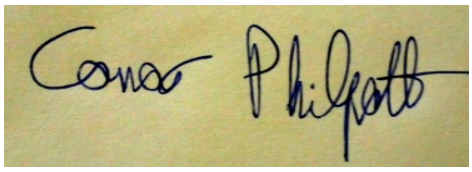
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Declaration

"This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism."

Candidate:	**ID:**	**Date**
		
Conor Philpott	**114362901**	**5th October 2022**

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Abstract

Investigating the relationship between perceived motor competence and actual motor competence in adolescent youth

Conor Philpott

Background: Research across the globe has highlighted that adolescents are lacking proficiency in fundamental movement skills (FMS) and functional movement patterns, i.e. in their actual motor competence (AMC). Additionally, research in the domain of self-perceptions illustrates that adolescents possess inordinate levels of perceived motor competence (PMC) relative to their low level of actual ability. Evaluating the role of the school community (i.e. physical education class and other classroom settings) in the development of AMC and realistic self-perceptions is key, as they form essential facets to growth in these areas. This PhD research encompassed three phases. The first phase saw the gathering of cross-sectional baseline motor competence data on adolescent youth by sex and school year (i.e. grade) across the first three years (Junior Cycle) of post-primary education. The second phase formed part of a randomised controlled trial (RCT) to examine and evaluate an eight-week multi-component, school-based motor competence intervention entitled Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency), and its role in improving the alignment between PMC and AMC among youth. A third phase of this research comprised of a validity and reliability study to gauge the utility of a tool (utilised in phase one and two) to assess PMC data among adolescent youth.

Methods: Phases one and two (baseline and RCT) recorded data among adolescents (phase one: N = 373; mean age: 14.38 ± 0.87 years; phase two: N= 324; mean age= 14.5 ± 0.88 years), in six schools (two all-male, two all-female, and two mixed-sex). In both phases, the primary outcomes measures involved 10 FMS (locomotor, object-control, and stability subsets) assessed through established measures the Test of Gross Motor Development-2 and the Get Skilled Get Active resource, in addition to 7 movements from the Functional Movement Screen™ (FMS™). Perceived Motor competence was assessed using the Project FLAME Perceived Movement

Competence Tool (PF-PMC) and the perceived functional motor competence tool. The Project FLAME intervention was structured around four components, the (i) Teacher component, (ii) Student component, (iii) Whole-School component and (iv) Digital component. Multi-level regression models were used to assess the effect of the intervention for improving the alignment between PMC and FMS. Age and sex were controlled for during these analyses, with interaction effects for the intervention and time assessed. The phase three reliability and validity study (N = 147; mean age: 13.61 ± .93 years) recruited participants from three second-level schools (one all-male, one all-female, and one mixed-sex) for a seven-day test-retest reliability assessment of the PF-PMC and concurrent validity which compared the PF-PMC with the pictorial scale of Perceived Movement Skill Competence (PMSC).

Results: Results from baseline data indicated that fundamental and functional movement proficiency remained low, with high levels of self-perception not reflective of AMC. Pre-Post-intervention data following the Project FLAME intervention trial observed no significant effect for the intervention on alignment between PMC and AMC, however a small significant relationship between PMC and AMC remained (β = .23, p < .001). Phase three reported strong concurrent validity between the PF-PMC and PMSC (r = 0.83, p<.001), in addition to excellent internal consistency, and test-retest reliability.

Discussion: The findings from phase one demonstrate the necessity for movement-oriented interventions in adolescent youth. Though prior research under the Project FLAME remit has previously demonstrated an ability to improve AMC in youth across 8-weeks, phase two indicates that an increase in the number of sessions may be needed to provoke greater alignment between PMC and AMC. Phase three illustrates that the PF-PMC is fit for use, though additional research for construct validity may be needed.

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Chapter 1

Introduction

1.1. Publications and Conference Proceedings.

Journal Articles Published

Philpott, C., Donovan, B., Belton, S., Lester, D., Chambers, F., & O'Brien, W. (2022). **Motor Competence Among Irish Adolescents: An Investigation of Sex Differences and Relatedness Between Fundamental Movement Skills and Functional Movement.** *Perceptual and Motor Skills*, 0(0). https://doi.org/10.1177/00315125221137182

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O'Brien, W., Khodaverdi, Z., Bolger, L. E., Murphy, O., **Philpott, C**., & Kearney, P. (2023). **Exploring Recommendations for Child and Adolescent Fundamental Movement Skills Development : A Narrative Review**. *International Journal of Environmental Research and Public Health*, *20*(4). https://doi.org/10.3390/ijerph20043278

O'Brien, W., Khodaverdi, Z., Bolger, L. E., Tarantino, G., **Philpott, C.,** & Neville, R. D. (2022). **The Assessment of Functional Movement in Children and Adolescents: A Systematic Review and Meta - Analysis**. *Sports Medicine*, *52*(1), 37–53. https://doi.org/https://doi.org/10.1007/s40279-021-01529-3

O'Brien, W., **Philpott, C.,** Lester, D., Belton, S., Duncan, M. J., Donovan, B., Chambers, F. C., & Utesch, T. (2021). **Motor competence assessment in physical education – Convergent validity between fundamental movement skills and**

functional movement assessments in adolescence. ***Physical Education and Sport Pedagogy*****,** *0*(0), 1–14. https://doi.org/10.1080/17408989.2021.1990241

Journal Articles under review

Philpott, C., Donovan, B., Belton, S., Lester, D., Chambers, F., Barnett, L., & O'Brien, W**. (2022). Validity and Reliability of the Project FLAME Perceived Movement Competence Scale in Irish adolescents.** Measurement in Physical Education and Exercise.

Oral Presentations

Philpott, C., Belton, S., Chambers, F., Lester, D., Barnett, L., Duncan, M., & O'Brien, W. (2022) Validity and Reliability of the Project FLAME Perceived Movement Competence Scale in Irish adolescents. ***PEPAYS Research Forum*****, Limerick**, Ireland.

Philpott, C., Utech, T., Belton, S., Donovan, B., Chambers, F., Lester, D., & O'Brien, W. (2021) Effects of an 8-week intervention targeting the veridicality of actual and perceived motor competence in adolescents in Project FLAME. ***International Motor Development Research Consortium Online***, Greece.

Philpott, C., Donovan, B., Belton, S., Lester, D., Duncan, M. J., Chambers, F., & O'Brien, W. (2020). Investigating the age-related association between perceived motor competence and actual motor competence in adolescent youth in Project FLAME. ***North American Motor Development Research Consortium Online***, South Carolina, USA.

Donovan, B., **Philpott, C.,** Belton, S., Lester, D, & O'Brien, W. (2020). The Refinement and Development of the Project FLAME Movement Oriented Intervention in Ireland. ***UK and Ireland Children's Motor Competence Network*****,** Liverpool, UK.

O'Brien, W., Lester, D., Donovan, B., **Philpott, C.,** Duncan, M., & Belton, S. (September 2019). Putting a focused lens on Irish adolescent movement skill

proficiency. ***International Motor Development Research Consortium (I-MDRC),*** Verona, Italy.

Poster Presentations

Philpott, C., Donovan, B., Belton, S., Lester, D, & O'Brien, W. (2020). Project FLAME- Exploring a new avenue for PMC. ***UK and Ireland Children's Motor Competence Network***, Liverpool.

Philpott, C., Donovan, B, Belton, S., Lester, D, & O'Brien, W. (2019). Project FLAME- A School-Friendly Approach to Holistic Motor Competence Data Collection. ***Healthy and Active Children Conference organised by I-MDRC & CIAPSE***, Verona.

Philpott, C., Donovan, B; Belton, S; O'Brien, W.(2018). To evaluate the efficacy of the Project FLAME intervention in the development of adolescent physical literacy. ***PEPAYS Research Forum***, Limerick (Ireland).

Lester, D., **Philpott, C**., Belton, S., Duncan, M., Donovan, B., Chambers, F., Utesch, T., O'Brien, W. (2022). The Practicalities of assessing motor competence in a holistic manner- how Project FLAME measures both fundamental movement skills and functional movement at a secondary school level. ***AISEP Specialist Seminar- Motor competence in educational settings***. Brixen-Bressanone, Italy.

Donovan, B., **Philpott, C.,** Belton, S., Lester, D, & O'Brien, W. (2019). The Refinement and Development of the Project FLAME Movement Oriented Intervention in Ireland. ***British Heart Foundation: Motor Competence in Children- The Forgotten Pathway Conference,*** Coventry, UK.

O'Brien, W; Philpott, C; Donovan, B; Lester, D. 2019). Evaluating and Developing Project FLAME (Fundamental & Functional Literacy For Activity and Movement Efficiency. ***PHE Canada Research Council Forum***, Montreal, Canada.

1.2. Introduction to Thesis.

1.2.1. Background

Within the field of health and exercise sciences, two critical terms continuously appear when evaluating the health status of a population. These terms are physical activity (PA) and overweight/obesity. PA is defined by the World Health Organisation (WHO) as “bodily movement produced by skeletal muscles that requires energy expenditure – including activities undertaken while working, playing, carrying out household chores, travelling” (WHO, 2018). Overweight and obesity refers to: ''abnormal or excessive fat accumulation that presents a risk to health'' (WHO, 2020, p.IX,). Failure to obtain sufficient PA (i.e. inactivity) represents a great risk to personal health (WHO, 2010). The combination of an overweight or obese weight status, and a failure to meet PA guidelines culminates in a high risk for mortality (Guthold et al., 2018). Prominent mediators of PA and obesity include motor competence (i.e. MC, referring to an individual’s ability to perform any form of goal-directed human movement) and perceived motor competence (PMC), which is one’s belief in their ability to perform skills in context respectively (Bardid et al., 2019, Estevan & Barnett, 2018). These mediating factors form essential components in practical efforts to improve PA and weight status in helping children and adolescents to develop the skills and lifelong positive attitudes towards PA (Belton et al., 2019; Lai et al., 2014; Lubans et al., 2010).

1.2.2 Motor Competence, Perceived Motor competence, and their role in PA and health

Individuals with a higher weight status have been shown to possess lower levels of MC across both systematic reviews and empirical studies (Barnett et al., 2022; Cattuzzo et al., 2016; Chagas et al., 2021). It is difficult to determine if poor motor skills are a precursor or a consequence of an unhealthy weight status, though a recent systematic review has highlighted the presence of a bidirectional relationship between these variables (Barnett et al., 2022; Chagas et al., 2021).

According to Stodden's developmental mode of MC theory, high levels of MC will contribute to greater PA. This combination of higher MC and greater PA will contribute to reduced weight status, and greater levels of skill and physical fitness (Stodden et al., 2008). These elements interact in a bidirectional manner (i.e. greater skill, lower weight, more PA, better state of health-related physical fitness), referred to as a positive spiral of engagement (Barnett et al., 2022; Robinson et al., 2015; Stodden et al., 2008). A negative spiral of disengagement is a probable outcome if MC is not sufficiently developed and targeted (Robinson et al., 2015; Stodden et al., 2008). A negative spiral is likely to result in high weight status (i.e. overweight or obesity), low levels of skill, as well as low levels of physical fitness and PA (Robinson et al., 2015; Stodden et al., 2008). While the pathways from higher MC to improved weight status, and from greater levels of MC to physical fitness would appear to be supported by research-informed evidence, the extent of the relationship between MC and PA has been scrutinised of late (Barnett et al., 2022; Cattuzzo et al., 2016). The Barnett et al. (2022) systematic review of typically developing children aged 2-18 years of age reported the relationship from MC to PA as indeterminate, with just 41% of analyses (26/63) derived from 19 studies providing significant evidence of a pathway between MC and PA (Barnett et al., 2022). This strong systematic review evidence is a surprising contrast in light of research from prior reviews, and studies noting a consistent association between MC and PA (Graham et al., 2022; Jaakkola et al., 2016; Lubans et al., 2010).

Currently, global levels of MC could be described as poor, perhaps due to the increased sedentary and physically inactive lifestyles of modern children and teenagers (Bolger et al., 2021; Lopes et al., 2021). Irish MC research typically assesses MC through fundamental movement skills (FMS), these skills are the rudimentary building blocks which contribute to lifelong PA, and are typically divided into three subsets; locomotor (transport skills i.e. walking, running, jumping), object-control (using a ball or a bat e.g. kicking, striking, throwing), and stability (balance skills) (Gallahue et al., 2019). FMS are often synonymous with the idea of MC, though other research acknowledges that MC is construed as being more comprehensive than FMS alone (Bardid et al., 2019; Logan et al., 2018; Utesch & Bardid, 2019). Irish children

and adolescents possess subpar movement skills, with evidence of stagnation or delays among the adolescent group (Behan et al., 2019; Duncan et al., 2022; Kelly et al., 2020; Lester et al., 2017; McGrane et al., 2018).

FMS, much like MC, are a key contributor to health-related physical fitness in children and adolescents, with those who display higher FMS are also found to accumulate more PA, and greater cardiorespiratory fitness (Bremer & Cairney, 2018; Logan et al., 2015; Lubans et al., 2010). Previous research has also noted higher FMS being associated with lower BMI and while this association is not causative, it reiterates the importance of MC as a strategy to address and manage weight status appropriately (Behan et al., 2022; O'Brien et al., 2016a, 2016b). In addition to MC and FMS, and their role in PA and healthy behaviours, another important personal factor, that of PMC is worth noting.

Stodden's developmental model of MC notes that positive self-perceptions and one's belief in their skill performance (i.e. PMC) have the potential to contribute to increasing physical activity and skill level, while also serving as a variable that contributes to reducing weight status (Stodden et al., 2008). Lower perceptions being associated with increased weight has been affirmed in several studies (Fairclough et al., 2012; Morrison et al., 2018; Utesch et al., 2018). Debate arises with regard to perceptions and PA. A recent systematic review and meta-analysis of 13 studies examined pathways from PA to MC, with PMC analysed as a mediating variable (Barnett et al., 2022); from this study, only 5 of the included studies found evidence in favour this PA and MC pathway. Conversely, no evidence for the MC to PA pathway was observed when PMC served as a specific mediating variable (Barnett et al., 2022). This review did note that a mediating effect is more likely to occur in later childhood and adolescent groups as all evidence in favour of the PA to MC (PMC as mediator), and MC to PA (PMC as mediator) pathways was observed in children older than 9 years old (Barnett et al., 2022). Further studies affirm the latter point, with older adolescent-centred research highlighting that higher levels of PMC can contribute to motivation to participate in PA and in Physical Education (Bardid et al., 2016; Estevan et al., 2021a; Visser et al., 2020).

Recent research examining the alignment between perception and ability notes that high perception levels aligned with high actual ability levels important to skill ability and development, and sustained and long-term patterns of PA (Utesch et al., 2018; Estevan et al., 2021b). In contemporary research, high levels of PMC or physical self-perception in contrast to low actual levels of ability have been noted in numerous diverse studies in Ireland (McGrane et al., 2017; O'Brien et al., 2018), Belgium (Bardid et al., 2016), America (De Meester et al., 2016), and Australia (Rogers et al., 2018).

In children and youth, the repeated high perception levels observed in spite of the low actual ability suggests that targeting actual skill abilities as a means to improve their alignment may be necessary, in light of the evidence on the importance of skill and perception alignment for longer-term PA (Utesch et al., 2018; Estevan et al., 2021b). By targeting MC at the heart of a model of movement development, educators and coaches can nurture perceptions, PA levels, and improve health and physical fitness to manage weight status (Cattuzzo et al., 2016; Stodden et al., 2008). Targeting actual ability may develop the necessary level of understanding and knowledge of movement capacity, which culminates in realistic self-evaluations which improve the accuracy in the relationship between PMC and MC (Kruger & Dunning, 1999; Stanley & Krakauer, 2013). Such intervention approaches targeting actual skills have previously proven efficacious in boosting self-perceptions (Bryant et al., 2016; Lander et al., 2019). This also links well with recent research on the importance of promoting cognitive learning and understanding within PE, as it is an area which is underserved (Belton et al., 2022; Dudley et al., 2022). In addition to PMC, and FMS, other aspects of movement may serve an essential and functional role to the growth and development of an individual. Functional Movement, refers to moving the body effectively and efficiently, with proper muscle and joint functioning and commonly comprises of assessing elements such as core stability, thoracic mobility and shoulder mobility (O'Brien et al., 2022; Cook et al., 2006a). These elements are not only pivotal to many forms of sport and PA, a high level of performance of them may be pertinent to greater health and improved quality of life (O'Brien et al., 2022; Lim & Park, 2019).

1.2.3. Functional Movement- A new component of MC?

While not commonly viewed as a branch of MC, functional movement is a component of effective and safe physical movement (Coker, 2018; Cook et al., 2006a; Duncan et al., 2013). There is some evidence of an association between functional movement concepts and more commonly assessed elements of MC. Thoracic mobility is required in the performance of different functional movement tests, and is necessary for the performance of locomotor skills (Campa et al., 2019a; Kramer et al., 2019; Mason et al., 2016). As certain functional movement patterns (example deep squat, trunk-stability push-up) are akin to common resistance training exercises, functional movement elements could be seen as 'foundational movements' to PA and sport (Hulteen et al., 2018). It is unclear if poor functional movement in children and youth are a precursor to poor FMS and MC, or if poor FMS and MC precedes for low functional movement levels (O'Brien et al., 2022).

Developing elements of flexibility and mobility as assessed through functional movement interventions are likely to assist with the performance of MC, suggesting that the inclusion of functional movement within MC development programmes would prove beneficial (Cattuzzo et al., 2016; O'Brien et al., 2021). Notably, functional movement and MC both possess a relationship with body mass index (BMI), with high level of ability in MC (and functional movement) typically corresponding with an individual possessing a low BMI (Barnett et al., 2022; O'Brien et al., 2022). This shared connection suggests that a rounded MC development programme which focuses on functional movement and MC/FMS could prove helpful to addressing global health concerns of low PA and high BMI (Barnett et al., 2022; O'Brien et al., 2022; Stodden et al., 2008). Given the open-ended definition of MC, the incorporation of functional movement into the domain of MC research appears logical, given the associations between functional movement performance and markers of health in children and youth (Cattuzzo et al., 2020; O'Brien et al., 2022).

Functional Movement patterns across the globe could be characterised as average, with several studies noting that adolescent participants fail to obtain maximal scores during performance (Abraham et al., 2015; O'Brien et al., 2022). Irish research similarly notes deficits in flexibility and mobility among adolescents, with Irish performers failing to register above the normative values established for adolescent populations (Lester et al., 2017; O'Brien et al., 2018). Working on flexibility and mobility through exercises such as yoga, Pilates, and appropriate warm-up techniques are among efficacious techniques to develop functional movement, with positive functional movement development seen in as little as 6 weeks (Campa et al., 2019b; Coker, 2018; Lim & Park, 2019). The low cost and easy implementation for these strategies, suggests that the inclusion of functional movement interventions in sporting or schooling contexts may aid physical performance (Baron et al., 2020).

The school setting has frequently been suggested as the ideal avenue for delivery of PA and MC interventions due to the mandated time for Physical Education (PE) afforded to children and adolescents, and the provision of qualified subject-specific specialists (Lai et al., 2014; Tompsett et al., 2017). School-centred interventions from pre-school to second-level schooling have previously demonstrated effective results for improving FMS and functional movement across the globe in Ireland (Belton et al., 2019; Kelly et al., 2021), Britain (Bryant et al., 2016; Duncan et al., 2019), America (Brian & Taunton, 2018; Coker 2018), China (Chan et al., 2019), and Australia (Lander et al., 2017).

While physical education class is critical for developing skills, increasing involvement from the wider school body, and the home environment is essential to nurturing longer-term skill and self-perception growth (Belton et al., 2019; Ma et al., 2021). The home and community setting plays an essential role in supporting children to develop their MC and PA, as parental and sibling involvement influences children in their PA patterns (Petersen et al., 2020; Serrano-Sanchez et al., 2011). This is particularly pertinent in Ireland, where only 23% of Irish secondary schools meet the current government recommended allotments for physical education (120-minutes a week is recommended), and 18% of primary school pupils receive less than 30

minutes of physical education a week (Woods et al., 2018). A commitment from outside of physical education is necessary to appropriately develop skills and positive levels of self-perception (Cohen et al., 2015; Lubans et al., 2012; Smith et al., 2012). The use of multiple stakeholders (i.e. parents, whole-school body, community sport etc.) can contribute to tackling the problem on different fronts, while providing the positive environment conducive to skill development and positive growth in self-perception (Ma et al., 2021; Van Sluijs et al., 2021).

1.3. Significance of the Study.

This research study intends to examine the extent of the relationship between PMC and MC among Irish adolescents. This study based on previously established protocol and evidence-based practice, will examine the growth and evolution of PMC among adolescents, who undergo a period of heightened vulnerability due to the biological and social upheaval they experience during this time (Bandura, 2005; Lalor et al., 2007).

This study will provide insight and reflection into the effectiveness of Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency), a movement-oriented intervention centred on the first three years of post-primary schooling in Ireland, on several levels (Lester, 2020). It will examine its ability to develop Actual Motor Competence (AMC; actual motor competence and MC are essentially the same term as outlined in definitions section) and PMC in adolescents, establishing the reliability and validity of a PMC tool for use with adolescents, in addition to providing information on the potential of the Project FLAME intervention to improve the alignment and accuracy of PMC and MC. This study will provide detail on the project's feasibility and capacity for dissemination at a local or national level.

Project FLAME was initially developed under the premise that improving FMS and functional movement may arrest the decline in PA among Irish adolescents (Robinson et al., 2015; Stodden et al., 2008). While this remains a central tenet of the project, examining the relationship between FMS, functional movement, and PMC is pivotal. This will help identify if pedagogical tools and activities designed for use

within FLAME are adequately improving skill ability and students' understanding of the process behind skill performance. Examining PMC is vital to evaluating if adolescents possess both a level of self-efficacy in their skills, in addition to them having the knowledge and understanding of what constitutes strong performance in order to execute them in different and varied settings (De Meester et al., 2020; Stanley & Krakauer, 2013).

This study was based on an experimental research design (i.e., pre- and post-intervention data collection time points), utilising a randomised controlled trial design (Campbell et al., 2000). A positivist research paradigm and conceptual framework served as the foundation of the study. Informed by the developmental model of MC, further theoretical constructs were essential to the development of the Project FLAME intervention, principally dynamic systems theory, competence motivation theory, and mastery motivational climate (Newell, 1985; Thelen, 2005; Harter, 1978).

In brief, dynamic systems theory elucidates that the onset of MC and FMS must be viewed through multiple lenses (Newell, 1985; Thelen, 2005). The central nervous system (perceiving and responding with action), neuromuscular elements of our body interact with one another to produce movement in response to our environment (Clark & Whitall, 1989; Newell, 1985; Thelen, 2005). The multitude of body systems and constraints (physical, environmental, and mental) which are required in the performance and development of skill is often referred to as dynamic systems theory (Thelen, 2005). Competence motivation theory, pertains to PMC and physical self-perceptions, and it suggests that higher perceptions culminate in greater persistence in activity, i.e. higher perceptions of movement leads to more PA (Barnett et al., 2008; Harter, 1978). In early theoretical work, and more recent findings, high perceptions aligned with actual skills were deemed vital for sustained participation in activity (Estevan et al., 2021b; Harter, 1982). A dynamic systems theory approach providing diversity of challenge and opportunity during skill development may harness an individual's motivation if a mastery motivation climate can be appropriately provided (Newell, 1985; Thelen, 2005; Martin et al., 2009). A mastery motivational climate proposes that children must be actively engaged at the

centre of their learning experiences, and that if tasks are suitably challenging, they possess an inherent motivation to master and persist with tasks (Hastie et al., 2019; Martin et al., 2009).

Teachers play a significant role in changing the environment (i.e. task or games, equipment, rules, groups used etc.) to ensure that students experience success, enjoyment, and developmentally appropriate opportunities for skill development (Hastie et al., 2019; Lander et al., 2019). The developmental model of MC, at the heart of Project FLAME, proposes MC as the focal point for improving levels of PA, physical fitness, and levels of PMC (Stodden et al., 2008). Targeting MC should positively impact on PMC, through either growing PMC or improving on the alignment between PMC and MC (Robinson et al., 2015; Stodden et al., 2008).

1.3.1. Aims and Objectives of the Study:

Aim:

- To evaluate and investigate the alignment between perceived motor competence (PMC) and actual motor competence (AMC) in early adolescent youth in Ireland.

Objectives:

- Study 1 and Study 2 aim to collect cross-sectional data on fundamental movement skills, functional movement, and perceived motor competence in Irish adolescents.

- Study 2 will investigate age and gender-related differences in perceived motor competence, functional movement, and fundamental movement skills among Irish adolescent youths.

- Study 3 aims to refine the existing Project FLAME intervention to make it suitable for implementation in diverse post-primary settings.

- Study 3 intends to assess changes from pre-test to post-test in perceived motor competence, and fundamental movement and compare and contrast these findings with the control group populations.

- Study 3 will evaluate the efficacy of Project FLAME, a multi-component movement-oriented intervention, in developing fundamental movement skills, functional movement, and perceived motor competence.

-Study 4 seeks to establish reliability and validity for a new perceived motor competence tool for use among an adolescent populace.

1.4. Research Questions:

Attempting to answer these research questions is a key target of this thesis.

1. What level of motor competence (fundamental movement and functional movement) do Irish adolescents currently possess?
2. To what extent are there gender and age-related differences in fundamental movement, and functional movement among Irish adolescents?
3. What level of perceived motor competence do Irish adolescents possess, and do levels change as individuals age?
4. Is Project FLAME currently catering to best practice in motor competence intervention research and providing a robust attempt at addressing adolescent motor competence and perceived motor competence?
5. How aligned (i.e., accurate) are levels of perceived motor competence in comparison to fundamental and functional movement, and can the Project FLAME intervention improve the alignment between levels of perceived motor competence and fundamental movement?
6. Can reliability and validity for a new PMC tool be established among Irish adolescents?

1.5. Structure of the thesis

Following this introduction, chapter 2 provides a critical reflection of the literature in fundamental movement, functional movement, and physical self-perceptions/perceived motor competence. The two following chapters (chapters 3 and 4) provide cross-sectional baseline data on adolescent youth, differentiated by age (school-year grouping) and gender across the first three years (Junior Cycle) of post-primary education. This data helps justify the role of Project FLAME given the expected low levels of motor competence, and high levels of perceived motor competence reported. Chapter 5 provides pre-post randomized controlled trial (RCT) data on the effectiveness of the Project FLAME intervention in improving the alignment between actual motor competence and perceived motor competence in adolescent youth. Chapter 6 is a validation study examining the efficacy (test-retest reliability, concurrent validity, and internal consistency) and potential for a new PMC toolkit, adapted from previous Irish studies focusing on 'perceived confidence'.

Chapter 2: Literature Review: This chapter provides a detailed and comprehensive of overview of pertinent literature related to fundamental movement skills (FMS), functional movement (FM), and perceived motor competence (PMC). It provides an examination of relevant toolkits, common intervention practices, gender and sociological differences within these areas, in addition to how these facets may be intertwined.

Chapter 3: Motor Competence among Irish adolescents: An investigation of sex differences and relatedness of Fundamental Movement Skills (FMS) and Functional Movement (FM). This chapter analyses some cross-sectional baseline data of school-aged Irish adolescents, differentiated by gender and maturation status, in both fundamental movement and functional movement. A preliminary analysis on the associations between fundamental and functional movement is also provided in this paper.

Chapter 4: Investigating the age-related association between Perceived Motor Competence and Actual Motor Competence in adolescence. This chapter

presents baseline cross-sectional data on Irish adolescent youth differentiated by age (class year group) in fundamental movement, functional movement, and perceived motor competence. In addition, the paper examines the associations between perceived motor competence and actual motor competence in adolescents.

Chapter 5: Effects of an 8-week intervention targeting the veridicality of Actual and Perceived Motor Competence among Irish adolescents in Project FLAME. This chapter examines pre-post intervention data, differentiated by gender in fundamental movement skills, and perceived motor competence. It examines the effectiveness of the Project FLAME intervention in improving the alignment between adolescent perceptions and their actual levels of motor skills across the intervention. For this pre-post examination, data were collected at two separate intervals prior to and following the completion of the intervention programme

Ch.6: Validity and Reliability of the Project FLAME Perceived Movement Competence Scale in Irish adolescents: This chapter provides evidence of test-retest reliability, concurrent validity, internal consistency, and some preliminary data for the perceived motor competence tool utilised throughout the data collection process. This cross-sectional analysis of school-aged children is critical to validating a new scale for perceived motor competence in adolescents.

Ch.7. Conclusions and Future directions for Project FLAME This chapter offers an overview and summary of this thesis and its findings in a comprehensive fashion. It reflects on the status of Project FLAME, makes suggestions on how the intervention must adapt for future research in light of this thesis, in addition to the evolving landscape in schools, PE, and community sport.

1.6. Definition of Terms

Actual Motor Competence (AMC): Also referred to interchangeably throughout this thesis as Motor Competence (MC), actual motor competence iis defined as any form of goal-directed human movement (Bardid et al., 2019; Estevan & Barnett, 2018). It is frequently cited as a global or umbrella term to reflect a wide variety of previously published terms in relation to human movement (Bardid et al., 2019). It refers to the performance of a diverse number of motor tasks displaying adequate coordination and efficiency (Bardid et al., 2019; Gallahue et al., 2019).

Assessment for Learning (AfL): Also referred to as formative assessment, this style of assessment places students first by using testing and assessment as a means for student growth and development (Chan et al., 2016). AfL is characterised by assessment informing and shaping changes in the teaching and learning process, while sharing criteria for success with students and providing them with positive constructive feedback to try and enable them to meet their goals (Black & Wiliam, 2010; MacPhail & Halbert, 2010; Tolgfors, 2018).

Competence Motivation Theory: Competence motivation theory is framework that explores one's motivation to partake and persist with an activity. The primary philosophy of the theory is that individuals will be inclined to participate in activities they feel they can perform well or excel in. In this framework, positive and constructive feedback and developmentally appropriate activities are critical.

Concurrent Validity: Refers to the level of correlation between one measure, and an established measurement tool. Both measurements must be collected within a similar time frame. This is conducted to assess if both measurements (i.e. newer measurement, and established one) are measuring the same construct (Ryan & Bernard, 2000; West & Beckman, 2018).

Dysfunctional Movement: Refers to a poor level of performance in a Functional Movement Screen^{TM} (FMS^{TM}) test. Dysfunctional movement refers to a score of 1 (out of a max score of 3) with the individual exhibiting improper mobility and

flexibility in their efforts to complete the FMS^{TM} and needing a compensatory action to complete the movement (Cook et al., 2006b; Karuc et al., 2020).

Fine Motor Skills: Refers to use of the small muscles in the hand for controlled, accurate and precise movements of an object (Bruininks & Bruininks, 2005; Lane & Brown, 2015). They are most commonly associated with grasping and clutching, while common examples of fine motor skills in daily life may be seen through holding a pencil, tying shoelaces, and cutting with a scissors (Bruininks & Bruininks, 2005; Henderson et al., 2007).

Functional Asymmetries: In the case of bilateral assessments in the functional movement screen, asymmetry is where different scores on the left and right side of the body are recorded (i.e., 2 for the left side and 1 for the right side). These asymmetries may be linked with injury and poorer movement patterns (Cook et al., 1998, 2006b; Karuc et al., 2020).

Functional Movement: Functional movement is defined as the "the ability to move the body with proper muscle and joint function" (Coker, 2018)

Functional Movement Screen (FMS™): The FMS™ is an evaluation tool comprised of seven movements designed to assess the quality of movement patterns in multiple domains primarily in the areas of stability, mobility, and flexibility (Cook et al., 2006a, 2006b).

Fundamental Movement Skills (FMS): FMS are motor patterns that are typically developed between the ages of 4 and 7, which serve as building blocks to more complex movement patterns and lifelong PA (Gallahue et al., 2019). FMS are composed of 3 subsets; locomotor skills, which require transporting the body from one area to another e.g. run and vertical jump, object-control skills which require the manipulation of an item e.g. kicking a ball or striking with a bat, and stability (skills of balance) (Logan et al., 2018).

Interrater Reliability: is consistency of scores from at least two raters evaluating the same performance of the test. High level of reliability is necessary to help ensure confidence in recorded scores (Maeng et al., 2016, 2017; Teyhen et al., 2012).

Intrarater Reliability: is the consistency of an examiner (i.e., rater) in the scoring protocol across repeated test evaluations (commonly two occasions within a short period of time, days, weeks, months). Stable and consistent scoring from the rater is expected across their repeated scoring (Bonazza et al., 2017; Maeng et al., 2017). Consistent administration and test calibration, and both knowledge and experience of the rater must be present for effective intrarater reliability.

Locomotor Skills: Locomotor skills are skills of transport, moving the body from one position to another in a horizontal or vertical trajectory (Gallahue et al., 2019; Logan et al., 2018).

Mastery: Mastery is defined as the correct performance of all skills fulfilling all the pertinent criteria outlined by the battery across the necessary number of trial performances (Booth et al., 1999; van Beurden et al., 2002).

Mobility: is the range of motion, flexibility and ability to move a segment of one's body freely without pain, discomfort while moving safely and efficiently (Cook et al., 2006b; Kramer et al., 2019; van der Woude et al., 2020)

Motor Competence (MC): MC is defined as any form of goal-directed human movement (Bardid et al., 2019; Estevan & Barnett, 2018). It is frequently cited as a global or umbrella term to reflect a wide variety of previously published terms in relation to human movement (Bardid et al., 2019). It refers to the performance of a diverse number of motor tasks displaying adequate coordination and efficiency (Bardid et al., 2019; Gallahue et al., 2019). MC and AMC are interchangeable terms from this thesis. On published manuscripts as part of this thesis, a different abbreviation from MC was sought by editors and reviewers hence the addition of AMC.

Motor Development: is the process of transitioning from simple and rudimentary forms of movement to more complex skills (Haywood & Getchell, 2014). Motor development occurs with aging throughout childhood and interactions with diverse environments which promote a myriad of movement solutions and opportunities to perceive and act to solve a movement solution (Newell, 2020). It is a dynamic process which can both improve and disimprove on due to aging, varied movement

environments and physical body changes one experiences (Malina et al., 2004; Newell, 2020; Newell & Liu, 2014).

Object-control Skills: Are skills that require the use and/or manipulation of an implement or object (stick/racquet, or a ball) receiving or propelling this implement is typically performed with the hand or the foot (Gallahue et al., 2019; Logan et al., 2018).

Perceived Motor Competence (PMC): PMC is one's belief and awareness in their capabilities to perform goal-directed human fundamental movement skills and what would be considered as motor competence" (Estevan & Barnett, 2018).

Physical Activity (PA): "bodily movement produced by skeletal muscles that requires energy expenditure – including activities undertaken while working, playing, carrying out household chores, travelling" (WHO, 2018).

Physical Education (PE): PE is a socially-constructed activity which is a component of physical culture inclusive of sport and PA (Penney, 1998; Penney et al., 2012). It is designed to provide opportunities for movement, skill development and an appreciation and motivation for the lifelong pursuit of physical activity (Kirk, 2005; Siedentop et al., 2004).

Physical Literacy: Physical Literacy is defined as the motivation, confidence, physical competence, knowledge, and understanding to pursue PA throughout the life course (Whitehead, 2001, 2010).

Physical Self-perception: Physical self-perceptions refer to one's view or beliefs in their self in physical domains strength, endurance, sport ability, and physical appearance (Fox, 1990; Fox & Corbin, 1989). These perceptions are often formulated on the following five concepts (i) previous experience (ii) task difficulty, (iii) persuasion and interaction with others (iv) intrinsic motivation (v) vicarious experience (Harter, 1978).

Process-oriented Perspective: A process-oriented view on movement is focused on how a movement is performed (i.e. features of quality and patterns utilised when performing the movement), a qualitative movement perspective is provided through

this view and outlook (Bardid et al., 2019; Logan et al., 2018). This outlook can provide very specific and constructive feedback which may be useful for teaching or intervention design purposes (Bardid et al., 2019; Logan et al., 2018).

Product-oriented Perspective: The product-oriented view of movement evaluates the outcome of movement (e.g. speed of a ball travelling, distance of the ball travelling), providing a quantitative perspective of movement (Bardid et al., 2019; Logan et al., 2018).

Reliability: Relates to the scoring consistency in a test. For a test to be reliable, administration procedures must be thorough, and replicable as their work should produce a result within an acceptable range of difference (Maeng et al., 2016; Morgan et al., 2001; Thomas et al., 2011).

Stability: Refers to maintaining balance and showing postural control in a position in order to avoid falling, including the use of compensatory movements if necessary when noticing a shift in one's balance (Gallahue et al., 2019; Rudd et al., 2017).

Test-retest Reliability: Test-retest reliability is a method of assessing scoring consistency on a measure. It assesses whether a participant produces a similar set of results over a particular period of time. It assesses test consistency and scoring variability and fluctuation (Ingram & Ternes, 2018; Ryan & Bernard, 2000).

Validity: Is a measurement of the capabilities of a test to measure what it purports to assess (Thomas et al., 2011). It provides evidence for the use of a testing assessment and whether it is fit for purpose (Maeng et al., 2016; Morgan et al., 2001).

Veridicality: Is the degree of alignment between perceptions of oneself and the reality (i.e., their actual ability or capacity). In the context of this thesis, it primarily refers to the alignment between perceived motor competence (PMC) and actual motor competence (AMC) (Clark et al., 2018; Schmidt et al., 2013).

1.7. List of Abbreviations

AMC = Actual Motor Competence

AfL = Assessment for Learning

ANOVA = Analysis of Variance

ASLR = Active Straight Leg Raise

AR = Axial Region

BMI = Body Mass Index

BOT-2 = Bruininks-Oseretsky Test of Motor Proficiency second edition (BOT-2).

CDC = Centers for Disease Control and Prevention

CI = Confidence Interval

CMT- Competence Motivation Theory

CPD = Continuing Professional Development

CRF = Cardio-respiratory Fitness

CSPPA = Children's Sport Participation and Physical Activity Study

CY-PSPP- Children and Youth Physical Self-Perception Profile.

DKE = Dunning-Kruger Effect

Project FLAME = Project- Fundamental and Functional Literacy for Activity and Movement Efficiency

FMS = Fundamental Movement Skills

FMS™ = Functional Movement Screen™

ICC = Intraclass Correlation Coefficient

ICT- Information and Communications technology

JASP- Jeffreys's Amazing Statistics Program (Stats software)

KTK = Körperkoordinationstest für Kinder

LE = Lower Extremity

MABC-2 = Movement Assessment Battery for Children-2

MQ = Motor Quotient

MVPA- Moderate-to-Vigorous Physical Activity

N = Number of Participants

NCCA = National Council for Curriculum and Assessment

NLME- Nonlinear Mixed Effects (Stats package software)

PA = Physical Activity

PE = Physical Education

PF-PMC= Project Flame Perceived Movement Competence Scale

PHV= Peak Height Velocity

PL = Physical Literacy

PLAY = Physical Literacy Assessment for Youth

PMC = Perceived Motor Competence

PMSC- The Pictorial Scale of Perceived Movement Skill Competence

PSC- Physical Self-confidence Scale

PSPP = Physical Self-perception Profile

QR = Quick response

RCT = Randomised Controlled Trial

SAAFE= Supportive, Autonomous, Active, Fair and Enjoyable

SD = Standard Deviation

SREC = Social Research Ethics Committee

SES = Socioeconomic Status

SPPC= Self-perception Profile for Children

SPSS = Statistical Package for Social Sciences

SREC = Social Research Ethics Committee

STS = Supine-to-Stand Measurement

TGfU- Teaching Games for Understanding.

TGMD = Test of Gross Motor Development

TGMD-2 = Test of Gross Motor Development-2

TGMD-3 = Test of Gross Motor Development- 3

UCC = University College Cork

UE = Upper Extremity

UNESCO = United Nations Educational, Scientific and Cultural Organization

Y-PATH = Youth-Physical Activity Towards Health

WHO = World Health Organization

1.8. Schematic Overview:

Figure 1.1: Schematic Overview of Project FLAME 2018-2022



[BMI = body mass index; FMS = fundamental movement skills; FMS™ = Functional Movement Screen; JA 1 = journal article 1 etc. PMC= Perceived Motor Competence; PMSC= Perceived Movement Skill Competence; RCT = randomised controlled trial; RQ 1 = research question 1 etc.]

1.9. References

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Chapter 2

Literature Review

2.1. Health, Physical Activity, and the role of MC

Participation in physical activity (PA) is a critical component of a healthy lifestyle for children and adults, specifically to reduce the risks of high blood pressure, diabetes and heart disease (Piché et al., 2018). PA has also been highlighted as a key preventative measure to relieving anxiety, improving resilience, wellbeing and promoting positive mental health in youth, particularly relevant following the Covid-19 pandemic where higher levels of stress and anxiety have been recorded (Brooks et al., 2020; Murphy et al., 2021). The World Health Organisation (WHO) recommend that children and adolescents attain 60 minutes of moderate-to-vigorous levels of PA daily, with examples of such activities including fast cycling, soccer, and hopscotch (World Health Organization, 2020b). The childhood and adolescent years are critical to establishing long-term PA patterns that translate to adulthood necessitating the importance of providing maximal opportunities for youth populations to participate in PA (Bentham et al., 2017; Janz et al., 2014).

A common risk factor for physical inactivity (i.e. failure to meet the PA guidelines for health), is an individual's predisposition towards overweight and obesity, which refers to the ''abnormal or excessive fat accumulation that presents a risk to health'' (WHO, 2020a, p.IX,). A greater degree of fat accumulation in terms of body composition distinguishes obesity from overweight i.e., obesity involves a greater degree of fat accumulation (Piché et al., 2018). Both obesity and overweight pose significant and adverse health risks, which include a higher risk of infectious disease, coronary heart diseases, and cancer (Bastien et al., 2014; Piché et al., 2018). Body Mass index (BMI) is a practical, feasible, and valid way of measuring body composition in adult, child and adolescent groups (Cole & Lobstein, 2012; Johnson et al., 2020). Most recent evidence would suggest that just under 20% of adolescents globally are either overweight or obese, which indicates the clear need to tackle adverse body composition levels (Van Sluijs et al., 2021). Among adults globally, updated WHO figures indicate that 39% of adults are overweight, and a further 13% are obese, again signposting the poor health trends related to obesity in adulthood (WHO, 2021).

Motor Competence (MC) relates to any form of goal-directed human movement, and is frequently cited as a global or umbrella term to reflect the wide variety of previously published terms in relation to human movement (Bardid et al., 2019). MC forms a key component of PA engagement and obesity management in children and youth (Barnett et al., 2022; Coppens et al., 2019). A positive association between MC and a higher inclination for PA participation in children and adolescence has been widely reported (Holfelder & Schott, 2014; Lubans et al., 2010b; Opstoel al., 2015. A recent systematic review reported that higher rates of obesity in childhood are likely to inhibit MC performance (Barnett et al., 2022). While a causative effect between MC and body composition has not been extensively researched, an association between greater levels of MC, and reduced weight status has been consistently reported (Barnett et al., 2022; Kaioglou et al., 2022; Chagas et al., 2021). Further research has corroborated the association between higher levels of MC, and higher levels of physical fitness (muscular strength, cardiorespiratory fitness, and body composition) (Cattuzzo et al., 2016; Graham et al., 2022; Kaioglou et al., 2022). The key role of MC in health-related fitness and PA illustrates how crucial MC promotion is among children and youth (Lopes et al., 2021; Vandorpe et al., 2011).

Performance of MC-related activities typically accumulates intensities reaching moderate to vigorous PA, with more skilled individuals appearing to expend more energy (Sacko et al., 2019, 2021). As MC performance among children contributes to higher PA intensity, and is associated with longitudinal PA behaviours, in addition to improved weight status over time, a greater focus on MC could prove to be a key determinant in the management of physical health globally (Loprinzi et al., 2015).

Additionally, higher levels of MC have been associated with increased cognitive skills in children and youth, verifying the importance of movement in the enhancement of mental and physical status (Haapala, 2013). It appears likely that high levels of MC promote long-standing positive benefits to aspects of health namely body composition, however unpacking MC as a term and how movement is evaluated in practice remain key concerns (Barnett et al., 2022; Newell, 2020).

2.1.1. FMS- The Motor processes and factors contributing to human movements

One term synonymous with MC and frequently used in research and practice (i.e. school and sporting environments) when referring to MC is fundamental movement skills (FMS) (Logan et al., 2018; Robinson et al., 2015). While FMS can contribute to MC, and they are often viewed as one and the same, it is important to note that MC is comprised of more than FMS, and there are many movement aspects contributing to MC (Bardid et al., 2019; Logan et al., 2018; Tyler et al., 2018). The origins of our modern understanding of MC and FMS can be traced to Wickstrom (1977), who expressed the notion that a fundamental motor skill is as "a common motor activity with a general goal [that serves as] . . .the basis for more advanced and highly specific motor activities" (Wickstrom, 1977, p.3). The term 'Fundamental Motor Skills' is often used interchangeably with FMS, with studies evaluating either 'fundamental motor 'or 'fundamental movement skills' assessing similar constructs, without discernible differences (Logan et al., 2018).

FMS are simple motor patterns that are typically developed between the ages of 4- and 7- years of age, which serve as building blocks to lifelong PA engagement, with mastery expected by the age of 10 (Gallahue et al., 2019). FMS are typically divided into three distinct subsets; 1) Locomotor skills, which require transporting the body from one area to another e.g. run and vertical jump; 2) Object-control skills, which require the manipulation of an item e.g. kicking a ball or striking with a bat; and 3) stability, which refers to maintaining and restoring balance by adjusting one's movement and actions e.g. static balance on one foot (Logan et al., 2018; Gallahue et al., 2019). FMS should be developed in an age-appropriate manner, requiring support, purposeful practice and teaching from educators, parents, or other influences (Barnett et al., 2016b). FMS and MC development is provoked through multiple body systems, the multitude of neuromuscular and body systems working together to develop skills is referred to within dynamic systems theory (Clark et al., 2019; Thelen, 2005).

FMS ability, much like MC has been positively associated with numerous aspects of health such as PA, cardiorespiratory endurance, muscular strength,

flexibility, and body composition (Behan et al., 2022; Lubans et al., 2010b; Robinson et al., 2015).It is possible that either FMS, or MC may be an indirect contributor to mental health. Previous studies have reported associations between high levels of sport skills, fitness and mental health, and given the association between FMS, PA, and fitness, FMS may indirectly improve mental health (Gu et al., 2019).

Consistent debate rages regarding the pedagogical influences on FMS and their development. There is evidence supporting free-play and nature-based programmes for promoting FMS growth, while direct methods (i.e. instructor-centred approaches which cater for minimal autonomy of the participant) are equally effective in childhood populations (Brian & Taunton, 2018; Wainwright et al., 2018). There are physiological, mental, social, and environmental constraints interacting on the decisions of how and when the body moves, which must be considered during skill development (Thelen, 2005). Ultimately, an effective teaching approach for FMS development considers the individual (their age, and development rate), the environment, the tasks, and manipulating the constraints (e.g. space, equipment, groups size etc.) to engender fun and valuable learning experiences, which improve children's skills (Newell, 1985). Though it is difficult to advocate for a singular method or style in physical education or coaching, given the unique elements inherent to teaching environments, there are certain concepts that can be recommended (O'Brien et al., 2023). As consistent practice, feedback, and support is required to develop FMS, teacher-centred methods are likely to prove more advantageous than "free play" initiatives alone (O'Brien et al., 2023; Taunton Miedema et al., 2022). This is particularly true in early childhood populations, and for teachers or coaches with minimal experience (Brian & Taunton, 2018). Technique-focused direct instruction tasks fulfil a key role at different stages of learning across childhood, adolescents, and into adulthood (Foweather et al., 2008; O'Brien et al., 2023). Where direct methods are implemented, a semblance of balance is required in the interest of achieving broader outcomes outside of skill development (O'Brien et al., 2023; Rudd et al., 2020a). Providing children with enjoyable FMS experiences is critical to developing sustained pattern of PA across the lifespan (Cairney et al., 2019; Farmer et al., 2020; Kriellaars et al., 2019). The lack of fun games being implemented, and a

strict drill-oriented process being utilised are among common critiques of FMS-led approaches to movement (Pot et al., 2018; Smith, 2016). A direct instruction approach may be preferable, but the provision of enjoyable learning experiences which caters for safe exploration of movement is essential for all physical education, and coaching environments to develop skill and lifelong PA (Kriellaars et al., 2019; Roberts et al., 2019).

2.1.2. Criticism of FMS as a concept

Common critiques of FMS as a concept exist. Movement (i.e., the pattern of the body in motion) constantly evolves in response to the constraints in the environment. An individual adapts and organises their movements to complete an action in the most appropriate form in a given context, i.e. fun or efficient movement depending on factors such as time, experience and competition (Kugler & Turvey, 1987). Labelling any form of motion as fundamental has been previously critiqued as reductive, given that all movements are reactive and adaptive to differing circumstances (Newell, 2020). A recognition of the role of dynamic systems theory and the impact of the environment on skill development is often not considered within FMS research and practice, as constraints are not readily manipulated during activities (Renshaw, 2011). Furthermore, the term FMS and associated testing toolkits, have been derided as 'narrow', with what testing batteries deem 'fundamental' not reflective of the differing global movement cultures (Hulteen et al., 2018).

If taught correctly in dynamic sporting and teaching environments, students have the potential to possess both basic (as tested through toolkits) and advanced forms of movement, necessary for further PA participation (Barnett et al., 2016b). As per their guidelines and instructions, the majority of FMS toolkits are primarily designed to assess if students can perform basic motor skills highlighting the key role of MC assessment for both researchers and practitioners (Brown & Lalor, 2009; Bardid et al., 2019).

2.2. Assessment of MC

Movement assessment is a vital element MC and FMS research. Given the broad definition of MC and FMS, there are a myriad of different assessments utilised in research (Bardid et al., 2019). Both MC and FMS research (defined as fundamental motor or movement) have primarily been assessed through process-oriented outcomes of movement though product-oriented assessments also exist (Connolly et al., 1968; Logan et al., 2018). The process-oriented perspective is characterised by the aforementioned need to understand the motor processes occurring within the body systems, while recognising the role that the environment plays in contributing to skill performance and development (Thelen & Fisher, 1982; Thelen & Ulrich, 1991). Process measures emphasise movement quality during a performance (looking at the presence or absence of particular performance aspects) while product measures are outcome-focused, looking at elements such as speed of movement or distance covered (Logan et al., 2018). This section of the literature review outlines 3 common toolkits from across the world (Körperkoordinationstest für Kinder, Movement Assessment Battery for Children, and Test of Gross Motor Development). Other toolkits that assess movement in a dynamic capacity exist (e.g. Motor Competence Assessment, Dragon Challenge, Canadian Active Movement Skills Assessment etc.) but were not included in this review (Longmuir et al., 2017, 2018; Luz et al., 2016; Tyler et al., 2018). Though they are validated in childhood and teenage groups, these assessments have not been utilised across a number of countries. The author felt the current selection was justified as these assessments capture a range of movements inherent to the Irish movement culture (e.g. two-handed strike being assessed as it is essential to the Irish sport of hurling), have established reliability and validity and are commonly used across cultures (Henderson et al., 2007; Kiphard & Schilling, 1974, 2007; Rey et al., 2020). As MC is a complex measure, utilising different testing measures with children and adolescents is recommended as a means of providing a more comprehensive understanding of an individual's movement capacity (Freitas et al., 2015; Vinçon et al., 2017; Khodaverdi et al., 2021). This section will explore some of these testing measures highlighting how and why they are used to evaluate MC through the lens of FMS, dynamic balance, gross and fine motor skills.

2.2.1. Test of Gross Motor Development (TGMD-2 & TGMD-3)

The Test of Gross Motor Development (TGMD) is a process-oriented tool that focuses on the presence or absence of particular movement criteria (Bardid et al., 2019; Rey et al., 2020). The TGMD is currently in its third edition, and to-date, all editions contain both locomotor and object-control subsections, with minor variations enacted throughout each edition (Ulrich, 1985, 2000, 2017). The first edition contained the following locomotor skills: run, gallop, hop, leap, horizontal jump, skip, and slide, and the following object-control skills, the two-handed strike, stationary bounce, catch, kick, and the overhand throw. The second edition (TGMD-2) omitted the skip and added an object-control skill in the underhand roll (Ulrich, 2000) for an equal proportion of locomotor and object-control assessments i.e. 6 FMS in each category. The most updated TGMD-3 assessment has since restored the skip from the original TGMD, removed the underhand roll and leap, while adding the underhand throw and the one-handed strike creating 13 assessments (Ulrich, 2017). Through its three editions and alterations to-date, the reliability and validity of the TGMD assessment has remained strong, with the TGMD-2 garnering the greatest level of use within research (Cools et al., 2009; Rey et al., 2020).

Table 2.1. TGMD-2 Skills and Scoring procedures-

Skill	**Description of skill**	**Success Criteria (Each skill performed twice and scored twice)**
Run	Participant runs as fast as they can over a distance of 50 feet (15 metres)	1. Arms move in opposition to legs, elbows Bent. 2. Brief period where both legs are off the ground. 3. Narrow foot placement landing on heel or toe.

		4. 4. Non-support leg bent 90 degrees
Gallop	Participant gallops from one cone to another over a distance of 15 feet	1. Arms bent and lifted to waist level at take-off 2. A step forward with the lead foot followed by a step forward with the trailing foot to a position adjacent to or behind the lead foot. 3. Brief period where both legs are off the ground. A rhythmic patten is maintained for four consecutive gallops
Hop	Across 15 feet of space, a participant must hop 3 times on their preferred foot, and 3 times on their non-preferred foot.	1. Non-support leg swings forward in a pendular fashion to generate force. 2. Foot of non-support leg remains behind body. 3. Arms flexed and swing forward to produce force. 4. Takes off and lands three consecutive times on preferred foot. Takes off and lands three consecutive times on non-preferred foot
Leap	20 feet of space is measured out using a tape. The tape is parallel to a bean bag on the floor. Running along the tape, a child must leap over a beanbag	1. Take off on one foot and land on the opposite. 2. A period where both feet are off the ground longer than running.

		Forward reach with the arm opposite the lead foot.
Horizontal Jump	Mark out 10 feet of space and a starting line. Instruct the participant to jump as far as they can.	1. Preparatory movement includes flexion of both knees and arms extended behind body. 2. Arms extend forcefully forward and upward reaching full extension above the head. 3. Take off and land on both feet simultaneously Arms are thrust downward on landing.
Slide	A 25 feet space is marked out using cones and a line. The participant is asked to slide from the starting point to the end point.	1. Body turned sideways so shoulders are aligned with line on the floor. 2. A step sideways with lead foot with a step sideways with the trailing foot to a point next to the lead foot. 3. A minimum of four continuous step-slide cycles to the left. 4. A minimum of four continuous step-slide cycles to the right
Striking a Stationary Ball	A ball is placed on a batting tee at appropriate height (belt level). Participant is asked to hit the ball hand.	1. Dominant hand grips bat above non-dominant hand. 2. Non-preferred side of the body

		faces the imaginary tosser with feet parallel. 3. Hip and shoulder rotate during swing 4. Transfers weight during swing. Bat contacts ball.
Stationary Dribble	Participant dribbles ball without moving feet, and using one hand, 4 consecutive times. They stop after 4 dribbles and catch the ball.	1. Contacts ball with one hand at belt level. 2. Ball pushed with fingertips (not a slap) 3. Ball contacts surface in front of foot or to the side of foot on preferred side. Maintains control for 4 bounces without having to move feet to control ball
Catch	2 lines are marked out 15 feet apart. Participant stands on one line as the ball is tossed to them from the other. Ball is tossed in an underhand fashion with a slight arc aiming for chest height. Participant is to use 2 hands to catch the ball.	1. Preparation phase where arms are flexed in front of the body. 2. Arms extend while reaching for the ball to arrive. Ball is caught using hands only.
Kick	Mark out two lines one 20 feet from a wall, and one 30 feet from the wall. Place a ball on the 20 feet line, with the participant standing on the line 30 feet from the wall. Participant should kick the ball as hard as they can against the wall.	1. Rapid continuous approach to the ball 2. An elongated stride or leap prior to contact with the ball. 3. Non-kicking foot placed even or slightly behind the ball. Kicks ball with instep (think shoelaces) or toe.

Overhand Throw	Have the participant stand 20 feet from a wall. The participant stands just behind the line and throws the ball as hard as they can against the wall.	1. Windup is initiated with a downward motion of the arm 2. Rotates hips and shoulder to the point where non-throwing shoulder faces the wall. 3. Weight is transferred by stepping with the foot opposite the throwing hand. Follow-through beyond ball release diagonally towards the non-preferred throwing side.
Underhand Roll	Place two cones against a wall four feet apart. Mark out a space 20 feet from this space between the cones. Instruct participant to roll the ball hard in between the cones.	1. Preferred hand swings down and back reaching behind the trunk while chest faces cones. 2. Strides forward with foot opposite the preferred hand toward cones 3. Bends knees to lower body. Releases ball close to the floor so ball does not bounce more than 4 inches high

The TGMD-2 has illustrated consistently strong measures of reliability across cultures. The initial American sample (N= 1,208; age range= 3 to 10 years old) demonstrated concurrent validity through fair to good correlation values at the subset levels (object-control and locomotor), and in the overall scores respectively. Excellent internal consistence and inter-rater reliability correlations were further reported, with good to excellent ratings found for test-retest reliability, alongside acceptable construct and content validity (Ulrich, 2000) A more recent Portuguese

study (N=330; age-range 5-10 years old) utilising confirmatory factor analysis proposed a two-fit model of locomotor and object-control skills, while internal consistency as measured by Cronbach Alpha showed acceptable consistency across total skill, locomotor, and object-control domains (Lopes et al., 2018b). High levels of internal consistency in the TGMD-2 and good levels of test-retest reliability were corroborated in studies in Iran, Myanmar and Belgium (Aye et al., 2017; Simons et al., 2008; Soltanian et al., 2012).

While the TGMD-2 is intended for children between the ages of 3 to 10 years old, previous evidence suggests that the assessment tool is usable for an adolescent population. An Irish study (n= 844 participants; 456 male; mean age= 12.03 ± 0.49 years) found acceptable test-retest reliability values in the locomotor and object-control subsets, and excellent test-retest reliability for overall gross motor score (Issartel et al., 2016). This confirmatory factor analysis proposed a reduction to 10 skills for an overall one-fit model (leap and slide excluded) (Issartel et al., 2016).

Most recently, the TGMD-3 has shown acceptable psychometric properties in children aged 3 to 10 years old (Ulrich, 2017). A 2017 Canadian study (n= 277, 129 males; age range 8-9 years), assessed the developmental validity of the TGMD-3 (Temple & Foley, 2017). The capacity of the TGMD-3 testing battery to distinguish performances as people age and the absence of a ceiling effect illustrated its developmental validity effectiveness (Temple & Foley, 2017). A large-scale Italian study (n= 5210; mean age years = 8.38 ± 1.97; 2709 male; mean age = 8.38 ± 1.97 years) supported the strength of a two-factor model (locomotor and object-control) of the test through confirmatory factor analysis, while the test-retest reliability measures across all locomotor, object-control and the overall skills illustrated excellent consistency (Magistro et al., 2020). A German study (n=189; 99 male; mean age 7.15 ± 2.02 years) of the TGMD-3 prompted further strong evidence of the assessment tool's validity and reliability (Wagner et al., 2017). A two-factor model was proposed through confirmatory factor analysis (Wagner et al., 2017). Interrater and intra-rater reliability across the TGMD-3 subscales in American and Finnish studies was cited as excellent (USA) and good-to-excellent (Finland) respectively (Maeng et al., 2017; Rintala et al., 2017).

A recent systematic review found that across its various editions, the TGMD has continued to retain high markers of reliability and validity across various metrics; namely good-to-excellent interrater reliability, moderate-to-excellent internal consistency, good-to-excellent intra-rater reliability, and moderate-to-excellent test-retest reliability (Rey et al., 2020). This highlights that the TGMD assessment tool is an effective global testing battery, for assessing process forms of MC in children and adolescents (Bardid et al., 2019).

The TGMD is, however, vulnerable to criticism. Notably, the testing environment is quite static, and skills are performed following a demonstration by a researcher, resulting in a repetitive and unnatural performance environment, which fails to account for movements being performed in context (Pot et al., 2018). While the process format has positives, the assessment tool proposes that there is only a single correct way to move, ignoring the influence of the environment, task, and other constraints, while failing to account for those with physical limitations (Lederman, 2011; O'Sullivan et al., 2020).

2.2.2. Körperkoordinationstest für Kinder (KTK)

The Körperkoordinationstest für Kinder (KTK) is another MC assessment, which was principally designed to identify children with poor motor functioning as a result of cognitive impairment (Iivonen et al., 2015; Kiphard & Schilling, 2007). The assessment battery is a product-based movement assessment tool, with the following four testing items: Walking backwards, Moving Sideways, Hopping for Height, Jumping Sideways (Kiphard & Schilling, 1974). Table 2.2 below outlines the test and scoring procedures for the KTK, as adapted from prior publications (Kiphard & Schilling, 2007; Laukkanen et al., 2019).

Table 2.2: KTK Skills and Scoring Procedures

Task	Description	Progression/Size	Success Measured by
Walking backwards	Participants walk backwards on a balance beam (6cm width, 3m high and 5 m long). A maximum of 8 steps is allowed with 3 trials per each level	Progression to 4.5cm width Progression to 3.5cm width	Steps counted and number of trials needed
Moving sideways	Moving side to side over wooden boards for 20 seconds, two trials are used to count the number of jumps that are made, with the average number of jumps over the two trials counted.	Size Two wooden boards length 25cm, width 25cm, height 5.7cm	Total number of transitions across 2 20-second trials
Hopping for Height	Involves travelling (hopping one foot at a time) over a series of pillows of escalating height. The pillows begin at the following level (60cm width, 20cm depth, 5cm height). 3 trials for each level (12 total) are in place	Initial pillow size 60cm width, 20cm, depth 5cm height. Progresses up to 12 levels with 12 pillows of same dimension added	3 trials are awarded for each level. Failure to clear the obstacle in 3 results is test failure. Fewer trials accumulated leads to greater scoring.
Jumping sideways	Sideways jumping over a wooden plinth (60cm x	Wooden lath (60cm x 4cm x 2 cm)	Total number of jumps performed

	4cm x 2 cm) on a jumping base (100cm x 60 cm). Two trials are performed over 15-seconds to calculate maximum number of jumps.	Jumping base (100cm x 60 cm). -No progression	across 2 15-second trials

The KTK works on a norms-based scoring system, after scores are totalled across all four tests, the participants receive a total Motor Quotient (MQ) score. This MQ is often graded as a percentile of the normative values from Kiphard & Schilling's (1974) manual. Participants are graded into percentiles (P) on the outlined criteria: lower than or equal to P2 ("impaired"), between P2 and P16 ("poor"), between P16 and P84 ("normal"), higher than P84 ("good") and higher than P98 ("high") (Kiphard & Schilling, 1974). This product-based assessment is as a reliable and valid tool for use among general populations with good test-retest reliability, and discriminant validity, convergent validity and excellent inter-rater reliability (Camacho-Araya et al., 1990; Fransen et al., 2014; Iivonen et al., 2015). Research utilising the KTK indicates that the majority of children and adolescents possess average, or below average skills, when compared with previous generations (Kiphard & Schilling, 2007; Lopes et al., 2014).

The use of norm scores within the KTK has prompted criticism among researchers, as the original figures are over 40 years old and outdated, while the sample was not heterogenous, as data collection only took place in Germany (Iivonen et al., 2015). The assessment may also struggle to distinguish development at the lower and upper echelons of the scoring spectrum, as previous convergent validity research highlights that the KTK did not agree on what constitutes a higher level performer, when compared to other MC assessments (Bardid et al., 2016b; Fransen et al., 2014).

A product-based test focused on outcome can also be scrutinised. As participants may only have to complete one performance to succeed, luck may aid participants, as the test is not sensitive enough to detect poor movement quality, which may be detrimental to health (French et al., 2018; Logan et al., 2017). While the assessment tool is not widely used in research currently, a modified version of the KTK, known as the KTK3+ has been validated as a more practical tool for use (Coppens et al., 2021). The inclusion of an object-control task (throwing a tennis ball with one hand and catching with the other) assures the KTK3+ presents a more rounded and thorough depiction of MC than the original KTK (Coppens et al., 2021). In this validation study (n=2,271; 1,112 male; age-range 6-19 years), a one-dimensional structure (object-control task with 3 previous KTK tasks) was deemed a suitable fit, with correlations ranging from moderate to very good ($r = 0.453–0.799$, $p<.01$). Construct validity was also affirmed through the ability of the KTK3+ to distinguish performance ability between age group and sex (significant multivariate interaction effect, $p = 0.001$) and between age group, sex and organised sport participation ($p < 0.001$) (Coppens et al., 2021).

2.2.3. Movement Assessment Battery for Children-2 (MABC-2)

The Movement Assessment Battery for Children-2 (MABC-2), is another product-oriented assessment toolkit for MC, which assesses skill impairments from early childhood throughout adolescence (ages 3-16) (Brown & Lalor, 2009; Henderson et al., 2007). The assessment tool evaluates gross motor (i.e. skills requiring large muscle groups and whole-body movements such as jumping) and fine motor control (i.e. manual-dexterity, clutching objects using small-hand muscles), moving beyond the confines of other MC related assessments (Lane & Brown, 2015).

The MABC-2 provides developmentally appropriate challenges for participants, as norm scores are provided across 3 separate age-bands; ages 3-6, 7-10, and 11-16 (Henderson et al., 2007). The table below provides a simple breakdown of the test, as associated with each age-band; there are 3 skill components for each

age-band: 1) Manual dexterity, 2) Aiming and Catching, and 3) Balance (Static/Dynamic). Once the raw scores are calculated, these are then converted to item standard scores. For skills assessed on the left or right side, an average (rounded away from 10) is utilised. Scores are tallied to form component scores, and subsequently total score.

Table 2.3. MABC-2 Skills and Scoring Procedures

Tasks	**Age-Band 1 (Ages 3-6)**	**Age-Band 2 (Ages 7-10 years)**	**Age-Band 3 (Ages 11-16 years)**	**Success Measured**
Manual Dexterity 1	Posting coins in a box	Placing and shifting pegs by rows	Turning Pegs	Completion time in seconds: 2 trials, best time.
Manual Dexterity 2	Threading beads	Threading Lace	Threading nuts on a bolt	Completion time in seconds: 2 trials, best time.
Manual Dexterity 3	Drawing Trail 1	Drawing Trail 2 (more complex)	Drawing Trail 3 (More complex)	No. of errors: 2 attempts, best attempt goes to score: no second trial if first is perfect.
Aiming and Catching 1	Catching beanbag	Catching with 2 hands	One-handed catch	No. of correct catches.
Aiming and Catching 2	Throwing beanbag onto mat	Throwing beanbag onto mat (with a target)	Throwing ball at wall-mounted target	No. of correct throws (out of 10).
Balance 1 (Static)	One-leg balance	One-board Balance	Two-board balance	Seconds maintaining balance (max 30): Both legs assessed, 2 trials, best score.
Balance 2 (Dynamic One)	Walking heels raised	Walking heel-to-toe forwards	Walking heel-to-toe backwards	No. of correct steps. (Max

				15): 2 trials, best score.
Balance 3	Jumping on mats	Hopping on mats	Zigzag hopping	No. of correct hops/jumps out of 5: 2 trials, best score.

Note. No. = Number; Max = Maximum.

The MABC-2 has demonstrated an ability to track and predict the motor status across differing age-bands, illustrating that the battery's status is a leading assessment tool (Griffiths et al., 2017). In the Zoia et al., (2019) study, (N=718; 357 male; age-range: 3-10), a confirmatory factory analysis confirmed that the subtests of the MABC-2 are structurally sound and fit for purpose. Criticisms, however, have arisen regarding the norm values, with contrasting norm values to the original figures cited in Italy, Netherlands, and Asia respectively (Livesey et al., 2007; Niemeijer et al., 2015; Zoia et al., 2019). Country-specific norms which reflect the intricacies of different movement cultures may be necessary for the growth of the tool (Hands et al., 2015). Two Japanese studies suggest that culture may play a part with their mean scores residing in the typically developed region, in contrast to other findings using the MABC-2 (Kokštejn et al., 2017). The Kita et al., (2016) study (n=132; 84 male; mean age= 8.8 ± 1.2 years) presented mean values of 10.8 ± 2.8 in their overall test score (Kita et al., 2016). The Hirata et al., (2018) study (n=252; 112 male; mean age= 62.7 ± 12.3 months) would posit slightly lower mean values (10.3 ± 3.0). These findings, however, indicate that some countries may be predisposed to higher MABC-2 scores (Hirata et al., 2018). The positive MABC-2 results within Japan have partially been attributed to their high usage of public transport, and use of items such as chopsticks contributing to fine motor and dynamic balance skills (Hirata et al., 2018).

Valid concerns of the MABC-2 test do still remain. In the MABC-2, a second trial is not advised if the participant achieves a maximal score in their first trial in all balance exercises, and one of the manual dexterity tasks in age bands 2 and 3. A child may succeed in their first attempt due to luck, which does not accurately reflect their true ability, while success on the first attempt is likely to reduce the impact of fatigue on performers (French et al., 2018).

The positives of the MABC-2 assessment tool are numerous. The tool's consideration of fine motor, object, and locomotor elements assures that it captures a greater conception of movement than other toolkits, alongside the assessment's easy administration procedures and high levels of children's enjoyment are among its benefits (Capistrano et al., 2015; Zoia et al., 2019).

When selecting an assessment toolkit aspects such as ease of administration procedures, time required and which particular skill aspects (i.e. locomotor, fine-motor, and object-control etc.) are to be prioritised must remain key preoccupations (Bardid et al., 2019). In the absence of a 'gold standard' assessment, logistical limitations (i.e. number of researchers and assistants needed, space available to conduct research etc.) may also play a role in selection (Bardid et al., 2019). Ontological view point with regard to MC assessment, and whether one views a product or process-oriented view point to be of greater importance will further factor into selection of a toolkit (Logan et al., 2017). The TGMD, is a challenging assessment to implement, as it is a process- measure with a high volume of skills that demands a good amount of time, space, and staffing to administer (Bardid et al., 2019; Rey et al., 2020). The process-nature can make it difficult to score in real time, often necessitating camera equipment and video recording (Barnett et al., 2014). However, it is quite diverse with a range of both object-control and locomotor skills (Bardid et al., 2019; Logan et al., 2017). The KTK, lacks a high volume of work outside European settings, and while its locomotor and balance elements are strong, it lacks the rounded elements of other assessment batteries (Bardid et al., 2019). The recent additions of the object-control element to the KTK do provide it with a promising future outlook (Coppens et al., 2021). The MABC-2 is unique in comparison to the aforementioned assessments with its fine motor coordination elements, which are highly beneficial in assessing individuals with an array of neurological conditions (Henderson et al., 2007; Zoia et al., 2019). However, it does not contain an extensive locomotor focus (primarily limited to jumping tasks), with normative values appearing to fluctuate across countries (Hands et al., 2015). It may be better used to gauge activities of daily living on an individual basis rather than MC among a large number of participants (Bardid et al., 2019).

Given its extensive usage across the globe, and within the island of Ireland, assessments using the TGMD (namely the the TGMD-2) will primarily be utilised within this thesis (Rey et al., 2020). The conception of movement and its wide depiction of MC catering to an extensive range of locomotor and object-control skills is of great value (Rey et al., 2020; Ulrich, 2000). Its high usage among childhood and adolescents, who are often inadequately assessed within MC and FMS research, further illustrates its justification as a critical toolkit for implementation in research and practice (Issartel et al., 2016; Lander et al., 2017; O'Brien et al., 2016).

2.3. National and Global FMS Levels

Global research consensus across testing metrics suggests that FMS levels are quite poor, with considerable evidence indicating that such FMS skills have declined from previous generations (Bolger et al., 2021; Khodaverdi et al., 2021). Children possess the developmental capability to master (i.e. perform skills correctly without error) FMS from the age of 7 years old, with mastery of FMS theorised as a key to advancing to more complex forms of movements performed in sports and exercise (van Beurden et al., 2002).

Across regions and test measures, low FMS scores are cited across countries globally. A Chinese study (n = 282; mean age 8.4 years ± 0.56 years) recorded average mean scores with values of 21.16 ± 5.60 out of a possible 42 on a subset of TGMD-3 skills (jump, hop, skip, dribble, catch, and overhand throw) reported (Chan et al., 2019). An Australian and German study sample (n= 358; 191 male; mean age= 8.35 ± 0.65 years) provided evidence of FMS raw scores being below maximal capacity (locomotor max score 46; object-control max score 50) with German boys (27.4 ± 5.13) and girls (27.6 ± 5.52) recording higher scores on the locomotor subset, when compared to their Australian counterparts, (males; 24.9 ± 4.48; females 25.5 ± 4.74) (Tietjens et al., 2020). Object-control skill proficiency remained close to the average mark, however, Australian youth appear to possess greater skill proficiency in this domain (males 28.4 ± 4.56; females 23.0 ± 5.10), when compared to their German counterparts (males; 26.7 ± 4.56; females 21.2 ± 5.15), respectively (Tietjens et al., 2020). A cross-comparison study examining Portuguese, Chinese, and American

children (n=3,289 participants), amplifies this by highlighting the mastery percentage (i.e. number of participants to master the FMS tested) achieved by the age of 10 years old (Dos Santos et al., 2016). From this study, Americans showed 63% mastery, with Portuguese and Chinese students at 44% and 51% mastery, across all of the assessed skills, illustrating the vast need for skill growth (Dos Santos et al., 2016).

In a 2019 cross-cultural study of Finnish (n=690; mean age 7.81 ± 1.19 years), Belgian (n=1896; mean age 8.25 ± 1.09 years), and Portuguese children (n=758; mean age 8.31 ± 1.02 years) utilising the KTK assessment battery, all 3 regions from the ages of 6- to 9- years old were in the typically developing category (Laukkanen et al., 2019). While a high number of Belgian and Finnish children were above the typical range at 33.8% and 18.4% respectively, a substantial number of Portuguese children (29.3%) recorded poor KTK scores (Laukkanen et al., 2019). When assessed by KTK percentiles, the Bardid et al., (2016b) study of Belgian children (n=638; 323 male; age-range= 5-6 years old), noted that 67.2% of the sample were in the typically developing category of MC (Bardid et al., 2016b). A Spanish KTK study (n= 236; 128 male; mean age= 13.01 ± 0.72 years) reported that over one third of the study population were in the poor category, and worryingly, the mean value (86.11 ± 16.18) was below the categorisation of normal (100), with no overall values in the 'high' category recorded (Estevan et al., 2021a).

In general, scoring in the MABC-2 assessment tool could be described as moderate-to-below average (Kokštejn et al., 2017). Scores below the 50th percentile are deemed to be poor, and may indicate a child is below typical MC development rates (Kokštejn et al., 2017). Findings of scores just above the 50th percentile have been found in studies across the globe indicating that dexterity, gross motor, and balance skills are encouraging, but this category still warrants MC improvement (Hirata et al., 2018; Kita et al., 2016; Kokštejn et al., 2017). A Brazilian study (n=844; 440 male; mean age= 8.31 ± 2.91 years), positively reported that 73% of participants possessed typically developing skill levels (i.e. at the 50th percentile or above), in comparison to the 18% who were categorised as possessing developmental coordination disorder (DCD), and the 9% who were deemed 'at risk' (Valentini et al., 2014).

Within Irish research, there is consistent evidence of subpar FMS performances (Duncan et al., 2022). In the Bolger et al., (2018) study (n = 102, M age: 6.0 ± 0.4 years), only 50% of a 6-year-old cohort recorded mastery in the run and leap, while several skills languished below 20% (hop, jump, slide, bounce, roll and throw). The 10 year-old cohort (n = 101, Mean age: 9.9 ± 0.4 years) did not possess full mastery for any skill, exceeding only 50% mastery in 5 (kick, run, gallop, leap, dribble) of the 12 skills assessed by the TGMD-2 (Bolger et al., 2018). One Irish study indicated that just over 50% of Irish children between the ages of 5- to 12- years old (n=2,098) displayed mastery or near mastery across all locomotor and object-control skills in the TGMD-3 (Behan et al., 2019).

A large portion of Irish FMS research has been conducted among adolescent populations, and they similarly indicate a worrying trend (Duncan et al., 2022; O'Brien et al., 2018). The Lester et al., (2017) study (n=181; 108 male; mean age: 14.42 ± 0.98 years) reported that by the end of their third year of post-primary (secondary) schooling (ages 15- to 16- years old), less than 40% of Irish adolescents displayed mastery in two locomotor skills (vertical and horizontal jump), and four object-control skills (kick, dribble, strike, throw), with no apparent skill development improvement as participants aged (Lester et al., 2017). In the O'Brien et al., (2018) study, (N = 219; 120 males; mean age: 14.45 ± 0.96 years), all participants possessed less than 50% mastery in five of the ten FMS assessed (dribble, strike, throw, vertical jump, horizontal jump). Furthermore, full mastery was not recorded in any skill, with the absence of mastery across these studies notable, given the expectation of mastery among adolescents (O'Brien et al., 2018).

These studies, and systematic reviews indicate that contemporary FMS skills are lower than those established in previous normative samples, suggesting that progressive decline in FMS has occurred in recent decades due to prolonged physical inactivity, and societal change (Bolger et al., 2021; Ulrich, 2000). Children and adolescents appear to reach a ceiling effect on their FMS scores, with minimal growth and even decline recorded in the early adolescent years, (Behan et al., 2019). However, positive intervention effects can be achieved among adolescent

populations when sufficient time and suitable pedagogies are adopted to increase activity and skill level (Duncan et al., 2022).

2.3.1. Gender differences in FMS Globally

Previous reviews of FMS performance among children and adolescents have highlighted evident differences between the genders in terms of performance, with superior male performances often reported in MC (Bolger et al., 2021; Foulkes et al., 2022; Hardy et al., 2013). Males commonly record higher overall skills, with significant male superiority recorded for the object-control subset in childhood and adolescence (O'Brien et al., 2018; van Beurden et al., 2002). The Bardid et al., (2016c) study conducted in Belgium (n=1614; 841 male; age-range 3- to 8- years old) highlighted superior male overall MC performances, however, significant differences ($p<.001$) only arose in the object-control skills (Bardid et al., 2016c). The Barnett et al., (2018) study in Australia (n=118; 62 male; mean age 9.9 ± 0.7 years old) illustrated significantly superior object-control skills among males ($p<.001$), yet, locomotor skills were relatively equal between genders (Barnett et al., 2018).

This gender discrepancy in the object-control subset has been reported in countries such as Britain (Bryant et al., 2014), America (Ulrich, 2000), China (Chan et al., 2018), Finland and Portugal (Laukkanen et al., 2019), The locomotor subset presenting with relatively equal levels of performance or female superiority has been found in several forms of research in the past using the TGMD-2 assessment tool for FMS measurement, suggesting that there is less of a clear gender divide in this subset (Lopes et al., 2018a; Tietjens et al., 2020).

Notably, in several studies using the KTK, a test comprised solely of locomotor and balancing activities, no significant gender differences are as apparent. This research extends to varying regions across the globe including Belgium and Australian children (n=496; 252 Belgium; 244 Australia; 232 male; age range; 6- to 8-years old); Belgian adolescents (n=214; 142 male mean age= 13.64 ± 0.68 years), and

Brazilian children (n=424; 224 male; age range= 5-10 years old),) suggesting that performance is equal across genders (Bardid et al., 2015; De Meester et al., 2016b; Ré et al., 2018).

A systematic review of the MABC-2 has found male superiority in gross motor skills (aiming and catching, and throwing), while females appear to exhibit higher skills in conventional fine motor skills, and in balance (Rodrigues et al., 2019). This gross motor finding has been affirmed in separate studies across diverse regions, including in Australian pre-schoolers (n=514; age range 3- to 5- year olds), Danish children (n=607; 299 male; mean age= 5.8 ± 0.3 years), Czech teenagers (N = 121; 50 male; mean age 16.0 ± 0.5 years) and early Czech adolescents (N=589; 310 male; age range= 11-16) (Livesey et al., 2007; Olesen et al., 2014; Valtr et al., 2016).

Across different toolkits, females appear to possess greater locomotor skill proficiency, while their object-control skill performances appear to be consistently weaker than their male counterparts (Barnett et al., 2016a; Bolger et al., 2021). Some of these differences may be attributable to female preferences for locomotor-based activity (Bardid et al., 2016c).

2.3.2. Gender differences in Irish FMS research

Irish performance in FMS has recently been decreed as consistently substandard and below expectations across both childhood and youth populations (Belton et al., 2022; Duncan et al., 2022). Across 3 Irish childhood studies utilising the TGMD-2 and TGMD-3, gender differences were again apparent in the primary school setting. The Bolger et al., (2018) study (N=203, age range 6- to 10- years old), reported significant male superiority for object-control skills, and superior female superiority (both at $p<.05$) for locomotor skills (Bolger et al., 2018). The Kelly et al., (2021) study (N=255, 158 male; mean age = 7.4 ± 0.6 years) only recorded significantly higher male object-control performances ($p<.0001$) (Kelly et al., 2021). The Behan et al., (2019) study (n=2,098; 1,111 male; mean age= 9.2 ± 2.04 years),

reported significantly superior locomotor performance among females, and superior object-control performance among males (both at p<.01) (Behan et al., 2019).

Across the plethora of Irish adolescent research, familiar gender patterns remain. In the O'Brien et al., (2016) study (n=223; 124 male; mean age= 12.50 ± 0.52 years; 99 female; mean age= 12.32 ± 0.49 years), males were significantly superior in overall FMS performance, and object-control performance (both at p<.05) (O'Brien et al., 2016). The McGrane et al., (2018) study (N=584; 278 male; mean age= 13.78 ± .42 years), reported significantly superior (p<.001) male performances across both object control and locomotor subsets (McGrane et al., 2018). The O'Brien et al., (2018) study (N = 219; 120 male; mean age=14.45 ± 0.96 years) found that males had significantly superior scores in overall FMS performances, and in the object-control subset (p=.001) (O'Brien et al., 2018).

2.3.3. Accounting for Gender differences in FMS performances

Until the ages of 8- to 9- years old, boys and girls are physiologically similar suggesting that biological differences do not impact FMS or MC performances (Malina et al., 2004). From the ages of 9- to 10- years old, however, growth spurts and other developmental changes provoked by puberty (e.g. increased strength, height, flexibility gains, potential coordination issues) impact on performance (Malina et al., 2019). While decline in sporting participation during adolescence is common for males and females, the greater degree of female dropout may explain the greater FMS divide evident in the literature (Jaakkola & Washington, 2013; Woods et al., 2018).

Sociological factors also appear to contribute strongly, with females often feeling pressure from society or their family to dropout of sporting participation due to cultural or religious affiliations, or face pressure to partake in particular forms of PA which reflect acceptable norms for femininity e.g. dance and gymnastics (Dagkas et al., 2011; Humberstone, 2001). To combat these issues of declining participation among females in sport and PA , it is clear that more female-oriented activity programmes which respond to female needs and interests are required in addition

to providing them with greater responsibility in their activity choices (Cowley et al., 2021; Farmer et al., 2020; Murphy et al., 2022).

Female-oriented interventions have proven successful in improving motor skill proficiency in previous Australian research. The Lander et al., (2017) study (n=190; mean age= 12.47 ± 0.34 years) saw significant increases in both locomotor ($p=.004$) and object-control skills ($p<.001$), utilising a teaching principle known as SAAFE (Supportive, Autonomous, Active, Fair and Enjoyable) (Lander et al., 2017). This pedagogical approach recognises female interests in PA, by reducing the competitive and games-oriented nature of physical education, while promoting personal motivational goals and increasing their level of responsibility and decision making (Lubans et al., 2017). The fun, autonomous, and social aspects of PA have been deemed a key influence on female participation in sport and PA, as girls value playing with their peers and a sense of community, in addition to having greater choice in how they exercise (Cowley et al., 2022; Garcia et al., 2016; Murphy et al., 2022).

If parents positively model PA effectively for their children, their child is at an increased likelihood of participating in PA, which may create a domino effect, fuelling the participation of other children in PA and sport, while promoting more engagement (Maturo & Cunningham, 2013; Petersen et al., 2020). Progressive societal values such as parental support could be a key factor in reducing the existent gender-based MC differences. A cross-cultural study noted that in Finland, a country lauded for progressive gender equality practices in PA, less of the variance in MC abilities was explained by gender, in comparison to both Portugal and Belgium (Laukkanen et al., 2019).

2.3.4. Socioeconomic differences in FMS Performance.

Differences in Socioeconomic status (SES) can contribute to FMS performance. A person from a lower SES setting, may have fewer opportunities to partake in games and PA due to a lack of safe play spaces, while their parents may

not have the time or financial means to support their extra-curricular activity, culminating in the possibility of poorer MC (Barnett et al., 2019; Eyre et al., 2020; Spracklen et al., 2015).

A 2012 Australian study (n=6,917; 3,666 male; age-range 7-14 years old), found that performance in several FMS was impacted by SES (Hardy et al., 2012). Among boys, a non-English speaking background was associated with lower object-control skills in comparison to peers, while males from low SES were 35% more likely to demonstrate poorer locomotor skill proficiency compared to higher SES peers. Among girls, students from low SES were 54% more likely to show poorer locomotor skill proficiency compared to high SES girls (Hardy et al., 2012). A study among Belgian children (n= 1955; 1,017 males; age range= 6- to 11- years old) posited similar findings. Girls of higher SES performed significantly better ($p<.01$) in hopping for height, jumping sideways, and walking on balancing beam tests, when compared to that of their middle and lower SES peers. Among boys, there were no significant differences, however, children from lower SES regions displayed poorer MC (Vandendriessche et al., 2012).

Reducing participation costs for children from lower SES regions and ethnic minority backgrounds is a key concern (Liu, 2009). Targeting adult support in addition to the in-school programmes which respond to the needs of students from lower SES regions and ethnic backgrounds could resolve such deficits due to the positive modelling effect families have on PA habits, which enables skill development (Petersen et al., 2020).

2.3.5. FMS- Intervention Strategies

Across childhood and adolescent populations, the role of interventions in improving MC across different subdomains cannot be understated (Engel et al., 2018). This ontogenetic view of MC proposes that environmental surroundings, and task constraints are essential facets in the growth and hinderance of skill development (Brian & Taunton, 2018). Skill-specific, and focused teaching is typically advocated to promote the onset of FMS in male and female populations (Dudley et al., 2011; Eather et al., 2018).

Effective MC interventions are often led by a specialist (i.e. researcher or practicing physical education teacher), supporting the utility of schools for intervention studies (Mannocci et al., 2020; Lai et al., 2014). A recent systematic review examining the success of interventions on FMS and PA in youth noted that teacher-led interventions (predominantly by specialist physical education teachers but occasionally physiotherapists or exercise physiologists) were more effective than interventions led by generalist teachers, who received minimal FMS training (Engel et al., 2018). Other systematic reviews support these viewpoints, with clear indications suggesting that specialist trained teachers improve FMS outcomes among study participants (Tompsett et al., 2017).

2.3.6. Skill-focused direct interventions

Direct-teaching approaches for MC focus on skill-specific improvements with a high level of structure and a teacher-centred step by step approach (Rink, 2014; Tompsett et al., 2017). An Australian study (n= 165; 68 male; mean age= 8.2 ± 1.1 years), found an activity programme (10 x two hour weekly sessions, and home component) using direct teaching methods focusing on skills in isolation (through individual, pair, or game activities) resulted in significant ($p<.001$) improvement in overall locomotor and object-control skills (Cliff et al., 2011). A further study in New Zealand (n= 701; age range 5- to 12- years old) utilised direct teaching methods through specialised FMS instructors known as “energizers” (Mitchell et al., 2013), and the intervention had a significantly positive effect on all skills tested ($p<.001$). An American study (N = 109; 56 male; mean age = 54 months ± 7 months) examined the influence of direct methods on skill development using experienced physical education teachers and novice preservice teachers with no physical education qualifications (Brian & Taunton, 2018). The study found that the expert and direct methods of MC instruction yielded the highest improvements in the locomotor subset, while expert-led indirect methods were more effective for object-control (Brian & Taunton, 2018). For novice teachers, direct teaching resulted in the greatest improvements (Brian & Taunton, 2018). Furthermore, a Spanish intervention (n=380;

195 male; age range= 6-to 11- years old) wholly focused on balance tasks proved highly effective for improving balance scores in the MABC-2 and other balance measures (Rodríguez-Negro et al., 2019).

Direct approaches to MC are critiqued for their inability to provide individualised teaching programmes, and their lack of developmentally appropriate tasks and diverse environments has the increased potential to create unskilled movers (Morgan et al., 2013). This approach may also inhibit motivation and creativity as participants lack ownership and control of their learning (Fasko, 2001; Seifert et al., 2018).

2.3.7. Indirect FMS Teaching approaches

There is a large body of research suggesting that the more indirect teaching methods are more preferable for skill development (Button et al., 2020; Lee et al., 2014). Indirect approaches can promote more autonomous decision-making, and learner-led self-regulation which promote individuals acquiring diverse skills they can apply to different active environments (O'Sullivan et al., 2022; Rudd et al., 2021). The aforementioned Lander et al., (2017) study utilised open student-centred methods (increasing responsibility, non-competitiveness, and choice) and reported significant growth in locomotor ($p= .04$) object-control ($p<.001$), and overall gross scores ($p= .02$) in female adolescents (Lander et al., 2017).

A British study (n=39; White=21; South-Asian= 18; age range 4- to 6- years old), utilised a novel intervention approach for developing FMS by integrating popular children's stories and characters into sessions (Eyre et al., 2020). The combination of storytelling with movement is a unique approach, as it is seen to improve memory recall, while enabling creativity and exploration of movement (Duncan et al., 2019; Eyre et al., 2020).

The Cohen et al., (2015) study in Australia (N=460; 211 male; mean age= 8.5 ± 0.6 years) centred its 12-month intervention on improving MC competence in youth

by supporting autonomy and creating connections between students and school stakeholders (Cohen et al., 2015). Strategies utilised included providing students with rewards (certificates and equipment) for partaking in a workshop, students assuming responsibility for organising lunchtime activity sessions, and school discussions on FMS and PA. Teachers also promoted more skill exploration, small-sided games, and guided discovery in physical education lessons and extra-curricular sport (Cohen et al., 2015). The intervention culminated in a statistically significant improvement in overall FMS ($p = .045$) and a non-significant growth in the locomotor and object-control subsets among intervention participants (Cohen et al., 2015).

A 2017 Australian study (n=333; 163 male; mean age= 8.1 ± 1.1 years) utilised a 16-week gymnastics programme to improve FMS measured by the TGMD-2 and KTK (Rudd et al., 2017). This programme incorporated a novel 'brain challenge' into a standard warm-up, while using circuit-based gymnastics practice targeting transport, stability, and balance (Rudd et al., 2017). The intervention significantly ($p<.05$) improved the stability and object-control abilities of the intervention group (Rudd et al., 2017).

A further unique approach was taken in a Belgian study with overweight/obese children (n=36; 24 male; mean age= 10.5 ± 1.4 years). The multi-disciplinary approach included psychological treatment, regular PA (4 hours/week aerobic exercise), and dietary restriction over 4 months (D'Hondt et al., 2011). The intervention successfully reduced body weight, with significant increases ($p< 0.01$) in overall and subset KTK scores also reported (D'Hondt et al., 2011). The De Oliveira et al., (2019) study in Australia (n= 511; 257 male; mean age= 5 years 5 months ± 3.58 months) utilised 'Animal fun' in its intervention programme (De Oliveira et al., 2019). Children move and act like animals in this intervention, which adds an element of fun, while providing context to key FMS (e.g. ''frog jumps'' emphasis importance of jumping for distance) being performed (De Oliveira et al., 2019). The intervention positively and significantly impacted on scores in catching ($p= .009$) and one-legged balances ($p=.048$) (De Oliveira et al., 2019).

While direct and indirect teaching methods both effectively develop FMS, indirect teaching methods may be more preferable as they develop secondary life

skills, such as responsibility, ownership, and leadership (Cohen et al., 2015; Smith et al., 2021). As many indirect teaching studies are guided by the principles of self-determination theory, and competence motivation theory, it is possible that participants in such interventions may become motivated to incorporate PA more readily into their regular lifestyle (Lubans et al., 2017).

Indirect methods are frequently cited as pivotal within skill acquisition research, as they demand users to be placed in varied surroundings (i.e. different pitch parameters, small-sided games etc.) (Rudd et al., 2020b; Smith, 2016). Notably, many of the outlined indirect teaching studies manipulate constraints and tasks by using different group sizes, and reducing competition, while altering pedagogy through guided learning and self-discovery (Cohen et al., 2015; Crotti et al., 2021; Lander et al., 2017).

A balance between direct teaching approaches (i.e., punctuated by isolation and repetition) and the development of skills through game-centred learning is endorsed, as it provides practice time to refine technique in addition to the meaningful environment (Smith, 2016).

2.3.8. Conclusion MC and FMS

Across the 3 assessments of MC and FMS outlined in this review, global levels of movement can be characterised as poor and substandard (Bolger et al., 2021; Duncan et al., 2022; Laukkanen et al., 2019). These values are concerning, though they should be countenanced by the fact that espouse that MC and FMS assessments may not depict the full picture of movement ability of an individual, nor do they necessarily evaluate skills or activities relevant to an individual and their movement experiences (e.g. activities such as swimming, cycling, and parkour are omitted) (Hulteen et al., 2018; Pot et al., 2018). While acknowledging that sociological and socioeconomic factors can account for skill differences, a clear divide between males and females exists, with consistent evidence illustrating that males display superior object-control skills, and females show slightly greater locomotor skill proficiency

(Hardy et al., 2013; Bardid et al., 2016c). To support a healthy weight status, and lifelong PA, effective teaching and pedagogical strategies for FMS are needed (Barnett et al., 2022). Indirect methods of MC instruction which promote exploration and varied environments appear to be key in developing skill and instilling fun for young participants by providing them with joy, independence, and motivation necessary for their lifelong participation in PA and skills (Cairney et al., 2019; Crotti et al., 2021; Rudd et al., 2021). Monitoring and developing childrens' perception of their own ability will be key to developing their skill and ensuring that their participation levels are high (Harter et al., 1978).

As MC and FMS are cited as 'goal-directed human movement', and 'building blocks' respectively, their application across other forms of movement is worth assessing (Bardid et al., 2019; Logan et al., 2018). These fundamental movements are stated to transition to increased PA, serving as a foundation to more complex or sports-specific movement (i.e. overhand throw translating to sports such as cricket or baseball) (Gallahue et al., 2019; Hulteen et al., 2018). A wide movement skillset is critical to accessing and participating in PA across the lifespan, and practicing skills under different constraints is essential to becoming a skilled performer (Clark & Metcalfe, 2002; Seifert et al., 2018). It is possible that high levels of MC and FMS hone elements of core and postural stability, which aid performance in musculoskeletal strength exercise and enable the body to functionally perform tasks in alternative settings (Cook et al., 2006b; Newell, 2020). This suggests that performing FMS tasks at a high level could help develop aspects of health-related physical fitness, such as flexibility, in addition to postural control (Barnett et al., 2022; Cattuzzo et al., 2016). Additionally, a high degree of performance in MC and FMS could promote higher levels of self-esteem, and physical self-perception in skill performance (Barnett et al., 2022; Lawson et al., 2022)

2.4. Introduction to Physical Self-Perceptions

Physical skill perceptions (referring to how one feels about their skill performance) are formulated on the following five concepts (i) previous experience (ii) task difficulty, (iii) persuasion and interaction with others (iv) intrinsic motivation (v) vicarious experience (Harter, 1978). The ability of children and adolescents to develop realistic and accurate perceptions of ability is predicated on the development of their cognitive domain as their understanding of vicarious experience, and task difficulty requires cognitive maturity (Kruger & Dunning, 1999).

Such assessment toolkits for perceptions of skill ability include the Children and Youth's Physical self-perception profile (Whitehead, 1995), the Self-Perception profile for Children (Harter 1985, 2012), the pictorial scale for Perceived Movement Skill Competence scale (PMSC) (Barnett et al., 2015), and the McGrane physical self-confidence scale (PSC) (McGrane et al., 2016). Each of these assessment toolkits are rooted in the pioneering work of Dr. Susan Harter on Competence Motivation Theory (CMT) (Estevan & Barnett, 2018; Harter, 1978). Both Harter's work and subsequent research indicates that perceptions of one's own ability are associated with motivation and willingness to persist with an activity, and challenge oneself in the pursuit of mastery (Barnett et al., 2008; Harter, 1978). This may partially explain why the MC field has historically focused primarily on self-perceptions and their influence on PA, rather than associations with actual skills (Fox, 1990; Whitehead, 1995). A desire to greater understand PA behaviour was further cited as a reason for the development of physical self-perception profiles targeting older and younger adolescent groups, indicating that PA was a pivotal area of focus particularly within early self-perception research (Barnett et al., 2008; Eklund et al., 1997; Fox, 1990; Whitehead, 1995).

To nurture higher and more realistic perceptions of competence, Harter's work suggests that the key factor lies in developing actual competence (Harter, 1978, 1982). While countless research has highlighted the potential positive impact of overestimation of abilities to assist motivation, and PA participation (Chen, 2015; De Meester et al., 2016b), instilling realistic perceptions of competence must remain a

priority (Harter, 1982; Utesch et al., 2018). Realistic perceptions are indicative of a more knowledgeable person, who has the potential to retain high motivation for daily PA participation, while several other studies also report that when high perceptions are aligned with actual abilities, higher levels of PA are accrued (Estevan et al., 2021b; Utesch et al., 2018). This finding is again rooted in Harter's theories. CMT suggests that improving the accuracy of relationship between perceived motor competence (PMC) and MC is critical (Harter, 1982).

2.4.1. Multi-dimensional perspective: Harter's perceived competence scale

Earlier scales examining physical self-perceptions included the Physical self-efficacy scale (Ryckman et al., 1982) and the Physical Self-estimation scale (Sonstroem, 1976), however, both of these self-report instruments failed to gain significant traction within the field. This may be due to their unidimensional outlook, characterised by evaluating perceptions in a singular domain, which fails to account for the interconnectedness of different elements that make up one's self-worth (Fox & Corbin, 1989; Harter, 1982). Harter's work and the Shavelson model of Self-Concept proved instrumental in the development of a multi-dimensional perspective outlook (Harter, 1982; Shavelson et al., 1976).

Harter's perceived competence scale for children (Harter, 1982) would be the guiding principle behind all future scales in the physical perception field. This scale examined 4 key subdomains that comprised one's self-worth: cognitive, physical, social, and general. These sub-domains were viewed as interwoven i.e. low perception in one domain could negatively impact another (Harter, 1990). The acknowledgment of numerous domains impacting on one another and on overall self-worth is the mark of a multi-dimensional perspective of self-perception (Harter, 1982; Shavelson et al., 1976).

The Perceived Competence scale introduced the 'structured alternative response format' to perception instruments, using a two-pronged response system. The scale asks a child to describe which person they are most alike e.g. 'some kids often forget what they learn or other kids can remember things really easily' (Harter, 1982, 2012). The child is then prompted to say whether their first answer is 'really

true for me or sort of true for me', thus reducing social desirability bias, as it proposes a viable alternative to higher perception (Harter, 1982, 2012). Responses are graded on a 1 to 4 scale, with 1 indicating the lowest level or perception, and 4 indicating the highest level of perception. Across three diverse study population samples in America, the perceived competence scale reported fair to good reliability across the four subdomains (Harter, 1982). Furthermore, the assessment tool reported good test-retest reliability across two different samples (Colorado; N=208, three months apart; New York; N=810, nine months apart) (Harter, 1982).

2.4.2. Harter's Self-Perception Profile for Children (SPPC)

Harter subsequently developed the Self-Perception Profile for Children (SPPC), an instrument that is still popular for modern perception and PMC assessments. The instrument is recommended for use from grades 3 to 8 in the American schooling system, or approximately ages 8- to 15- years of age (Harter, 1985, 2012). The self-report instrument retained elements from the 1982 perceived competence scale, however, it has added additional areas to comprise of six total domains: Scholastic Competence, Social Competence, Athletic Competence, Physical Appearance, Behavioural Conduct, and a combined domain of all areas in Global Self-Worth (Harter, 1985, 2012).

Each domain of the scale was tested for internal consistency (as measured by Cronbach Alpha) across 8 population samples during the 1980s and 1990s (Harter, 1985, 2012). The scholastic competence domain illustrated good internal consistency (range 0.80-0.85), while other domains displayed acceptable to good ranges in social competence (0.75-0.84), global self-worth (0.78-0.87), behavioural conduct (0.75-0.87), physical appearance (0.76-0.88), with athletic competence demonstrating acceptable to excellent reliability 0.76-0.91) (Harter, 1985, 2012). Convergent validity for the SPPC was also established with another instrument, the less publicised Physical Self-Description Questionnaire (Harter, 1985).

The SPPC has been used and translated internationally across numerous countries, including the Netherlands (Van Dongen-Melman et al., 1993), Portugal (Faria, 2001), Belgium (Van den Bergh & Van Ranst, 1998) and Spain (Broc, 2014). The translated versions (with minor variations in respect of cultural differences) have consistently demonstrated moderate psychometric properties (through different reliability and validity metrics etc.), indicating the suitability of the SPPC across a variety of different backgrounds (Broc, 2014; Faria, 2001; Van den Bergh & Van Ranst, 1998).

2.4.3. The Children and Youth Physical Self-Perception Profile (CY-PSPP)

The Children and Youth Physical Self-Perception (CY-PSPP) is utilised in older adolescents (typically older than 16- years of age), and was validated in research college-aged students (Fox, 1990; Fox & Corbin, 1989). The CY-PSPP evaluates four sub-domains which are all connected to the overarching domain of physical self-worth, epitomising the multi-dimensional perspective: Perceived sports/athletic competence, perceived bodily attractiveness, perceived physical strength, perceived physical condition. The CY-PSPP utilises the same perceived sports/athletic competence measure from the Harter perceived competence scale (Harter, 1982). The other testing domains utilised in the CY-PSPP were adapted from the Physical Self-Perception Profile (PSPP) of Whitehead (1995), with modifications designed to make the scale child-oriented and practical for research (Whitehead, 1995). The structured alternative response from Harter's SPPC and the adult PSPP were retained (Fox, 1990; Fox & Corbin, 1989).

The CY-PSPP possesses good and excellent levels of internal consistency in both male and female populations from 7th to 8th grade (N=459; 232 male, 7th-8th grade) (Whitehead, 1995). In a second study sample of 7th to 8th grade students (N=46) over a two-week period, excellent test-retest reliability was recorded across all scales (Whitehead, 1995). Both factor analysis and the analysis of variance work indicate that the tool has construct validity, as the tool distinguished between lower and higher order perception groups (Whitehead, 1995). Concurrent validity was established through comparisons with physical fitness tests. Moderate correlations

between CY-PSPP scores and the physical fitness tests were observed, indicating its efficacy as a toolkit (Whitehead, 1995).

2.4.4. A change in the perceived motor competence landscape - looking at the skill-specific level

The noticeable trend of earlier perception instruments is that their analysis was conducted as either a standalone topic (i.e., simply evaluating physical self-perceptions), or these tools were used to analyse the link between self-perceptions and PA. As the analysis of self-perceptions is rooted in CMT, analysing PA was a logical and clear step (Harter, 1978; Whitehead, 1995). CMT suggests that higher perceptions of one's physical self should result in a higher degree of motivation to partake in the activity (Barnett et al., 2008).

Contemporary work, again rooted in CMT explores the existence of a connection between physical self-perceptions, and actual MC skill level. A frequent critique of the Harter and Whitehead scales is their limitation in focusing on sport and athletic competence at a non-specific level (i.e. they do not refer to particular movements like throw, catch etc. but refer to performing well in general sporting or game-based activities (Estevan & Barnett, 2018). This resulted in the emergence of 'Perceived Motor Competence' (PMC), defined as "an individual's awareness and belief in his/her capabilities in goal-directed human fundamental movement skills and what would be considered as motor competence" (Estevan & Barnett, 2018, p.269). Newly developed MC tools focus on PMC, evaluating specific skills rather than general sport and athletic competence questions, derived from Whitehead and Harter publications (Harter, 1985).

MC research has hypothesised that perception is a strong mediating variable for both MC and PA, however, evaluating PMC at a skill-specific level is essential to exploring this relationship further (Robinson et al., 2015). Aligning instruments of perception with tests used in actual FMS and MC measurement is a key concern of future research (De Meester et al., 2020; Estevan & Barnett, 2018). The concept of alignment may be particular prevalent and prominent in later childhood and

adolescence where presumed growth in cognition may account for an improvements in assessing one's abilities (De Meester et al., 2020; Estevan & Barnett, 2018). A greater degree of studies, and evaluation of factors, such as gender and alignment of toolkits (i.e. how might the use of process PMC measures impact alignment when product MC measures are also used etc.), and longitudinal studies are required for more comprehensive views to be developed in the PMC field (Barnett et al., 2022; De Meester et al., 2020).

While the skill specific element of newer tools, namely the pictorial scale for Perceived Movement Skill Competence and the Physical Self-confidence Scale is commendable, these instruments may come at a cost (Barnett et al., 2015). These perception tools arguably take a uni-dimensional approach to perception by only focusing on the physical skill elements, neglecting social, cognitive or other physical elements, which impinge on perceived skill ability (Shavelson et al., 1976). There is no clear evaluation, however, of other subdomain elements (cognition, social skills etc…) within newer testing batteries (Barnett et al., 2016a). Additionally, there is a possibility that a more general measure of perception is more suitable for children and adolescents who may lack the specific ability to evaluate their ability in individual skills (De Meester et al., 2020).

2.4.5. The pictorial scale Perceived Movement Skill Competence scale (PMSC)

The emergence of PMC and skill-specific measurements led to the development of the pictorial scale for Perceived Movement Skill Competence (PMSC) for children (Barnett et al., 2015). Pictures of girls were used when girls were assessed, and pictures of boys were used when boys were assessed, with the questionnaire conducted on a one-to-one basis through a structured alternative response format (Barnett et al., 2015). Participants are asked which person they are most alike (e.g., a cartoon of a poor performance, and a good performance is

provided). If they select the good performer, they are asked if they think they are really good (highest score of 4) or pretty good (score of 3). If a person rates themselves as the poor performer, they are asked whether they are sort of good (score of 2) or not good at all (score of 1). These four potential scoring options are available for each of the twelve skills which match those of the TGMD-2 (see table 2.1) (Barnett et al., 2015).

The instrument demonstrated excellent test-retest reliability with intraclass correlation values of 0.83 (all skills), 0.78 (object-control subset of six skills; Kick, Roll, Bounce, Catch, Hit, Throw), 0.82 (locomotor subset six skills- Gallop, Hop, Jump, Leap, Run, Step Slide). Across the test re-test sample group (n=32; 18 male; mean age 6.0 years), and across a second sample group (N=58; 25 male; mean age= 7.2 years) of Australian children, the test demonstrated acceptable internal consistency, as measured by Cronbach's Alpha. Furthermore, the gender-specific scales demonstrated acceptable levels of internal consistency (between 0.69-0.81), when measured with the second sample group (Barnett et al., 2015).

Following the initial face validity and test-retest reliability, the PMSC added six additional 'Active-Play Skills', to reflect activities not traditionally accounted for in typical FMS testing, however, these additional skills were deemed be key to childhood PA patterns among children (Barnett et al., 2016c; Robinson et al., 2015). The added skills were as follows: bike cycling, board paddle (paddling a board using the arms in water), climbing, roller-blading/roller-skating, scooter, and swimming (Barnett et al., 2016c). As with the other PMSC scale, gender-specific scales were created for the Active-Play skills. These Active-Play Skills demonstrated acceptable to good test-retest reliability across a seven-day test-retest window (n=74; mean age= 6.4 ± 1.0 years) in young children (Barnett et al., 2016c).

2.4.5.1. The pictorial scale for Perceived Movement Skill Competence (PMSC) Cultural differences

Cultural differences have emerged when the PMSC is tested among global populations. The TGMD-2, aligned with the PMSC was developed in America, and

evaluates skills that are more common to the American sporting landscape (Ulrich, 2000). A lack of participant familiarity with an identified FMS may result in the participant self-reporting a lower perception of ability based on such cultural differences (Brian et al., 2018). Traditionally, across perception instruments, Chinese people have been found to have lower levels of perception in locomotor skills (skip, gallop, and slide), and this has been attributed in part to their own cultural modesty, and their sense of unity and collectivism (Diao et al., 2017).

The Feitoza et al., (2018) study involved a larger cross-country sample of participants examining perceptions across four countries (Brazil, Australia, Portugal and America) (n=614; aged 5- to 8- years old). In this study, American children demonstrated the highest self-perception scores, followed by Portuguese, Australian, and finally Brazilian children, with this ordering consistent at the locomotor and object-control subset level (Feitoza et al., 2018). These lower values found within the Brazilian population were further verified in the initial validity study for the Brazilian translation of the PMSC, which noted that for all subsets (inclusive of the Active-Play skills), Brazilian children demonstrated lower values than previous Australian and Portuguese studies (Barnett et al., 2016c; Lopes et al., 2016; Valentini et al., 2018). These lower Brazilian values are attributed to the religious values and collectivist nature of Brazil, when compared to the other nations assessed such as Portugal, Australia, and America (Feitoza et al., 2018; Hofstede, 1991).

2.4.6. McGrane's Physical Self-Confidence (PSC) Scale

A similar scale analysing perceptions at a skill level has emerged in recent years, and this is the McGrane Physical Self-Confidence (PSC) Scale (McGrane et al., 2016). The scale was designed to examine 15 FMS which form a part of the TGMD-2 testing battery (Ulrich, 2000). Participants grade their confidence in their ability to perform the skill on a Likert Scale of 1 to 10. A score of '1' indicates the participant is not confident at all, while a score of '10' indicates that they are very confident in their skill execution (McGrane et al., 2016). As with the PMSC, the PSC scale marks a

progressive evolution in perception research at a skill-specific level, in contrast to broader levels of sport and athletic competence (Robinson et al., 2015).

Perception of ability measures often refer to the efficacy and the outcome of a performance in a given context, i.e. how good is someone at a task, with confidence referring to their willingness to engage in a task (Bandura et al., 1999; Stewart et al., 2000). Self-confidence is not a direct measure of PMC, however the skill-specific elements of the scale, its extensive use among the adolescent population in Ireland, and its inclusion in a PMC systematic review do indicate it is worthy of examination (De Meester et al., 2020). The PSC scale was examined for test-retest reliability, in addition to content and concurrent validity in a single study conducted among an Irish adolescent population (n=376; 193 male; mean age = 13.78 ± 1.21 years) (McGrane et al., 2016). The scale demonstrated excellent test-retest reliability, with an intraclass correlation coefficient of 0.92, alongside good content and concurrent validity (correlation coefficient of 0.72) with the physical self-worth dimension of the Fox & Corbin PSPP (McGrane et al., 2016).

2.4.7. PMC and MC strength of relationship

A recent systematic review and meta-analysis highlighted the strength of the relationship across measures of physical self-perception and overall actual MC ability, with a statistically significant positive, yet small relationship (r.246, p<.001) found (De Meester et al., 2020). When examining the locomotor and object-control subsets, the correlation remained small and positive (r= .21, p= 0.0071).

Mixed study findings between both variables have been reported elsewhere in the literature, with several studies reporting significant small correlations between PMC and MC (Bardid et al., 2016a; Morano et al., 2020; Rogers et al., 2018), while moderate relationships between PMC and MC (or MC subsets) have been reported in several studies with older childhood and adolescent groups (Carcamo-Oyarzun et al., 2020; Estevan et al., 2021a; McGrane et al., 2017), suggesting the De Meester et al., (2020) meta-analysis has presented an accurate summation. The meta-analysis

also reported a surprising finding that neither age nor sex proved a significant impact on the strength of the relationship between PMC and MC, in spite of the consistent psychological theory which posits that greater accuracy between PMC and MC would occur as individuals progress from childhood to adolescence (De Meester et al., 2020; Harter, 1978). Greater research on the adolescent cohort is necessary to gain further insight in this area (De Meester et al., 2020; Estevan & Barnett, 2018).

2.4.8. Gender differences in Perception

While gender disparity in terms of perception values (i.e. males having higher values than females), are common, a recent meta-analysis reported no gender effect on the strength of the relationship between these variables (De Meester et al., 2020). Gender differences are quite common for the Harter SPPC (Broc, 2014; Muris et al., 2003). Typically, boys have higher values across measures, however, girls frequently possess higher behavioural conduct scores. This research has been found across a plethora of countries, including America (De Meester et al., 2016a), Spain (Broc, 2014) and the Netherlands (Muris et al., 2003).

Notably, high scores across both genders is a common finding when the CY-PSPP is used for assessment (Whitehead, 1995). The majority of research related to the CY-PSPP presents higher values for males than females, as evidenced by the findings among children and adolescents in England (Fairclough et al., 2012; Fairclough & Ridgers, 2010), Sweden (Raustorp et al., 2005), and America, (Welk & Eklund, 2005; Whitehead, 1995).

Boys typically exhibit higher perceptions than females in PMSC overall scores, however, significant differences only exist between genders in the object-control subset with boys presenting higher object-control values than their peers across numerous studies (Barnett et al., 2018; Barnett et al., 2016c; Tietjens et al., 2020; Van Veen et al., 2020). A gender imbalance within the PSC scores of males and females has been found in several studies, utilising the scale (McGrane et al., 2017; O'Brien et al., 2018).

This gender disparity in perceived object-control across the PMSC and the PSC is perhaps somewhat understandable, given the previous recognition in the literature of male superiority in actual object-control skills (Barnett et al., 2016a; McGrane et al., 2018). Overall, both males and females possess relatively high perceptions of ability across different toolkits, with males demonstrating higher perception levels, however, when compared with actual ability, most participants performed below expectations for their age (Barnett et al., 2010; Chan et al., 2019).

2.4.9. Overestimation of PMC ability

Each perception measurement instrument highlighted in this literature review has illustrated a problem with regards to higher self-reported perception values, i.e., high levels of perception when compared to low actual ability levels. The SPPC noted it within two studies (De Meester et al., 2016a; Vedul-Kjelsås et al., 2012), the later-adolescent PSPP cited similar problems (Barnett et al., 2008; Lander et al., 2019), as has the PMSC (Clark et al., 2018; Van Veen et al., 2020), CY-PSPP (Burgess et al., 2006; Raustorp et al., 2005; Whitehead, 1995) and the PSC (McGrane et al., 2017; O'Brien et al., 2018) scales.

High perceptions are not necessarily problematic, but alignment between perception and actual ability has been previously deemed as desirable (Harter, 1982). Overestimation of ability, however, is frequently considered to be beneficial, as it can promote efforts to achieve mastery potentially increasing proclivity for PA (Harter, 1978; Rogers et al., 2018).

Negative components of overestimation, however, also exist. Participants who overestimate their PMC may take dangerous risks, increasing their susceptibility to injury, and may refrain from engaging in complex and challenging tasks to preserve the illusion of their own high level of ability (Dweck, 1990; Plumert, 1995). Overestimation may lead to an individual expending too much energy attempting to resolve unachievable tasks, with failure to complete tasks damaging overall self-worth (Carver & Scheier, 1998; Vancouver et al., 2002). Low perception of ability

levels, when compared to greater actual skill levels have been deemed equally problematic, as it can lead to low motivation or apathy, or feelings of anxiety and doubt (Harter, 1999; Weiss & Horn, 1990).

2.4.9.1. The Dunning-Kruger Effect

Social and cognitive psychology provide further reasoning behind overestimation of PMC. Cognitive psychologists have theorised that those lacking competence in a domain are cognitively unaware of their incompetence, and this is referred to as the Dunning-Kruger Effect (DKE). Awareness of incompetence would result in efforts to improve their capabilities, which would improve one's actual ability (Miller, 1993).

Dunning & Kruger (1999) found people often falsely assume they have greater ability than their actual capacity. Their paper contained four studies on three disparate topics (humour, logic, and grammar): Humour (n=65), two logical Reasoning studies (n=45; n=140), and grammar (n=84). Overestimation of their ability was common across all individuals, however, those in the lower quartile of actual ability repeatedly overrated their competence, assuming they were above average (Kruger & Dunning, 1999). In the logical test, lower level performers were less effective in deciphering which answers were correct, demonstrating that 'overestimators' lack the knowledge to accurately identify success criteria (Kruger & Dunning, 1999).

The DKE has been proven in diverse topics such as driving performance (Ehrlinger et al., 2008) debating ability (Ehrlinger & Dunning, 2003), and within sports coaching (Sullivan et al., 2019). While not yet researched within the field of MC or PMC research, it is possible that the DKE is impacting on PMC results, resulting in overestimation of ability and high levels of perception. Study participants demonstrate such poor levels of MC, that it hampers their knowledge and understanding of their own skill level, and they struggle to comprehend what constitutes a high level of movement performance. This culminates in individuals overrating their own level of skill ability (Clark et al., 2018).

2.4.9.2. Aligning Perceptions- The emerging role of veridicality

The consistent findings of overestimation of PMC suggest a veridical (i.e., an accurate and aligned link between perception and actual ability) should be a central aim of research and practice (Schmidt et al., 2013a). In early work regarding CMT, alignment between perception of skills and reality was seen as more critical than merely raising perception itself (Harter, 1982). There is emerging evidence that more accurate, or veridical perceptions of ability are associated with an accrual of PA (Utesch et al., 2018).

Two recent studies (Estevan et al., 2021b; Utesch et al., 2018) have reported that higher levels of PMC, and a veridical relationship between PMC and MC is associated with more longer-term PA. The Estevan et al., (2021b) study reported that greater alignment between PMC and MC is associated with longer-term PA across three years, suggesting that alignment in middle childhood (participant aged between 4 and 9 years old at baseline) is essential to long-term PA. Furthermore, veridical perceptions are associated with higher levels of achievement motivation i.e. a desire to meet goals, and persistence in being successful (Nicholls, 1984). This suggests that even if actual skill abilities are low, those with veridical perceptions may persist with a task to improve their ability (Horn, 2008; Schmidt et al., 2013b). Veridicality of PMC must become a focus of intervention work within MC and PMC research, as better alignment between perception and actual ability reflects a person's growth in their cognitive understanding of their own body movement (Utesch et al., 2018).

2.4.9.3. Intervention Solutions for Enhancing Veridicality?

Growing actual skill ability has regularly been viewed as critical to boosting physical perceptions in the field (Barnett et al., 2008; Chen, 2015). Focusing on both actual competence and the instructional climate, however, has recently been determined as a possible way to improve alignment between perception and ability (Chan et al., 2016). Few intervention studies have specifically targeted alignment but conclusions regarding alignment can be drawn from their pedagogical approaches.

The Schmidt et al., (2013b) study (n=246; 126 male; mean age= 11 ± 0.56 years) focused on improving veridicality of perceptions through a method known as the individualised teacher frame of reference. Teachers were given prescriptive guidelines to improve perceptions through numerous tactics including; in-class reflections, reflective journaling, teachers providing purposeful feedback, self-directed learning at the students' pace, and avoiding peer comparison (Mouratidis et al., 2010; Schmidt, et al., 2013b). The intervention effectively grew perception levels, while also improving veridicality through reducing the number of under and overestimators of ability (Schmidt et al., 2013b).

A 2019 study from Hong Kong, (n = 276; 116 male; mean age 8.4 ±. 0.56 years) used similar teaching principles by promoting Assessment for Learning (AfL) techniques in physical education lessons to develop FMS and PMC (Chan et al., 2019). Lessons were predicated on sharing learning intentions, providing purposeful feedback, and engaging in peer and self-assessments, all key AfL principles (Black & Wiliam, 2010). This 13-week intervention did not significantly raise perceptions; however, a ceiling effect may have occurred. While veridicality was not measured, alignment between PMC and MC would have improved due to growth in their physical skill ability, and insignificant changes being reported in their PMC levels (Chan et al., 2019). As students were provided with the criteria to master the TGMD-3 by teachers (i.e. sharing learning intentions corresponding to AfL doctrine), the lack of change in PMC suggests that AfL methods make students more aware of their actual ability, resulting in realistic assessments of perceptions (Chan et al., 2019).

A 6-week aerobic dance intervention among adolescent girls (n= 50; mean age 13.5 ± 0.3 years) suggests learning topics may form a role in raising perceptions (CY-PSPP). In this cross-over trial, both intervention and control student groups partook in six weeks of normal physical education (swimming lessons), and a 6-week dance intervention, with one group completing the intervention first, and the other group completing standard physical education classes before commencing the intervention (Burgess et al., 2006). In both groups, the dance intervention proved successful, leading to reduced body image issues in salience ($p<.05$), increases in strength and fitness ($p<.0001$), and enhanced physical self-perceptions in body

attractiveness (p<.0001), physical self-worth (p<.0005), and perceived sports competence (p<.05) (Burgess et al., 2006).

A Danish study involving a 9-month PA-focused intervention fostered positive self-perceptions with the CY-PSPP. The study (n=2797; 1430 male; age range 10-13 years) utilised self-determination theory principles, by promoting student autonomy, enjoyment and socialisation to fuel positive associations with activity and develop perceptions within physical education class, break-times and in theme sports days (Christiansen et al., 2018; Ryan & Deci, 2000). While no effects were significant, the sports competence measure and all others (global self-worth, physical self-worth, body attractiveness, social competence) increased, while the divide at baseline between those with high perception and low perception levels was lowered at post-intervention (Christiansen et al., 2018).

The Lander et al., (2019) study examined the potential of a teacher-led intervention with adolescent girls (n=171; mean age 12.48 ± 0.34 years) predicated on the SAAFE principles (supportive, active, autonomous, fair, and enjoyable) of teaching. This approach places students at the centre of their learning experiences, by giving them greater choice, providing positive feedback, and reducing competitiveness (Lubans et al., 2017). This teaching method boosted perception of ability within adolescent girls, as it significantly improved their perceived physical self-perception, perceived total skill, perceived object control skill, and perceived locomotor skill (p<.01) (Lander et al., 2019). Having previously been shown to grow MC, this teaching method and intervention style may be successful in improving alignment by successfully targeting both physical self-perceptions and MC (Lander et al., 2017, 2019).

Many studies across these interventions note the presence of high perceptions at baseline, potentially limiting further growth of perceptions across an intervention due to a ceiling effect (Burgess et al., 2006; Chan et al., 2019). The Barnett et al., (2008) study and the Lander et al., (2019) studies further highlight the presence of high levels of perception and overestimation with regard to sport and athletic competence among adolescent populations (Harter, 1978; Stodden et al., 2008).

This further suggests a consistent problem of overestimation (i.e. high perception in spite of low levels of ability), and reiterates the need for realistic perceptions of ability (Harter, 1978; Utesch et al., 2018). While these aforementioned interventions have proven to be somewhat effective in their aim to grow perceptions, non-significant growth was reported in some studies (Chan et al., 2019; Christiansen et al., 2018; Lubans et al., 2010a). Given the high perceptions recorded at baseline, non-significant growth may be more indicative of participants understanding what constitutes a higher level of performance (Estevan et al., 2021b).

2.4.10. Conclusion

Examining physical self-perceptions has been a prominent area for research since the emergence of both hierarchical and multi-dimensional concepts (Harter, 1978; Shavelson et al., 1976). Rooted in CMT, the notion of higher perceptions resulting in greater motivation, and probable positive impacts on PA have been affirmed and supported across various toolkits, namely the SPPC (Bardid et al., 2016a; De Meester et al., 2016a), CY-PSPP (De Meester et al., 2016b), and subsequent skill-specific toolkits, like the PMSC (Visser et al., 2020), and the PSC (McGrane et al., 2018). The association between PA and high perceptions is notable, but the issue of high perceptions relative to low actual levels of MC persists across all instruments (Bardid et al., 2016a; O'Brien et al., 2018). This calls into question the accuracy of children and adolescents in assessing their capabilities and whether their PA self-report data is accurate

To reduce overestimation, and grow veridicality, targeting actual skills must be a key mechanism to ensure that quality PA emerges (De Meester et al., 2020; Harter, 1982). Interventions which target MC with a multi-component focus, and place students at the centre of the model have demonstrated the greatest success at growing perceptions and improving veridicality (Lander et al., 2019; Schmidt et al., 2013b). High levels of PMC, and high MC are proven to boost participation and

motivation for PA, and a multi-component focus is the best manner of achieving this (Estevan et al., 2021b; Utesch et al., 2018; Lawson et al., 2022).

2.5. What is Functional Movement?

Functional movement is defined as the "the ability to move the body with proper muscle and joint function" (Coker, 2018, p.367) and serves as the undercurrent to most forms of bodily movement (Duncan et al., 2013). Poor or compromised functional movement may increase the risk of injury and result in lower levels of PA, physical performance, and MC (Cook et al., 2006a; Karuc & Mišigoj-Duraković, 2019; Nesbitt et al., 2018). Several studies have noted an association between low levels of functional movement, low levels of PA, and high BMI in childhood, adolescent, and adult populations (Bergland & Wyller, 2004; Cattuzzo et al., 2020).

This final major section of the literature review chapter discusses several topics through the prism of one major functional movement testing battery, the Functional Movement Screen™ (FMS™), as it is commonly used in research across youth and adult populations with established validity (Cattuzzo et al., 2020; Nesbitt et al., 2018).

2.5.1. The Functional Movement Screen™

The Functional Movement Screen™ (FMS™) is an evaluation tool which comprises of seven movements designed to assess the quality of movement patterns (Cook et al., 2006a, 2006b). The seven movements of the FMS™ are as follows: 1) active straight-leg raise (evaluating hamstring flexibility, core stability, and active hip mobility), 2) trunk stability push-up (core, spinal stability, upper-body strength), 3) shoulder mobility (range of motion of the shoulders), 4) deep squat (mobility and stability of hips, knees, ankles and thoracic spine), 5) rotary stability (neuromuscular coordination shoulder/spinal stability), 6) hurdle step (bilateral mobility of hips,

knees, and ankles in a single-leg stance), and 7) the in-line lunge (hip and ankle mobility and spinal stability).

The FMS™ screening battery is utilised throughout the world in different populations, including athletes, armed forces, and children (Bonazza et al., 2017). Normative FMS™ values have been established in adolescent school-aged children, adults, and adolescent athletes (Abraham et al., 2015; Bardenett et al., 2015; O'Brien et al., 2022; Schneiders et al., 2011). The FMS™ is administered using pre-determined verbal instructions, and performances are typically scored using video recording, however, live-scoring is also deemed reliable (Moran et al., 2016).

The FMS™ operates on a 0 to 3 scoring scale, with participants given 3 trials to execute a movement, their best score across their 3 trial performances contributes to their overall awarded score. An inability to complete the movement correctly is characterised by a score of 1, which is also known as a dysfunctional movement. A score of 2 is awarded when a compensatory action is used in the movement performance. A maximum score of 3 is allocated to the participant for the correct performance of the movement, without compensation. A score of 0 is awarded, when a participant exhibits pain during performance (Cook et al., 2006a). Bilateral scores for 5 movements (active straight-leg raise, shoulder mobility, rotary stability, in-line lunge, and hurdle step) are used to compare imbalances and dysfunction between the left and right sides of the body (Cook et al., 2006a; Wright et al., 2015). The lowest score awarded for these bilateral movements on either side of the body contributes to the final overall composite score. For each of the 7 screening items, the highest score from the 3 trials is used to generate an overall composite FMS™ score, resulting in a maximum composite score of 21 available (Cook et al., 2006a).

The FMS™ has established reliability and validity, with various different study populations (Bonazza et al., 2017). The Schneiders et al., (2011) study (n=209; 101 male; mean age 21.9 ± 3.7 years), posted excellent (97.1%) inter-rater reliability for the FMS™ composite score, with a range of acceptable to excellent values for the interrater reliability across the individual movements of the FMS™ in adults (Schneiders et al., 2011). The Kramer et al., (2019) study conducted among adolescent athletes (n= 56; 28 males, mean age 16.4 ± 0.1 years) established

reliability for the individual FMS™ items among adolescent participants, with interrater reliability ranging from good to very good (as measured by weighted kappa values) (Kramer et al., 2019). A recent systematic review and meta-analysis of functional movement among adolescent populations totalling 19 studies reported the tool was viewed as both a reliable and valid tool use among this age group (O'Brien et al., 2022).

Validity findings for this instrument have been mixed, with many studies focusing on the utility of the FMS™ as an injury detection tool, however, the FMS™ assessment tool was not originally designed for this purpose (Cook et al., 2006b). The ability of the FMS™ to detect injury is based on recording a composite score on all 7 movements of "14". It has been theorised that scores above '14' may reduce propensity for injury with early research in professional and collegiate athletes supporting this stance (Chorba et al., 2010; Kiesel et al., 2007). Some systematic reviews have scrutinised the ability of the composite 'score of 14', to detect injury susceptibility, determining this score as inconclusive for injury detection (Moran et al., 2017; Trinidad-Fernandez et al., 2019), or requiring more effective research (Bonazza et al., 2017). However, within FMS™ research it is acknowledged that both low composite scores, (i.e. scores below 14) and poor scores in individual functional movement patterns are indicative of poor movement and motor control which may increase injury risk and are worth monitoring (O'Brien et al., 2022; Pfeifer et al., 2019).

Further research focuses on examining performance scores on the individual 7 tests, and this may be a feasible use of the instrument to examine stability and mobility (Everard et al., 2018). Asymmetry (scoring higher on one side of the body compared to the other) in the case of bilateral movements and movement should be scrutinised in functional movement evaluations (Trinidad-Fernandez et al., 2019). Asymmetries may occasionally be common or indeed beneficial in sporting circumstances (e.g. greater flexibility in the shoulder within the dominant throwing arm of a baseball player compared to their non-throwing arm) (Karuc & Mišigoj-Duraković, 2019; Smith et al., 2017). However, asymmetry may also be indicative of

injury susceptibility or risk, which requires further evaluation by a trained professional (Karuc & Mišigoj-Duraković, 2019; Smith et al., 2017).

2.5.2. Global and National levels of FMS^{TM} in school-aged children and adolescents

The Abraham et al., (2015) study (n=1005; 548 males; age range= 10- to 17-years old) established normative FMS^{TM} values in childhood and adolescent populations, with a generated mean score of 14.59 ± 2.48 (Abraham et al., 2015). A recent systematic review and meta-analysis totalling 19 studies in childhood and adolescents groups who were assessed using the FMS^{TM} established a further normative value for FMS^{TM} performance among this age cohort (O'Brien et al., 2022). This normative value which has been derived from research across Europe, Asia, and America is 14.06, (standardised Tau value of 0.56), lower than the previously established Abraham et al., (2015) normative value (O'Brien et al., 2022). The wider number of participants, their age, and geographic spread of participants used to generate this normative values is indicative of it being more reflective of the true ability of childhood and youth groups in the FMS^{TM} across the globe (O'Brien et al., 2022). A British study (n=90; 32 males; mean age= 9.6 ± 1.4 years), and a Croatian study (n= 730; 365 males; mean age= 16.6 ± 0.4 years), recorded composite scores below those cited in the O'Brien et al., meta-analysis. Mean scores of 13.2 ± 3 were recorded in Britain, with mean values of 12.7 ± 2.4, and mean values of 12.2 ± 2.5 reported among Croatian females and males respectively (Duncan et al., 2013; Karuc et al., 2020a). The Garcia-Pinillos et al., (2018) (n=333; 164 males; mean age= 9.68 ± 1.49 years) and the Coker (2018) (n=120; 54 males; intervention= 54; control= 66 mean age= 13.18 ± 0.39 years) studies, however, have presented values equal or above the O'Brien et al., 2022 normative values.

In Ireland, four Irish studies have examined functional movement performance (two study will not be examined here as it forms a thesis chapter). The O'Brien et al., (2018) study (n=219; 120 males; mean age: 14.45 ± 0.96 years) reported a mean score of 14.05 + 2.48 among all participants,. The Lester et al., (2017) study (n=181; 108 males; mean age= 14.42 ± 0.98 years) reported the same composite value of 14.05 ± 2.48 in its study. Both scores are below the normative

value established by the O'Brien et al. 2022 systematic review, and indicative of poor levels of movement (Lester et al., 2017; O'Brien et al., 2018, 2022).

2.5.3. Functional Movement and its association with Physical performance

Several assessments of the FMS™ evaluate thoracic mobility, namely the deep squat, in-line lunge, and shoulder mobility exercises, (Ditcharles et al., 2017). A high level of thoracic mobility is required to perform locomotor skills (Mason et al., 2016). Additionally, greater jumping height requires adequate knee flexion (assessed in the deep squat), in addition to a strong range of motion in the leg joints, suggesting that jumping skills could be interwoven with functional capacity (Papaiakovou, 2013; Sánchez-Sixto et al., 2018). These study findings provide a theoretical basis for the link between functional movement performance and locomotor skills which has been supported in recent research (O'Brien et al., 2021). Across a sample of 583 adolescents (256 male; mean age 14.42 ± 0.94 years) Bayesian factor analysis proposed that the relationship between the locomotion subset of FMS (skip, run, horizontal jump, and vertical jump) and FMS^{TM} score was very probable (r =. 170; BF_{10} = 7.737), with the likelihood of a relationship between FMS^{TM} performance and locomotion skills 7 to 8 times more probable than not (O'Brien et al., 2021).

Further studies have provided further evidence of a link between functional performance and locomotor skills. An Italian study of male soccer players (n=36; mean age= 16.6 ± 0.5 years) utilising the FMS™ found a negative association between functional movement and mean repeated sprint time (r= -.0.68, p <.01) and best sprint time (r= -.58, p <.01), indicating that higher FMS™ performance results in lower sprint times (Campa et al., 2019a). The Kramer et al., (2019) study in American adolescent athletes examined the association between FMS™ scores and the one-legged balance, as measured by the Y-balance test (Kramer et al., 2019). Moderate positive correlations (male: r = 0.42; female r = .41; p <.01 for both) between the FMS™ composite score and balance were reported in both genders (Kramer et al., 2019). Furthermore, a moderate negative association (r= -.44, p <.01) between FMS™ score and agility performance was also reported (Kramer et al., 2019).

Interestingly, a Portuguese study of young adults (n= 92; 68 males; mean age male= 20.1 years old; mean age female= 19.70 years old) examined the link between general MC (locomotor, manipulative, and stability) and functional movement (Silva et al., 2019). The study reported a small positive correlation between the composite FMS™ score and total MC score ($r= 0.26$; $p <.05$), with moderate positive correlations reported in the stability domain ($r= 0.47$; $p <0.05$) (Silva et al., 2019).

A further study on male soccer players (n=48; age range 15 to 18-years old), examined FMS™ performance and links to the squat jump, countermovement jumps, shot speed and anaerobic sprints (Silva et al., 2017). No significant links between composite FMS™ score and any measure of physical performance were found, however, at the individual FMS™ movement level, there were significant associations between the hurdle step, and squat jump ($r= -0.37$, $p <.05$), anaerobic sprint power ($r= -.29$, $p <.05$), and anaerobic sprint fatigue ($r= -.34$, $p <.05$) were noted (Silva et al., 2017).

Correlation values often fluctuate between FMS™ scores and markers of performance, with other studies finding minimal or no association between FMS™ and performance (Hartigan et al., 2014; Silva et al., 2017). Several other studies with children or adolescents, have found positive associations between FMS™ scores and measures of performance, including balance, kicking, throwing, agility and jumping for distance (Kramer et al., 2019; Silva et al., 2017, 2019).

Functional movement may have some utility in predicting athletic performance but current research is far from conclusive in assessing the association between composite functional scores or individual movements and athletic performance (Bonazza et al., 2017; Fitton-Davies et al., 2022; Girard et al., 2016). A recent systematic review analysing 13 papers among adolescent populations (11-17 year olds), concluded that those who score high on FMS™ typically do score higher on agility, running speed, and strength measures (Fitton-Davies et al., 2022). However, it cautioned that the strength of the associations was only weak to moderate, and that FMS™ performance is not a direct measure of athletic performance and does not specifically evaluate physical performance in a sport or athletic context (Fitton-Davies et al., 2022). The variability in association within

individual movements (i.e., no individual FMS™ movement consistently highlighted as a key association for high barometer of physical performance across studies) may suggest correlations are spurious, and that associations between FMS™ and physical performance are questionable (Silva et al., 2017; 2019; Girard et al., 2016). The capacity of functional movement assessments to assess elements such as postural control, core strength, and stability does indicate it may have utility when used in conjunction with other assessments. Thought it is limited to gauge physical performance as the tests are of a static nature, functional movement assessments may be pertinent to exercises, movements and sports that are not commonly observed in MC assessments (O'Brien et al., 2021). For example, popular sports such as Parkour (core stability, strength, and ankle mobility), cycling (core and postural stability) and swimming (hip flexion and extension, core strength, shoulder flexion) rely on elements examined through functional movement assessments (Abt et al., 2007; Fitton-Davies et al., 2022; Heinlein & Cosgarea, 2010; Morais et al., 2021; Strafford et al., 2018; Williams et al., 2021; Yamakawa et al., 2022). Functional movement assessment, in conjunction with conventional MC assessments, or other evaluations of mobility, flexibility, and strength may for a key tool in evaluating the ever broadening range of PA experiences of youth and adult populations (Fitton-Davies et al., 2022; Hulteen et al., 2018; O'Brien et al., 2021). Notably, FMS™ performance does appear to positively related with greater health, with evidence in support of higher functional performance being associated with greater cardiovascular endurance and weight status (Fitton-Davies et al., 2022; O'Brien et al., 2022; Silva et al., 2017).

2.5.4. BMI and Functional Movement Associations

BMI is frequently used when evaluating the general body composition of a population, and it is a critical measure of population-based health, given the association between higher weight status and the increased risk of non-communicable diseases (Piché et al., 2018; Rolland-Cachera, 2011).

The majority of FMS™ and BMI-focused studies have been undertaken with childhood and youth populations. The Duncan & Stanley (2012) study (n= 58; 29

males; mean age= 10.7 ± 0.4 years), reported several key findings, with BMI strongly negatively associated with FMS™ composite scores (r = −.806, p= .0001), with normal-weight participants scoring significantly higher than their overweight and obese peers (Duncan & Stanley, 2012).

The Duncan et al., (2013) study further found a significant negative association (r= −.572, p = .0001) between BMI and FMS™ composite scores. Normal weight participants scored significantly higher than their obese peers in composite scores (p <0.05), and at the individual functional movement level, specifically in the deep squat (p = .0001) and shoulder mobility (p= .04) (Duncan et al., 2013). Furthermore, overweight participants performed significantly better than their obese counterparts in 4 of the 7 individual skills (in-line lunge, p=.05; hurdle step, p= .0001; shoulder mobility, p=.04; active-straight leg raise p=.016) and in the overall FMS™ composite score (p=.01), highlighting how high BMI appears to contribute to poor functional movement (Duncan et al., 2013). A Spanish study (2018) by Garcia-Pinillos et al., (n=333; 164 males; mean age= 9.68 ± 1.49 years), reported a moderate negative correlation reported between BMI and FMS™ scores among the sample (r= -0.479, p < 0.001). The O'Brien et al (2022) systematic review of FMS^{TM} performance among school-going adolescents examined BMI across 9 total studies, documenting a moderately negative correlation (r = − 0.42, 95% CI − 0.57 to − 0.24) between FMS^{TM} performance and weight status (O'Brien et al., 2022). Overweight children were also reported to score approximately two units worse on the FMS^{TM} in comparison to healthy weight individuals (O'Brien et al., 2022).

The litany of evidence indicates that BMI is a negative correlate of functional movement, highlighting that high BMI is likely to impede functional movement ability (Duncan et al., 2017; Fitton-Davies et al., 2022; O'Brien et al., 2022). The relationship between BMI and functional movement warrants further research; for if excess weight appears to impede efficient bodily movements, lower levels of PA are likely, which has an impact on long-term health (Duncan et al., 2013; Karuc et al., 2020b). A reciprocal relationship between PA, functional movement, and weight status appears probable indicating that targeting functional movement to lower BMI and improve PA is vital among youth (Fitton-Davies et al., 2022; Nantel et al., 2011;

Stodden et al., 2008). Examining the youth population, and their FMS™ performance, with an acknowledgement of the impact of both chronological age, and maturation status is of key concern to future research (Fitton-Davies et al., 2022; O'Brien et al., 2022).

2.5.5. Age and Maturity-related Associations in Functional Movement

There is a glaring absence of FMS™ research examining the effect of aging and maturation status among non-sporting populations, with few studies examining this impact, and only one examining maturation to the best of the author's knowledge (Fitton-Davies et al., 2022; Ghasempoor et al., 2018; O'Brien et al., 2022). Looking specifically at aging, mixed findings are reported. The Garcia-Pinillos et al., (2018) study (N= 333; 164 males; mean age 9.68 ± 1.49 years), reported no significant relationship between aging and FMS™ performance (Garcia-Pinillos et al., 2018). The Garcia-Pinillos et al., (2019) study of Spanish primary school children (n=172; 89 males; mean age= 9.70 ± 1.55 years) found age to be a moderate predictor of performance (R^2= 0.206, p <0.001) on the composite FMS™ score, with significant differences found across the three age groups (under-8, under-10, and under-12, p= .003) (Garcia-Pinillos et al., 2019). The aforementioned Abraham et al., (2015) study reported no significant correlation between age and functional performance (Abraham et al., 2015). The impact of aging on FMS™ performance among childhood and adolescent populations is not clear, one study (Garcia-Pinillos et al., 2019) reported positive associations (i.e. with increasing age, FMS™ score improves) while others found no significant association (Abraham et al., 2015; Garcia-Pinillos et al., 2018).

Examining maturation, the Ghasempoor et al., (2018) study (n= 700; 350 males; age range- 9 to 18- years old) reported a small significant correlation between maturity offset and FMS™ score (r= 0.154; p <.001), with those of greater maturity performing better (Ghasempoor et al., 2018). Adolescence, and the pubertal phase were deemed to be a prohibitive factor in performance, with this disruption to performance more commonly found among males than females (Ghasempoor et al., 2018). It seems possible that aging or maturational impacts on FMS™ performance

may not occur until the pubertal ages, given the many biological similarities between males and females during childhood (Fitton-Davies et al., 2022; Malina et al., 2004; O'Brien et al., 2022). Findings from athletic studies in adolescence help provide evidence for this assertion, as such studies have reported associations with age or maturity and improved FMS™ capacity (Kuzuhara et al., 2018; Paszkewicz et al., 2013). Puberty is often punctuated by teenagers experiencing 'adolescent awkwardness' a phase during puberty of disrupted motor control, where issues such as compromised flexibility, or performance may be apparent (Bar-Or, 2004; Quatman-Yates et al., 2012). Prior research has highlighted the role that the years following puberty are commonly associated with gains in strength, and flexibility, with the period prior to the pubertal peak (i.e. Peak Height Velocity or PHV) often culminating in compromised flexibility or coordination (Malina et al., 2004; Martínez-Silván & Johnson, 2020; Peitz et al., 2018). Maturation and age differences are among the factors which account for the performance differences among males and females however there is a need for greater examination of the impact of maturation on FMS™ performance.

2.5.6. Sex differences in functional movement performance

Looking at adolescent athletic populations, some distinctive gender findings arise when assessing functional movement through the FMS™. The Paszkiewicz et al., (2013) study (n=66; 37 males; mean age = 11.45 ± 1.98 years) with a mixed adolescent athlete sample reported no significant gender differences in FMS™ composite scores (Paszkewicz et al., 2013). The Anderson et al., (2015) study (N=60; 31 males; mean age = 16.0 ± 1.1 years; female= 29; mean age = 15.9 ± 1.3 years) of secondary-school athletes, however, found significantly lower female composite score (13.8 ±1.8 years), when compared with males (15.3 ± 2.1 years, p= 0.004). Specifically within this study, males obtained significantly superior performances in the trunk stability push-up ($p<.01$), and in-line lunge ($p<.05$) assessments (Anderson et al., 2015). The Kramer et al., (2019) study (n=56; 28 males; mean age 16.4 ± 0.1 years) countered these findings, by noting significant female superiority in composite scores (females; 14.2 ± 2.1, male; 12.7 ± 2.6, $p<.05$) (Kramer et al., 2019).

The general childhood and adolescent studies trace a similar pattern, to athletic youth-based samples. The Karuc et al., (2020a) study reported a significant gender difference, with females recording higher composite scores than males (12.7 ± 2.3 females; 12.2 ± 2.4 males, p=.0054) (Karuc et al., 2020a). Females recorded significantly fewer dysfunctional scores in the shoulder mobility, in-line lunge, and active straight-leg raise assessments, while males showed fewer dysfunctional movements in the trunk stability-push-up and rotary stability assessments (both at p<.01) (Karuc et al., 2020a). The Duncan et al., (2013) study of English primary-school children only reported significant gender differences at the individual functional movement level (Duncan et al., 2013). Females reported significant superiority in the hurdle step (p = .03) and in the active straight leg raise assessments (p= .004), while males showed superior scores in the trunk stability push-up (p = .014) (Duncan et al., 2013).

A 2018 Spanish Study (n=40; 20 males; mean age= 8.5 ± 0.5 years) reported that females recorded significantly higher composite FMS™ scores than males (15.3 ± 1.99 females; 13.75 ± 1.97 males; p = .017), and at the individual functional movement level in in-line lunge (p<.01), and deep squat (p=.01) (García-Jaén et al., 2018). The Garcia-Pinillos et al., (2018) study, (n=363; 164 males; mean age 9.68 ± 1.49 years), found no significant gender differences between boys and girls within the overweight and obese weight categories, however, normal weight females did significantly outperform their male counterparts (p = 0.046) in the FMS™ composite score (Garcia-Pinillos et al., 2018). Specifically, normal weight females significantly outperformed their normal weight male peers in the in-line lunge, active straight leg raise and the shoulder mobility assessments, while normal weight males significantly outperformed their normal weight female peers in the trunk stability push-up assessment (p<.05) (Garcia-Pinillos et al., 2018).

The O'Brien et al., (2018) study reported a significant gender difference in the overall composite FMS™ score, with female superiority evident (females, 14.70 ± 2.16; males, 13.58 ± 2.59, p=.01), alongside female higher performances in the active straight leg raise (p=.01) and the shoulder mobility assessments (O'Brien et al., 2018). Conversely, the Abraham et al., (2015) study noted a significant composite FMS™

score gender difference between males and females (males 14.93; females 14.17), in addition to significant male superiority at the individual movement level across the in-line lunge, trunk stability push-up, and rotary stability assessments (all at $p<.01$) (Abraham et al., 2015). The recent systematic review establishing global values of FMS™ among male and female adolescents, reported an FMS™ performance between males and females (mean score composite values of 13.91 for males, and 14.56 for females) though the effect statistic ($p = .14$) was not significant, suggesting only a small level of difference between genders (O'Brien et al., 2022). The extent of the evidence (5 individual studies, and a systematic review noting higher female values) would appear to suggest that females possess a marginally, though perhaps not significantly higher level of functional movement ability than males, with numerous reasons for this including sociological and biological ones (O'Brien et al., 2022).

2.5.6.1. Accounting for Gender differences in Functional Movement performance

Sociocultural factors may impede functional movement performances across gender. The Abraham et al., (2015) study is one of the few studies in the field of general childhood and adolescent populations which reported a significantly superior male performance in the overall FMS™ assessments (Abraham et al., 2015). Notably, this study was conducted in India, where conservative attitudes to female PA behaviours are common, with further evidence suggesting that Indian women typically obtain lower levels of PA, when compared to Europeans (Babakus & Thompson, 2012; Mathews et al., 2016). The PA patterns of females have been suggested as a reason for their greater flexibility, with girls often partaking in higher episodes of locomotor-based activities (i.e. dance and gymnastics) during their free-play, which can improve postural control and balance (Bolger et al., 2021; Duncan & Stanley, 2012). Females typically showcase a greater level of flexibility, mobility, and stability than males throughout their lives and particularly throughout adolescence (Bar-Or, 2004; Cook et al., 2006a, 2006b). The concept of maturity, however, must be broached in this literature review, given its relevance within the field.

For example, Peak height Velocity (PHV) refers to a period in adolescence where males and females experience their greatest growth spurt (Malina et al., 2015). Females typically reach PHV earlier, as their 'take-off' (i.e. age where they begin puberty) age typically commences before males (Malina & Kozieł, 2014a, 2014b).. Prior research suggests that the take-off age for girls begins at approximately 8.9 ± 1.1 years, and 10.5 ± 1.1 years for boys (Malina & Kozieł, 2014a, 2014b). Furthermore it is believed that females commonly surpass PHV between 11.89 ± 1.00 years, with boys not surpassing this milestone until approximately 14.06 ± 1.10 years (Malina & Kozieł, 2014a, 2014b).

In addition to these potential natural advantages in flexibility and mobility for females, the ages captured by these studies may amplify the level of female superiority, by capturing a period where females experience heightened strength, flexibility and neuromuscular gains, which their male peers may not have not acquired (males remain 'stronger' generally, but are not experiencing post-PHV gains) (Bar-Or, 2004; Quatman-Yates et al., 2012).

In the aforementioned Ghasempoor et al., (2018) study it was reported that males were outperformed by females in the FMS™ three years prior to reaching their PHV and up to three years after their PHV (Ghasempoor et al., 2018). While a significant association in the overall sample between maturity and FMS™ performance was found, when broken down by sex, no significant relationship was reported among the female subset (Ghasempoor et al., 2018). The period after PHV is accompanied by strength and neuromuscular gains in males, however, it may take several years after PHV for males to maximise their strength and neuromuscular gains (Ghasempoor et al., 2018; Malina et al., 2004). This explains the findings of the Ghasempoor et al., (2018) study, which provides evidence of a narrowing gender gap in functional movement performances after PHV is achieved, however, female superiority in flexibility sees them retain their existing performance advantage (Ghasempoor et al., 2018; Malina et al., 2015). As both male and female levels of FMS™ performance remain relatively low, improvement efforts through coaching, and intervention practice can and should be observed.

2.5.7. Functional Movement Intervention Studies

The majority of functional movement intervention research is conducted with athletic populations, however, many of the proposed intervention strategies may transfer to a general populace. An Iranian study on male adolescent soccer players (n=28; mean age 14.46 ± 0.24 years) completed a soccer-specific (The "FIFA 11+") warm-up three times a week, for 4 weeks, consisting of running, squatting, jumping, balance and core exercises (Kilding et al., 2008; Nemati et al., 2017). The intervention significantly improved FMS™ composite scores, as mean values increased from 12.36 ± 1.00 to 14.36 ± 2.37 ($p < .05$) (Nemati et al., 2017). Furthermore, a 36% decrease in asymmetries, and a 57% increase in the number of participants recording scores >14 was also reported at post-intervention (Nemati et al., 2017), illustrating the effectiveness of such an intervention approach.

The Bayati et al., (2019) study of Iranian male freestyle-wrestlers (N= 24; intervention= 12; control= 12; mean age= 16.16 ± 0.71 years intervention group; mean age= 16.41 ± 0.79 control group) utilised a wrestling specific warm-up consisting of running, grip exercises, counter-balancing, upper body, core, and leg strengthening movements for 12 weeks, with a prescription of 3 weekly sessions (Bayati et al., 2019; Gioftsidou et al., 2015). No intervention group member scored below 14 following the intervention, (considering that 75% were below 14 at pre-test), with significant improvements found in the deep squat, hurdle step, in-line lunge and trunk stability push-up (all significant at $p<.05$) (Bayati et al., 2019).

The Campa et al., (2019b) study of male Italian footballers (n= 62; intervention= 32; control= 30 mean age=15.89 ± 0.53 years) utilised a 20-week intervention consisting of foam rolling, core strengthening/rotation, spinal rotation, stretching, and balance exercises (Campa et al., 2019b). This intervention saw a 25% reduction in the number of participants recording asymmetries (19 down to 11), and 25% fewer participants recorded scores <14. Significant improvements were recorded in the overall FMS™ score (pre-test - 12.63 ± 1.80; post-test 14.59 ± 0.87), and in many of the functional movement stability and mobility subsets (trunk stability

push-up and rotary stability, deep Squat, hurdle step, and in-line lunge), all significant at the .05 level (Campa et al., 2019b).

The St. Laurent et al., (2018) study (n=28; 13 males; intervention= 17; control= 11; mean age 9.3 ± 1.5 years) saw participants partake in a 6-week intervention (2 x 1-hour sessions a week) programme using suspension-training activities and games targeting specific movement concepts, such as core strength, push, pull, and squatting movements in each session (St. Laurent et al., 2018). A significant 28.9% increase ($p < .01$) in overall FMS™ composite score was reported in the intervention group at post-intervention, while control group scores decreased by 7.1%.

Interestingly, the Nourse et al., (2015) intervention study (n=20; 11 males; mean age= 14.5 ± 2.1 years) utilised videoconferencing technology and dieting strategies (Nourse et al., 2015). In this study, aerobic and resistance training sessions (equipment used included skipping ropes, medicine balls, and resistance tubing) were conducted thrice weekly for 12 weeks, with the dietary element involving weekly consultations with a nutritionist, and tracking food consumption (Nourse et al., 2015). Significant improvements were again found in FMS™ scores (from 13 ± 2 to 17 ± 1, $p < .001$), in addition to improved health markers such as waist-to-hip ratio, and total cholesterol (Nourse et al., 2015).

The Coker et al., (2018) study (n=120; 54 males; intervention= 54; control= 66 mean age= 13.18 ± 0.39 years) is the largest intervention study conducted with a generalised adolescent population to the author's knowledge (Coker, 2018). The intervention targeted functional movement (ankle mobilisation, hip and pelvic mobility, stability) during physical education warm-ups, with 10 minutes of functional movement per lesson over 6 weeks, totalling 15 functional movement specific warm-ups (Coker, 2018). The intervention saw boys make significant improvements ($p = .007$) in mean functional movement scores gaining 0.83 ± 1.53 while control mean values declined 0.32 ± 1.275 ($p = .007$). Additionally, a significantly reduced the number of dysfunctional movement scores (score of 1) by 0.48 ± 1.13 ($p = .006$) compared to the control group (Coker, 2018).

2.5.7.1. Effective intervention methods for Functional Movement.

It is evident from the above case study intervention approaches that improvements in functional movement (as assessed via the widely established FMS™ assessment tool) can be achieved rather quickly, with positive results found in interventions ranging from 2 weeks to 20 weeks in duration (Campa et al., 2019b; Hofmeyer et al., 2002). Positive intervention effects have been achieved through different methodological and intervention design approaches.

Targeting functional movement in warm-ups through focusing on principles such as core stability, squatting, balancing and hip mobility is a common pedagogical approach (Bayati et al., 2019; Coker, 2018; Nemati et al., 2017). Alternative methods such as flexibility targeted through structured exercise environments like yoga and Pilates to refine balance, have also resulted in significantly positive FMS™ performances over time (Lim & Park, 2019; Manckoundia et al., 2020).

All functional movement intervention studies cited above appear to target the key components of the FMS™, by focusing on mobility, flexion, extension, and stability (Cook et al., 2006b, 2006a). The inconsistency in reporting the dose (i.e., how many sessions) makes comparisons in youth-based functional movement intervention approaches difficult. For example, some functional movement studies with children and adolescents specified the intervention length, however, the volume of weekly sessions was not reported (Baron et al., 2020; Wright et al., 2015). Long-term functional movement improvements were not measured across any intervention, while the varied sporting (e.g., wrestling, soccer etc.) and general populations (e.g. childhood, middle age etc.) partaking in these studies suggest a myriad of strategies can be effective.

While FMS™ studies examining general youth populations were limited in scope, it is notable that two of them used resistance training principles (Nourse et al., 2015; St. Laurent et al., 2018). Resistance training has innumerable benefits for all individuals including reduced risk of non-communicable disease, improved blood lipid profile, and greater mental health (Cox et al., 2019; Faigenbaum et al., 2009;

Peitz et al., 2018).The ease of implementation of a resistance training approach through minimal equipment (i.e. body weight exercises and low-cost equipment such as resistance bands and foam rollers) as found in several studies suggests functional movement could be rectified easily though resistance training (Baron et al., 2020; Lim & Park, 2019). The Coker (2018) intervention programme may be the most ecologically valid for a general adolescent population, given its minimal equipment usage and simplicity, short length (10-minute mobility/flexibility sessions over 15 weeks), and utilisation of ideas common to school-based physical education warm-up activities (Coker, 2018).

In the field of child and adolescent functional movement studies, a greater volume of intervention studies are required (Campa et al., 2019b; Cattuzzo et al., 2020). Regarding the specific FMS™ assessment tool, a greater insight into general childhood and youth populations are required to establish appropriate and effective intervention methods, suitable for widespread adaptation and dissemination (Cattuzzo et al., 2020). Improvements in randomised controlled trials and use of control populations will be essential to further functional movement-based research with children and adolescents.

2.5.8. Functional Movement Take Home Message

Functional movement may form a critical foundation to other forms of MC and PA, while assisting older adults in retaining a higher quality of life (Cattuzzo et al., 2020). Functional movement patterns are recognised as low in children and adolescent samples, which may impede their future PA and physical skill performances. More studies are needed for a declarative link between functional movement, PA, and motor skills (or more sports specific forms of movement) (Karuc et al., 2020a; Karuc & Mišigoj-Duraković, 2019). The O'Brien et al., (2022) systematic review provided strong evidence for higher weight status impeding functional movement, suggesting that functional movement ability may have a role in health (O'Brien et al., 2022). It is unclear whether or not high BMI is precursor or consequence of poor FMS^{TM} but insight from previous motor development models indicates that targeting both BMI and functional movement in tandem could prove

pivotal to boosting physical fitness (Barnett et al., 2022; Piché et al., 2018; Robinson et al., 2015).

Females appear to outperform males in functional movement across childhood, given the female advantages in flexibility and mobility, both of which are pivotal elements associated with the FMS™ (Catley & Tomkinson, 2013; O'Brien et al., 2022). In later adolescence, however, following their PHV, males begin to reduce the gender gap due to their accrued strength and neuromuscular gains (Bar-Or, 2004; Ghasempoor et al., 2018).

Greater and improved study quality for functional movement interventions are necessary in understanding this field further, however, diverse methods and short interventions targeting resistance training, and/or mobility suggest that positive advancements in functional movement can be acquired (Henwood & Taaffe, 2005; Manckoundia et al., 2020). There is some evidence indicating that specific knowledge of the FMS™ performance criteria in advance of assessment may benefit performance; such findings indicate that the cognitive element and use of external cues may assist future functional movement performances and intervention practices in children and adolescents (Frost et al., 2015; Wulf, 2013; Wulf et al., 2010).

2.6. Concluding Message- The importance of PMC and MC (FMS and functional movement) being developed in unison

A key philosophy behind Project FLAME is that of a shared conception of movement with fundamental and functional movement assessed and developed in tandem. As mentioned, associations between functional movement and fundamental movement have been observed, with functional movement components serving as an undercurrent for performance in locomotor skills (Ditcharles et al., 2017; O'Brien et al., 2021). While far from conclusive, the links between functional movement task execution and stability are worth noting and suggest that both FMS and functional movement have a utility and use across the lifespan (Nesbitt et al., 2018; Silva et al., 2019). Additionally, the findings reported across systematic reviews of higher FMS and functional movement ability being

associated with reduced BMI suggest that targeting both FMS and functional elements could prove to be a highly beneficial strategy for targeting health (Barnett et al., 2022; O'Brien et al., 2022).

Recent evidence has suggested PMC may not be as strong a mediator of PA as was once theorised, with indeterminate evidence reported for the PA to MC pathway mediated by PMC, and no evidence for MC to PA mediated by PMC (Barnett et al., 2022). PMC does retain a key role in health promotion, as it has been shown to be associated with higher participation and interest in physical education and inclination for PA particularly in later childhood and adolescent groups (Britton et al., 2019; Estevan et al., 2021a). As mentioned, the promotion and development of accurate self-perceptions may prove pivotal to sustained PA over the lifespan (Utesch et al., 2018). As PMC and MC have some shared tenets in nurturing health (through BMI and/or PA), it is clear that PMC and MC (contextualised as FMS and functional movement under the auspices of this research study) warrant development in tandem. By developing both together, greater movement ability and understanding should be observed which is likely to promote veridical self-perceptions and PA (Utesch et al., 2018). Additionally, targeting PMC and MC in unison could be described as in-line with contemporary views of physical education and health promotion in youth populations as physical literacy ideals of competence, knowledge and motivation are all embraced in these methods (Cairney et al., 2019; Young, et al., 2022). Evaluating and assessing the role PMC and MC is a central aim of this thesis, and this literature review has outlined the current level of understanding of these areas and highlighted how and why they remain critical to develop and assess in youth populations.

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Chapter 3

Motor Competence among Irish adolescents: An investigation of sex differences and relatedness of Fundamental Movement Skills (FMS) and Functional Movement (FM).

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3.1. Abstract

Evidence suggests that Irish youth display poor motor competence across fundamental and functional movements. Our purpose in this study was to compare fundamental movement skills (FMS) and functional movement (FM) across male and female Irish adolescents and to determine whether there are associations between fundamental movement skills and functional movement domains. Data were collected on 373 adolescents (178 females; Mean age = 14.38 ± 0.87 years) from six Irish secondary schools, including motor competence testing of 10 FMS, and 7 FM. Overall levels of motor competence of both FMS and FM were low and certain levels of dysfunctional movement were high. Significant sex-based differences were observed in both FMS and FM, and there was a moderate association between FMS and FM that warrants further investigation. There is a need for intervention and policy changes to address low levels of motor competence among adolescent youth.

3.2. Introduction

The ability to move well is theorised as integral to youth development and an essential factor in determining positive individual health behaviours during maturation (Stodden et al., 2008). Motor competence (MC) describes the ability to perform any form of goal-directed human movement (Robinson et al., 2015). Logan et al., (2018) described fundamental movement skills (FMS) as synonymous with MC (Logan et al., 2018). FMS, the 'building blocks' of efficient and effective movement, are generally categorised into three domains: object-control (catching, kicking, dribbling, striking and throwing), locomotor (running, skipping, jumping for height and jumping for distance) and stability (balancing) (Logan et al., 2018; Victoria Department of Education, 1996; New South Wales Department of Education and Training, 2000).

The associations between FMS and physical activity (PA), improved physical fitness, and lower body mass index (BMI) indicate that FMS development positively contributes to maintaining a healthy lifestyle among children and adolescents (Barnett et al., 2022; Graham et al., 2022; Logan et al., 2015). Recent expert statements and systematic reviews have highlighted that current FMS levels are poor, particularly in comparison to the original normative data of FMS measurement tools (Bolger et al., 2021; Duncan et al., 2022; Ulrich, 2000). FMS sex differences (with male superiority) have been frequently reported (Barnett et al., 2016; Lubans et al., 2010), with primary differences noted within the object-control subset of FMS (Bardid et al., 2016). Contemporary child research in Ireland recently documented poor levels of actual MC in FMS (Behan et al., 2019; Kelly et al., 2019), and these disconcerting levels of movement proficiency do not improve by adolescence, with average or below average levels also frequently reported (Lester et al., 2017; O'Brien et al., 2016). These findings are notable as children have the maturational and developmental capacity to successfully perform FMS from the age of 6 (Gallahue et al., 2012). Furthermore, mastery of FMS is expected to occur by age 10, after this period, children are expected to transition to more specialised movements that are conducive to sports, exercise, and other forms of PA which subsist across the lifespan

(Gallahue et al., 2012). Though chronological aging, and biological maturation can impact FMS performance among younger children, the expectation of mastery in FMS by age 10, assures that maturation status is a less critical component of assessment among older childhood and early adolescent groups respectively (Charlesworth, 2016; Gallahue et al., 2012). Rectifying a trend toward low FMS ability in younger children is crucial to better societal health, as child and adolescent FMS skills and PA levels typically subsist into adulthood (Engel et al., 2018).

Functional movement (FM) refers to efficient bodily motion, as characterised by adequate joint and muscle function that mitigates risk of injury and supports activities of daily living (Bergland & Laake, 2005; Cattuzzo et al., 2020; Cook et al., 2006b). FM has been deemed a component of MC, as FM ability requires mobility, and the capacity to control the body when executing tasks (Duncan et al., 2017; Stodden et al., 2009). Greater FM levels have also been positively associated with health outcomes, namely lower BMI, increased quality of life, higher PA level and lower risk of falling (Bergland & Laake, 2005; Duncan & Stanley, 2012; Karuc & Mišigoj-Duraković, 2019). FM proficiency among child and adolescent youth have been previously characterised as sub-optimal (Duncan et al., 2017), with several studies in India, Europe, and North America having reported low values when compared to normative values (Abraham et al., 2015; Coker, 2018; Garcia-Pinillos et al., 2018). Notably, females have outperformed males in FM as per a recent systematic review and several specific studies (Garcia-Pinillos et al., 2018; O'Brien et al., 2022; Pfeifer et al., 2019).

Relationships between FM and FMS are rarely examined together, but both concepts relate directly to the definition of MC as 'goal-directed human movement' (Robinson et al., 2015). There is also theoretical link between FM and elements of FMS that argues for their joint inclusion within the MC domain (Ditcharles et al., 2017). FM and an ability to control one's centre of mass have been deemed essential to bipedal locomotion (Cattuzzo et al., 2020; Nesbitt et al., 2017). The mere fact that greater jumping height requires adequate knee flexion (assessed in squatting, and lunging FM assessments) and strong range of motion and flexibility of all leg joints, suggests that jumping skills might be interwoven with functional capacity

(Papaiakovou, 2013; Sánchez-Sixto et al., 2018). Examining the potential relationship between these concepts is important, since FM and FMS have both been associated with positive health markers such as PA and BMI, and practice of both movement constructs may be pivotal to maximising these health benefits (Cattuzzo et al., 2016; Kaioglou et al., 2022; Lubans et al., 2010).

Prior studies examining the relationship between FMS and FM are scarce. One recent study with young adults (Silva et al., 2019), compared performances on a measure called the Functional Movement Screen™ (FMS™; Cook et al., 2006a) with measures of MC (i.e. throw and kick velocity) and found a small positive correlation between overall FM and the total MC score, and a moderate positive correlation reported in the stability domain (Silva et al., 2019). A recent paper examining 583 adolescents (56.09% female Mean age = 14.42 ± 0.94 years) reported a small positive correlation between FM scores and performance in locomotor skills, indicating that the relationship between these variables is seven to eight times more probable than not following Bayesian Pearson correlations, and a Bayes factor robustness check (O'Brien et al., 2021). There remains a need for further research on the link between FM and FMS, despite this early evidence and the theoretical basis for their association among adolescents. Past research examining FMS and FM proficiency among Irish adolescents demonstrated 'alarmingly' low levels of both FMS and FM (McGrane et al., 2017; O'Brien et al., 2018). To expand our understanding of the relationship between these constructs, in the present study, we sought to measure current levels of FMS and FM proficiency and relatedness, differentiated by sex, amongst Irish adolescents. Our hypothesis was that low levels of proficiency in FMS and functional movement would be evident among males and females, with females illustrating greater locomotor skills, and males displaying higher object-control skills. Maturity was expected to impact on functional movement score, with insignificant gender differences in functional movement expected within this study. Small to moderate associations between FMS and FM were expected, which would warrant further investigation of their relatedness among an adolescent population.

3.3. Materials and Methods

3.3.1 Overview

We gathered cross-sectional baseline data as part of a larger study that sought to evaluate the effectiveness of a physical education MC intervention in Ireland. Data were collected in 6 secondary schools over a two-week period in January and February 2019. Measurements relevant to this baseline study included measures of FMS, the FMS^{TM} and anthropometric measures of the participants' height and weight.

Ethical Approval for this study was granted by the Social Research and Ethics Committee in University College Cork (UCC Ethics log code "Log 2018-169", November 2018). All named researchers of the school-based project were qualified post-primary specialist physical education (PE) teachers, as recognised by the Teaching Council of Ireland. Approval for each school's participation in the study was sought and obtained from the respective school Principal (or Deputy Principal). Principal and physical education teacher consent to take part in the study was granted by the schools, and all guidelines in accordance with the Declaration of Helsinki were followed. Informed parental consent and child assent forms were distributed to the participating class groups, participants were free to withdraw from the study at any time and of their own volition. Only those children and parents who returned signed consent forms were permitted to participate in the data collection phase of this research.

3.3.2. Participants and Environment

Fourteen suburban secondary schools from Cork city, Ireland. were invited to partake in the study (five socioeconomically disadvantaged mixed sex schools, five all-male schools, and four all-female schools). Invitations to schools were based on the following minimal inclusion criteria for them: (a) Teaching Council-Qualified physical education teachers operating within the schools; (b) schools contained first, second, and third-year class groups (age 12–16 years old); (c) students within the schools received a consecutive double period of physical education on a weekly basis

totalling 80 minutes; and (d) all schools had access to a gymnasium hall. Following the school principals' and teachers' completion of a participation agreement, a class from years 1 to 3 across each school was randomly selected by the school principal and physical education teacher(s) for participation. Schools were pair-matched prior to data collection on the following criteria: socioeconomic status (disadvantaged; non-disadvantaged); sex composition (single-sex boys; single-sex girls, mixed sex); facility characteristics (physical education hall and outdoor pitches) and school size (small: 0–299 students, medium: 300–599 students, and large: 600+ students) (Belton et al., 2019). This process resulted in three pairs equally matched: two large single-sex boys non-disadvantaged schools, two single-sex medium girls non-disadvantaged schools, and two small mixed-sex disadvantaged schools. While the quality of the schools' physical education programs was not assessed, the matching criteria and the schools' standard provisions of qualified teachers, equal physical education time and a government mandated physical education curriculum indicated that the learning experiences of participating students were comparable (Philpott et al., 2020). Of 486 potential participants approached, 373 individuals (47.7% female; Mean age = 14.38 ± 0.87 years) provided required consent/assent and participated in testing for at least one skill (uptake rate = 76.74%), with 324 full participants (45.9% female; Mean age = 14.33 ± 0.85 years; age range: 12.23- 16.37) for MC data.

3.3.3. Measurement Tools

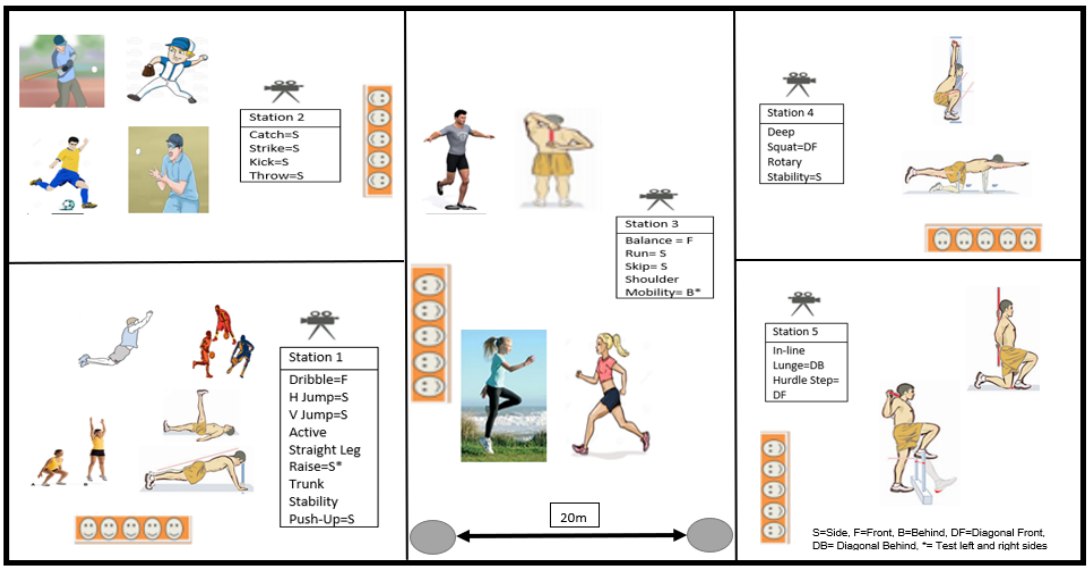


Figure 3.1*:* Our FMS and FMS^{TM} station collection approach.

Note: *Participants could start at any number station and would rotate to next station as appropriate (station 1 numbers go to station 2 when finished and so, or station 5 rotates to station 1 and so on to maximise time). Notes S, F, B, DB, and DF refer to camera angle positioning to capture full movement*

Movement measurements (FMS and FMS™) were administered together during the same 120-minute physical education class, using a station-based approach. All seventeen movements (ten FMS and seven FM) were divided among five stations that were carefully allocated to ensure equal time duration at each station, which is outlined in figure 3.1. Station 1 consisted of the dribble, horizontal jump, vertical jump, active straight-leg raise, and trunk stability push-up movements. Station 2 consisted of the catch, strike, kick and throw movements. Station 3 consisted of the run, skip, shoulder mobility, and balance movements. Station 4 consisted of the deep squat and rotary stability. Station 5 consisted of the in-line lunge, and the hurdle step. Participants completed the exercises in a different order (i.e., some participants began performing movements at station 5, and when finished would go to station 1, followed by station 2 etc.) to maximise the time period allocated to researchers in schools. The station in which the participant began their assessment in was primarily decided by their student code number which was generated through class lists and the school roll system. A diagram of how stations were prepared by the research team is provided in figure 3.1. Participants were grouped and rotated together to each of the stations until all groups had completed each of the five stations. Utilising recordings of these assessments, the principal investigators later scored the seventeen movement measures.

3.3.3.1 FMS Measures

Ten FMS were tested and scored across the FMS subsets of locomotor, object-control and stability. The scoring and subsets of FMS were broken down as follows: (a) locomotor (maximum score = 34): vertical jump, horizontal jump, run, skip (locomotor); (b) object control (maximum score = 40): catch, kick, two-handed strike, overhand throw and stationary dribble; and (c) stability (maximum score = 10): balance. The total maximum FMS score which could be achieved from scores across these 3 subsets was 84. FMS measurements relied upon the Test of Gross Motor

Development (TGMD; Ulrich, 1985) for skipping, the TGMD-2 (Ulrich, 2000) for horizontal jump, run, catch, kick, two-handed strike, stationery dribble, and overhand throw, and the Get Skilled Get Active resource for the balance and vertical jump (New South Wales Department of Education and Training, 2000; Victoria Department of Education, 1996). Construct validity and reliability of the selected FMS assessments have been established cross culturally in large samples of children and adolescents and have been reported in systemic analyses of motor assessment (Barnett et al., 2014; Issartel et al., 2016; Lander et al., 2017; New South Wales Department of Education and Training, 2000; Rey et al., 2020; Ulrich, 1985; Victoria Department of Education, 1996). The ten skills outlined above were selected due to their relevance in the Irish sporting and physical education context, in line with previously reported objective measurements of Irish adolescents (Issartel et al., 2016; O'Brien et al., 2016).

3.3.3.2 FM Measure

To measure FM, the Functional Movement Screen™ (FMS™) (Cook et al., 2006a, 2006b) was implemented. FMS™ is a physical activity pre-participation screening tool that assesses quality and function of movement to determine if individuals lack certain movement capabilities (Cook et al., 2006a, 2006b, 2014). Inter-rater reliability for the FMS™ has been previously established (Minick et al., 2010; Teyhen et al., 2012). Seven movements were assessed as part of the FMS™: active straight-leg raise, deep squat, in-line lunge, hurdle step, rotary stability, shoulder mobility and trunk stability push-up (Cook et al., 2006a, 2006b). Testing procedures were in line with the established guidelines for administering the FMS™, including the use of pre-determined verbal instructions to participants (Cook et al., 2006a, 2006b). The verbal instructions would prove beneficial to participants for whom these movements are unfamiliar and uncommon (Cook et al., 2006a, 2006b).

On the FMS™ participants received scores between zero to three on their performances of the seven aforementioned movements (Cook, 2010). An individual's full score for any movement was denoted as their 'raw' score. A raw score of zero was given if pain was reported by the participant at any time during testing. A raw

score of one was given to a participant, if they were unable to complete a movement and this was classified as a 'dysfunctional' performance of the movement (Cook et al., 2014). A raw score of two was given to a participant if they were able to complete the movement using some compensations (e.g., lifting one's heels during the deep squat). A raw score of three was given upon successful completion of the movement, without any use of compensatory movements. Five of the seven movement patterns were completed bilaterally: active straight-leg raise, in-line lunge, hurdle step, rotary stability and shoulder mobility. Scores were given for each side and, if the scores were not equal, the lower of the two scores was selected to make up the participant's 'raw' score for the skill. A composite FMS™ score (out of a possible 21) was derived by summing the seven raw scores together in accordance with the guidelines of screening (Cook et al., 2006a, 2006b).

3.3.3.3 Data Collection

All field researchers involved in data collection were required to undertake two specialised training workshops totalling approximately four hours to equip them with the knowledge and skills required to accurately implement the FMS and FMS^{TM} measurement protocols. Research assistants physically practiced their assigned FMS and FMS^{TM} measurements within the training workshops to ensure they could perform a demonstration, and these assistants worked with colleagues in following appropriate administration procedures, properly utilising the verbal instructions and guidelines of the respective FMS and FMS^{TM} testing measures as applied in a previous Irish study (O'Brien et al., 2018). This research assistant training involved an objective, criteria-informed process to ensure that field staff would apply consistency to their administration and implementation of the respective FMS and FMS^{TM} measurements. Field researchers were provided with an instructional handbook at the beginning of the workshops, which outlined their roles in the data collection process, and included instructions on how to implement the guidelines and measurement protocols accurately.

Participants were informed about the testing procedures for FMS (i.e., first performance being a practice performance and second and third performances being

trial performances) prior to station allocation. Before each FMS performance, a field researcher demonstrated the correct technique on one occasion for the participants to observe. Feedback was not given during or after performances of the skill. These protocols are consistent with previous research in FMS (McGrane et al., 2017; O'Brien et al., 2018; Philpott et al., 2020). All movement performances were video recorded using Apple iPads (4th and 5th Gen. Apple iPad, Apple Inc, California, United States of America). Participants with missing data due to errors regarding camera function/angle (i.e. the footage shot by did not fully capture the intended movement, or the incorrect frame rate was used and therefore the performance could not be accurately assessed) were omitted from the dataset for the individual skill where errors were observed, and from any composite or overall score ratings that would be generated from the associated skill.

3.4. Data Analysis

Prior to data scoring, inter-rater reliability was established on the current sample between two principal investigators (with prior experience of data scoring) on 10% of the dataset in accordance with a previously established protocol (Lester et al., 2017; Logan et al., 2017). Inter-rater and intra-rater reliability were established using the percentage agreement method commonly utilised in Irish FMS and international research (Lester et al., 2017; McGrane et al., 2018; Ré et al., 2018). The percentage agreement was calculated by the number of rating agreements divided by the total number of rating agreements and disagreements. Two experienced raters (i.e., with two years of experience coding over 200 children across the same 17 skills as a component of another research project) double-coded 10% of the data (n=38) to gather intra-rater reliability; both raters coded the same 10% of data to determine inter-rater reliability. The two principal investigators, each scored half of the dataset following completion of inter and intra-rater reliability.

Both the FMS and FMS™ datasets were analysed using the Statistical Package for the Social Sciences (SPSS, v. 25.0 for Windows, IBM Corp., New York). Descriptive

statistics, such as means and frequencies, for FMS and FM were prepared. Chi-square tests for independence were utilised to determine sex differences in dysfunctional movement performances. For the purpose of comparison across skills with differing maximal values (i.e., max score of 12 in vertical jump compared to max score of 10 in horizontal jump), mean raw scores were converted into normalised scores in both the FMS and FMS™ analyses. Normalising was conducted by noting the score of an individual participant in a skill as a percentage of the overall maximum score that could be obtained in the skill (e.g., a normalised value of 0.83 would be attributed to a participant who scored 10 out of a possible 12 on the vertical jump test). Independent samples *t*-test were used to determine sex-based differences in mean FMS performances. A one-way analysis of covariance (ANCOVA) was used to explore the effect of maturation on FM skill performance, with maturity offset calculated using the Moore et al. (2015) formula for maturity offset (Lloyd et al., 2015; Mirwald et al., 2002). Sex was an independent variable, maturity offset (i.e., age prior to or after peak height velocity) was the covariate, and the dependent variable across the ANCOVA tests consisted of scores in each FMS^{TM} movement. The ANCOVA provided results for sex-based mean different in FMS^{TM} performances. Maturity offset and its influence on FMS performance was not examined due to the expectation that FMS are expected to be mastered by the age of ten (Gallahue et al., 2019; O'Brien et al., 2016). Bivariate correlations between FMS and FM were calculated to determine any associations (i.e. the relatedness) between variables, with r = 0.10 – 0.29 denoting a low correlation, r = .30 - 0.49 denoting a moderate correlation, and $r \geq 0.50$ denoting a strong correlation (Cohen, 1988) . Statistical significance was set at $p < 0.05$, with the exception of the independent samples *t*-tests and the ANCOVA, where a Bonferroni adjustment of p=.002 was utilised to account for multiple comparisons (8 total comparisons during the ANCOVA measurements, and 13 comparisons for the independent samples t-test for a total of 21 adjustments) applied during data analysis. Effect size was calculated using eta squared formula with eta squared = 0.01- 0.05 denoting a small effect, eta squared= 0.06 - 0.13 denoting a moderate effect, and eta squared ≥ 0.14 denoting a large effect size (Cohen, 1988).

3.5. Results

Across all 17 FMS and FMS^{TM} assessments (and subsets of FMS), we obtained both inter-rater and intra-rater observer agreements of at least 95% using the percent agreement method. Descriptive data from the schools that participated is provided in table 3.1 below.

Table 3.1. Participant demographics and characteristics by school

School	Sex	N (324)		Age		Age at PhV		FMS Raw Score (Max 84)		FMS™ Raw Score (Max 21)	
		Male	Female	Mean	SD	Mean	SD	Mean	SD	Mean	SD
School 1	Male	63	-	14.29	0.87	13.61	0.34	66.70	5.37	12.68	1.75
School 2	Male	68	-	14.73	0.65	13.67	0.46	65.66	5.75	12.35	1.52
School 3	Female		65	14.28	0.86	12.26	0.48	63.69	6.07	12.23	1.66
School 4	Female		64	14.31	0.89	12.19	0.38	64.58	6.69	11.53	2.14
School 5	Mixed	14	5	14.14	1.02	-[a]	-[a]	62.16	7.77	11.63	2.24
School 6	Mixed	30	15	14.40	0.95	13.25	0.76	64.58	6.11	9.93	2.20

Note: a - Participants in this school did not consent to partaking in height and weight measurements resulting in no PhV data being compiled for this group.

3.5.1 FMS Assessment Results

No participant achieved complete mastery of all FMS. The highest FMS score of any adolescent was 78 out of a possible FMS gross motor score of 84, and the lowest score was 43 of 84. The overall mean composite FMS score was 64.90 (*SD* = 6.20). Having accounted for Bonferroni adjustments, an independent samples *t*-tests analysis showed no significant sex-based difference in the overall gross motor score. However, statistically significant sex differences were evident at the FMS domain level for both the object-control and locomotor skills subsets, with males scoring higher within the object-control subset; [$t(292.01) = -7.22$, $p < .001$]. However the magnitude of the differences in the means was only moderate (eta squared= 0.13). Females scored significantly higher in the locomotor skills subset; [$t(349) = 3.31$, $p < .001$], however the magnitude of the differences in the means was small (eta squared= .03). Table 3.2 highlights FMS proficiency differences between sexes. In statistical tests, normalised values were utilised for analysis. At the level of individual FMS skills, males (*M*= 0.77; *SD*= 0.20) significantly outperformed females (*M*= 0.53 *SD*= 0.26) in the overhand throw [$t(330.70) = -9.88$, $p< .001$]. Males (*M*= 0.77; *SD*= 0.15) significantly outperformed females (*M*= 0.70; *SD*= 0.17) in the kick [$t(360) = -4.54$. $p < .001$], with the magnitude of differences between the means found to be large (throw; eta squared= 0.21), and small (kick; eta squared= 0.05), respectively.

3.5.2. FM Assessment Results

On the FMS™, the highest total score achieved was 17 of a possible 21, and the lowest score was 7 of 21.. The overall mean descriptive (non-normalised) composite score was 12.01 (*SD* = 1.97). Normalised FMS™ were utilised for the ANCOVA, correlational analyses. One-way ANCOVA tests across all 7 FM on the FMS™ were conducted to compare sex differences in performance of the FMS™ while controlling for the effect of maturity offset on participants' performance in FMS™. Maturity offset was not significantly related to performance in any of the 7 movements (and composite score) with the exception of rotary stability [F(1, 311)=

5.323 $p < .05$]. Significant sex differences were reported in 4 FMS^{TM} movement performances, after eliminating the effect of maturity offset (Table 3.2). Females outperformed males in active straight-leg raise [F(1, 317)= 28.103, $p < .001$ (eta squared = .08)]. Males outperformed females in the hurdle step [F(1, 318)=56.229, p= .000 (eta squared = .15)], in-line lunge [F(1, 315)= 24.107, p <.001 (eta squared= .07)], and trunk stability push-up [F(1, 317)= 26.208, p= .000 (eta squared= .08)].

Chi-square testing showed that males demonstrated significantly more dysfunction (raw skill scores of 1) in the active straight-leg raise (p <.001; phi= .35), and deep squat (p=.004; phi= .11) movements, whereas females were significantly more dysfunctional in the hurdle step, in-line lunge, and the trunk stability push-up (all at $p < .001$; phi= -.35).

3.5.3. FMS and FM Associations

Bivariate correlations between FMS (overall, object-control, locomotor, and stability) and the seven FM and overall FM composite score measured by the FMS^{TM} are depicted in Table 3.3. There were moderate positive correlations found between the overall composite FMS and FMS^{TM} mean scores (r = .38, $p < .001$). A moderate correlation was also found between the overall FMS locomotor mean score and the overall FMS^{TM} composite mean score (r = .30, $p < .001$).

Table 3.2. Mean Values (and SD) for Fundamental Movement Skill and Functional Movement Screen Proficiencies by Sex.

Item Classification	Variable	Males	Females	*p*-Values	Effect size
FMS	Run	0.92 (.13)	0.89 (.15)	.066	0.01
	Skip	0.73 (.24)	0.78 (.22)	.019	0.01
	Horizontal Jump	0.59 (.20)	0.64 (.23)	.018	0.01
	Vertical Jump	0.83 (.17)	0.88 (.15)	.004	0.02
	Catch	0.80 (.18)	0.78 (.15)	.211	0.00
	*Throw	0.77 (.20)	0.53 (.26)	***.000****	0.21
	*Kick	0.77 (.15)	0.70 (.17)	***.000****	0.05
	Strike	0.80 (.15)	0.78 (.18)	.258	0.00
	Dribble	0.74 (.17)	0.73 (.16)	.333	0.00
	Balance	0.82 (.18)	0.81 (.16)	.503	0.00
	*Object-control	0.77 (.80)	0.70 (.10)	***.000****	0.13
	*Locomotor	0.78 (.10)	0.81 (.11)	***.001****	0.03
	Overall Gross Motor FMS	0.78 (.07)	0.76 (.08)	.019	0.02
FMS™					
	Active straight-leg raise*	0.48 (.17)	0.65 (.21)	***.000****	0.08
	Deep Squat	0.48 (.20)	0.52 (.21)	.116	0.01
	Hurdle Step*	0.64 (.14)	0.51 (.18)	***.000****	0.15
	In-line Lunge*	0.60 (.13)	0.55 (.17)	***.000****	0.07
	Rotary Stability**	0.58 (.14)	0.61 (.12)	.859	0.00
	Shoulder Mobility	0.66 (.24)	0.67 (.24)	.826	0.00
	Trunk-stability Push-Up*	0.50 (.21)	0.44 (.18)	***.000****	0.08
	FMS™ Composite Score	0.58 (.09)	0.56 (.10)	.015	0.00

Note: *Denotes Significance at the Bonferroni adjusted level of $p < .002$.

Eta-squared value of 0.01-.05 denotes a small effect size. Eta-squared value of 0.06- 0.13 denotes a medium effect size, and effect size *≥ 0.14* denotes a large effect size

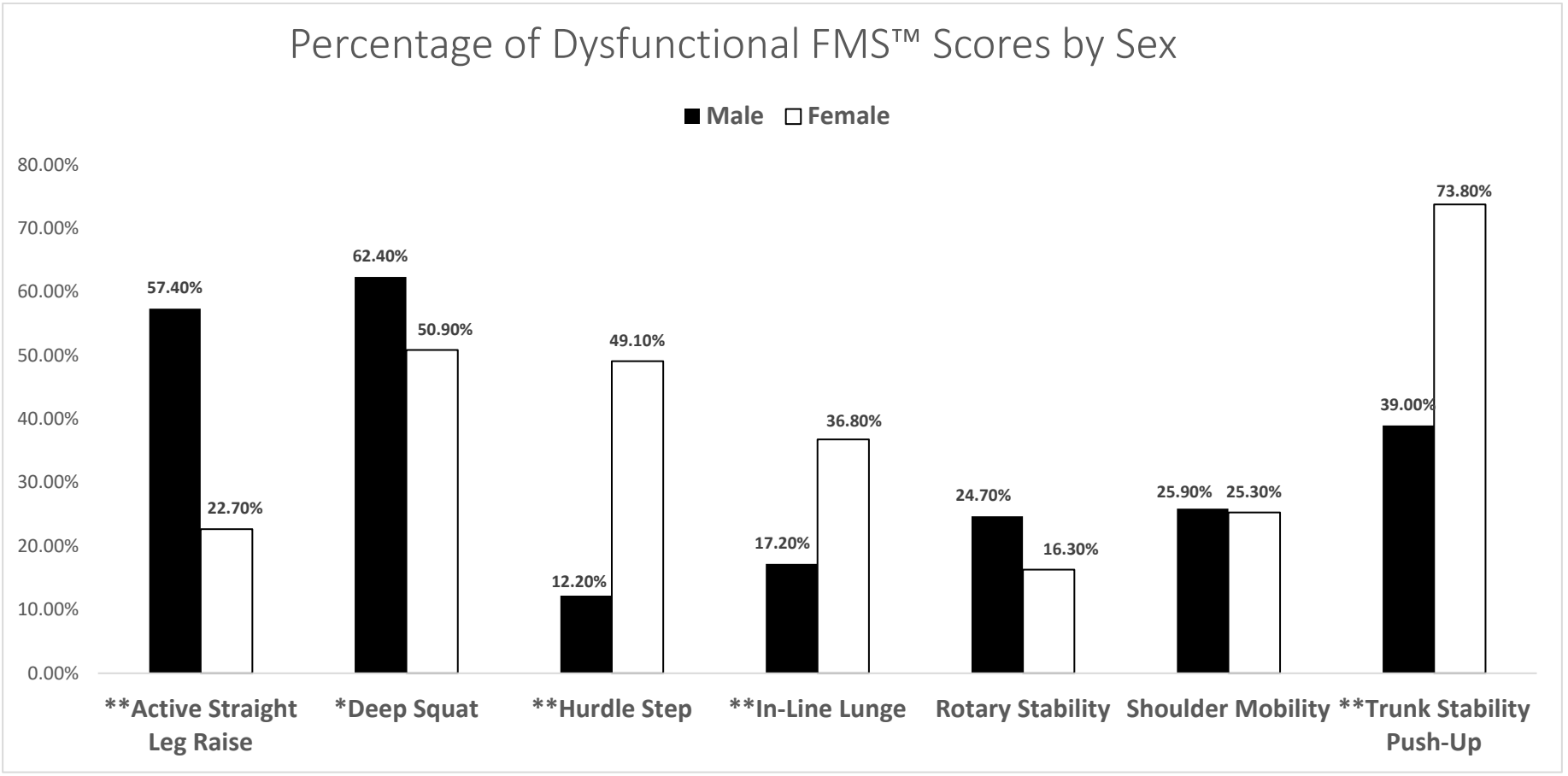


Figure 3.2: Percentage of Participants who scored a 'Dysfunctional' Score of '1,' by Sex.

Note: *Denotes Significance at the 0.05 level. **Denotes significance at the .01 level. FMS™ = functional movement screen.

Table 3.3. Correlations (R-values) Between FMS and FM (FMS™) Scores.

	FMS™	Active Straight-Leg Raise	Deep Squat	In-Line Lunge	Hurdle Step	Rotary Stability	Shoulder Mobility	Trunk Stability Push-Up	Overall FMS™
Fundamental Movement Skills Subsets									
Overall Locomotor		**.22****	**.18****	.01	**.14***	**.12***	**.17****	**.15****	**.30****
Overall Object-control		-.07	-.03	**.22****	**.24****	.11	.077	**.22****	**.22****
Overall Stability		.07	.10	.04	**.15****	**.19****	**.14****	.10	**.22****
Overall Gross Motor Score		.10	**.13***	**.14***	**.27****	**.18****	**.20****	**.24****	**.38****

Note: *Denotes significance at p < 0.05. **Denotes significance at p < .01 FMS™ = Functional Movement Screen.

3.6. Discussion

The purposes of this study were to (a) examine current levels of movement proficiency in terms of both FMS and FM among early adolescent Irish youth, (b) compare any sex-based differences, and (c) identify any preliminary associations between FMS and FM movement constructs that might warrant further investigation. Overall, we found low levels of FMS and FM proficiency. High levels of FM dysfunction among this large adolescent sample were evident, with many participants having failed to successfully complete the FMS that would be expected for their age cohort, and with FM proficiency below recently published normative values (Bolger et al., 2021; O'Brien et al., 2022). Most correlations between measures of FMS and FM were small, but there was a moderate correlation between overall FMS locomotor skill and the composite FM score from the FMS^{TM}.

Our results indicated that these Irish adolescents showed generally poor FMS proficiency, with an overall mean FMS score of 64.90 (*SD* = 6.20) out of a possible max score of 84, lower than two previous samples of Irish adolescent groups (Lester et al., 2017; O'Brien et al., 2018). These findings are consistent with previous work in FMS among Irish adolescents that have reported low levels of FMS proficiency (Duncan et al., 2022; Lester et al., 2017). Recent research has suggested a possible plateau in FMS abilities among young Irish children prior to their entry into adolescence (Behan et al., 2019; Kelly et al., 2021). While not assessed within the parameters of this study, low participation in PA by Irish children and adolescents (e.g., 17% of Irish children in primary school partaking in 60 minutes of PA a day, and 10% of secondary school children meeting this goal) is long documented (Woods et al., 2018). As has previously been noted in systematic research reviews, low levels of PA among children and adolescents are believed to contribute to lower levels of FMS (Graham et al., 2022; Holfelder & Schott, 2014; Logan et al., 2015).

In this study, we also reported significant sex differences (see Table 3.2) in favour of males for object-control and of females for locomotor skills. We found significant sex differences on individual FMS, with males displaying superior competencies on the throw and kick, with a large effect size of 21% observed for the

throw (Table 3.2). The throw was the only individual skill with such a significant difference and large effect size, with no other skill in the FMS section reflecting an effect size greater than small (i.e., no effect size greater than 0.05). Observed low levels of FMS proficiency amongst female adolescents in the object-control domain was also supported by previous Irish and international research (Bolger et al., 2021; Foulkes et al., 2022; Lopes et al., 2021).

Female students may not be receiving the correct pedagogy and learning experiences that would foster their development of object-control skills (Cowley et al., 2021). Trends toward higher levels of locomotor skills among girls have been commonly reported across prior Irish, and to a lesser extent, international research (Behan et al., 2019; Bolger et al., 2021; Tietjens et al., 2020). Female superiority in locomotor skills and lower female proficiency in object-control skills has previously been attributed to sociological factors, such as influences from family, teachers, and friends (Bolger et al., 2018; Hardy et al., 2010). These sociological influences on girls and their PA patterns often culminate in females partaking in locomotor-based PA activities such as dance and gymnastics that may be viewed as more feminine (Bardid et al., 2016; Bolger et al., 2018; Humberstone, 2001) .

Regarding FM, we found lower composite mean scores on the FMS^{TM} than were previously reported for children and adolescents (Abraham et al., 2015; Ghasempoor et al., 2018; O'Brien et al., 2022). We found significant sex differences on four of seven individual FM skills. Females significantly outperformed males on the active straight-leg raise, consistent with previous research (O'Brien et al., 2018; Silva et al., 2019); and, males significantly outperformed females on the in-line lunge, hurdle step, and trunk stability movements. Male superiority in the in-line lunge and trunk stability measurements has been recorded in previous adolescent and child samples (Abraham et al., 2015; Anderson et al., 2015; Garcia-Pinillos et al., 2018). Greater levels of male strength and core strength are likely to have contributed to their better performance in the skills of in-line lunge, hurdle step, and trunk stability, with the greater level of flexibility among females proving critical to their superior performance on the active straight-leg exercise (Catley & Tomkinson, 2013; Malina et al., 2015; Tomkinson et al., 2018).

Alarmingly, 91.7% of our study participants displayed a movement dysfunction (an inability to complete a movement), as denoted by a score of "1" for at least one of the seven movements assessed by the FMS™. Considering the level of dysfunctional movement observed in this Irish adolescent sample, it seems that our study participants may be inadequately prepared to take part in PA and/or were at risk of injury (Cook et al., 2014). Poorer FM levels have been associated with injury in prior studies; however no data from school-going children or its association with injury risk was contained within these past analyses (Attwood et al., 2019; Bonazza et al., 2017; Kiesel et al., 2007).

Significant FM dysfunction differences between males and females (Figure 3.2) were observed on five of the seven FM assessments, with males significantly more dysfunctional on the active straight-leg raise and deep squat movements and females significantly more dysfunctional on the hurdle step, in-line lunge and trunk stability push-up movements. Given natural biological advantages for females in flexibility and for males in strength, sex differences appear to have impacted these performances (Catley & Tomkinson, 2013; Renstrom et al., 2008; Tomkinson et al., 2018). Better female performances on the active straight-leg raise may be attributable to the increased flexibility, and mobility that females commonly possess over males (Bar-Or, 2004; Malina & Kozieł, 2014b).

Notably, the associated age profiles in this study (age range 12-16) may have relevance to the earlier commencement time of puberty for females (Malina & Kozieł, 2014b, 2014a). All females in this study surpassed their peak height velocity (PHV) age, and, as calculated using the maturity offset formula, 89.7% of participants were over a year past their PHV age (Moore et al., 2015). Females often experience greater accrued gains in mobility, flexibility and neuromuscular control in the years after PHV, peaking at approximately one-year after their PHV (Ford et al., 2011; Ghasempoor et al., 2018). This may be a factor in their lower level of dysfunction in movements predicated on mobility and flexibility (Ford et al., 2011; Ghasempoor et al., 2018).

Males retained core stability and upper-body muscular strength advantages on tasks of trunk-stability push-up, in-line lunge, and hurdle step which is supported

by prior findings from FMS™ research (Abraham et al., 2015; Karuc et al., 2020). As 64% of male participants in this study had not yet reached their PHV, or were less than a year past PHV, it seems possible that some males may have struggled with test elements demanding greater flexibility and mobility (i.e. deep squat and active straight-leg raise), helping to account for the higher rate of dysfunction among males in this targeted age group (Bar-Or, 2004; Ghasempoor et al., 2018; Viru et al., 1999).

We found two moderate associations between FMS and FM in this Irish adolescent population, as displayed in Table 3.3: (a) locomotor and overall FMS™, and (b) overall FMS and overall FMS™, providing reasonable evidence for the relatedness of these two concepts. The correlation between composite FMS™ and overall FMS locomotor skills (r = .30, p < .001,) and associations between composite FMS locomotor skills and the deep squat FM (r=.18, p < .001) and shoulder mobility FM (r=.17, p <.001,) may have been due to a high level of thoracic mobility underlying the biomechanics of both FMS locomotor skills and the FMS™ tests of FM (Cook et al., 2014; Mason et al., 2016). Several FMS™ assessments evaluate thoracic mobility - namely the deep squat, in-line lunge, and shoulder mobility exercises – while all FMS locomotor skills demand thoracic mobility (Ditcharles et al., 2017). In addition, ankle mobility, which is critical to performance of FMS™ tests such as the deep squat and in-line lunge, is a key component of locomotor skills such as jumping (O'Brien et al., 2021; Papaiakovou, 2013). Collectively, these past and present findings suggest links between locomotor skills and composite FMS™ performance, giving evidence of their relatedness that requires a deeper component analysis.

We found a small association (r= .224, p <.001) between the composite FMS™ score for FM and FMS static balance, as measured by the Get Skilled Get Active tool (i.e., standing on one leg, with non-standing leg bent behind the body, and arms stretched to the side of the body). Kramer et al. (2019) reported moderate correlations between composite FMS™ scores and dynamic balance among (males: r = 0.42; p<.01) and females (r = .41; p <.01), as measured by the Y-Balance test. The associations found across studies with both static and dynamic balance measures indicate that balance may serve as a key requirement for adequately performing tasks of the FMS™ (Cook et al., 2006b; Kramer et al., 2019; Silva et al., 2019).

A moderate correlation between overall gross FMS and overall FM on the FMS™ composite score was reported (r = .375, p <.001). This association may arise from biomechanical similarities between certain FM and FMS (e.g., between squat flexion and the preparatory and landing phases of the vertical jump) which may account for the relatedness observed between FMS and FM in this study (Tompsett et al., 2014). While this study and others have shown small to moderate associations between locomotor and stability FMS constructs and FM through FMS™ composite scores, further research and deeper analyses are necessary to determine if other underlying factors may contribute to the relatedness and associations observed between FMS and FM (O'Brien et al., 2021).

This study has highlighted movement deficiencies among Irish youth in FMS, low female proficiency in object-control skills, and low proficiency of males in locomotor skills. Additionally, we found dysfunctional movement scores in activities associated with flexibility and mobility among males, and dysfunctional movement scores in activities requiring upper-body core strength among females. While physical education is not the sole contributor to these movement skill issues, our findings suggest that there are gaps in Irish physical education curricula that may not be optimally developing particular skills among students. A number of gaps within physical education in Ireland must be addressed. As per the most recent nationally representative data, 18% of Irish children in primary school receive 30 minutes or less of physical education a week, with only 45% of children receiving PE 2-3 times a week (Woods et al., 2018). At post-primary level, only 23% of students meet the guideline of 120 minutes of PE per week, with the average weekly minutes of PE at post primary being 89 minutes (Woods et al., 2018). In addition to accruing more time within physical education, an effort to integrate terms such. While a low level of time spent in physical education remains a key problem, it is imperative that physical education teachers implement the entire curriculum and do not focus on certain strands (Woods et al., 2018; Lester et al., 2017). Outdoor education, adventure activities, aquatics, and gymnastics are key areas within curricular documents, but are not widely taught at both primary and post-primary level (Woods et al., 2018). To promote object-control skills among females, several studies have

cited the importance of providing girls with autonomous, feasible challenges, and interesting learning experiences in both physical education and sport (Cowley et al., 2021, 2022; Farmer et al., 2017). For males, promoting locomotor-based play and such curriculum strands as dance and gymnastics should nurture their deficiencies in flexibility and mobility to help them develop a rounded skillset that meets their activity needs (Coulter et al., 2020; Garcia-Pinillos et al., 2018). Ultimately, however, a physical education environment that invites high participation, enjoyment and a wide array of games and exercise opportunities (as well as embracing diversity across all strands of the curricula such as health-related fitness, aquatics, and adventure education) is essential to the requisite development of both strength and flexibility skills among male and females (Dudley, 2015; Kriellaars et al., 2019). It is within the best interests of physical education stakeholders to provide a well-rounded curriculum for their students in their efforts to promote healthy and active individuals, with diverse movement abilities, in addition to strong social and teamwork skills (Belton et al., 2022; Cairney et al., 2019; Smith et al., 2021).

3.7. Limitations and Directions for Further Research

A potential limitation of this research was that all participants were selected from a suburban are of Cork City, Ireland and socio-economic status was not controlled for, meaning that these participants may not be representative of Irish adolescents from rural and all socioeconomic backgrounds. The sparse number of movements used in the assessment of FMS stability is also a limitation, as this FMS category showed less performance variation than the object-control and locomotor FMS subsets. A more thorough examination of the link between the stability FMS subset and FM as measured by FMS™ may have been possible if the stability FMS subset had been more thoroughly examined using a combination of static and dynamic balance tests (e.g., those included in the Körperkoordinations test für Kinder, such as walking backwards on a balance beam, and moving sideways on wooden boards). This was not possible owing to our time constraints during data collection. This study serves as a preliminary investigation into the relatedness between FMS and FMS^{TM}. However, a more comprehensive examination (possibly

through divergent and convergent validity assessments or through confirmatory factor analysis), is still needed. Longitudinal studies would permit an analysis of cause-and-effect relationships. Comparative FMS^{TM} data from sporting and non-sporting adolescents would also assist data interpretation.

3.8. Conclusion

In this study, a large number of Irish adolescents displayed poor FMS and FM proficiency compared to previously established values. Moderate associations between FMS and FM measures in these cross-sectional data further suggests a need for further research into these MC components. Both FMS and FM represent movements that are important for PA throughout the lifespan, however, they must continue to be viewed separately and assessed using only validated testing measurements. Given the low levels of adolescent FMS and FM proficiency we observed in these Irish adolescents, interventions targeting the development of FMS and FM proficiency in early adolescent Irish youths are apt to be beneficial for improving later PA and health. Sex-specific interventions may be needed to ameliorate specific deficiencies observed in males and females respectively.

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Chapter 4

Investigating the age-related association between perceived motor competence and actual motor competence in adolescence

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4.1. Abstract:

Irish adolescents have been found to possess high perceptions of motor competence. There is, however, an evidential value to investigating the strength of the relationship between adolescent perceptions of motor competence and their low levels of actual motor competence. The purpose of this research was to gather data on fundamental, functional, and perceived motor competence in adolescents, differentiated by year group, to discern if participants could assess their perceptions of ability. Data were collected on adolescents (N=373; mean age: 14.38 ± 0.87 years; 47.7% female), across six second-level schools in Ireland, including measurements of fundamental movement skills, functional movement, and perceived motor competence. Poor levels of fundamental and functional movement were observed, with significant differences between year groups detected. Participants in 1st year scored highest in overall fundamental movement skills, however, for overall functional movement, 3rd year participants scored highest. High levels of perceived motor competence were reported across the entire sample. These scores did not align with actual motor competence, nor did alignment between these measurements improve with aging, countering theorised age-related associations. Future research should target low levels of actual motor competence, while emphasising cognitive aspects of movement, to ensure greater accuracy between actual and perceived motor competence.

4.2. Introduction

Global adolescent physical activity (PA) levels remain at disconcertingly low levels, with few signs of future improvements (Organisation for Economic Co-operation and Development, 2017). As low PA levels are associated with a higher degree of obesity, and an increased risk of non-communicable diseases increasing PA levels must become a vital part of future initiatives to improve the health status of future generations (Farooq et al., 2020). Irish PA participation levels for children and youth remain perilously low, with only 13% meeting current recommendations of 60 minutes of PA per day (Woods et al., 2018). Childhood and adolescent PA patterns typically subsist throughout the lifespan, clearly underlining the importance of establishing an active lifestyle as early as possible (Cattuzzo et al., 2016). Both fundamental movement skills (FMS) and perceived motor competence (PMC) are recognised as positive pillars that can form a critical role in boosting adolescent PA levels (Rogers et al., 2018).

Fundamental Movement Skills (FMS) are frequently cited as the 'building blocks' of intricate movements, necessary for participation in sports, games, and PA (Gallahue et al., 2012; Logan et al., 2018). FMS are comprised of three key subsets: locomotor skills which involve transportation of the body in any direction (e.g. vertical jump) (Logan et al., 2015), object-control, which require the manipulation or control of a projectile (Logan et al., 2015), and balance. Positive associations between FMS performance and cardiorespiratory fitness have been found repeatedly across systematic reviews (Holfelder & Schott, 2014; Lubans et al., 2010). An inverse relationship between FMS performance, and weight status has also been observed with greater FMS ability associated with reduced weight (Lubans et al., 2010; O'Brien et al., 2016b). Greater levels of FMS performance are associated with both increased PA time, and sustained engagement in PA throughout childhood and adolescence (Engel et al., 2018; Logan et al., 2015), which suggests that FMS form a vital part of the rounded skillset necessary for students to prosper in PA throughout their lifespan (Clark, 2007; Engel et al., 2018; Logan et al., 2015).

Global FMS figures vary by region, but the commonality found across countries is that of poor proficiency. Among a New Zealand childhood cohort (n=701) aged between 0-8 years old, less than half of children demonstrated proficiency in the skills of kicking, throwing, and striking (Mitchell et al., 2013). In a Brazilian study (n= 2,000), less than half of children between the ages of 3-10 years old demonstrated mastery across locomotor skills , and the object control subset measured object-control skills (strike, stationary dribble, catch, throw, underhand roll) (Valentini et al., 2016). A European cross-cultural study indicates that, 10% and 40% of children in northern and southern Europe respectively, possess poor levels of movement proficiency (Laukkanen et al., 2019).

Both Irish childhood and adolescent research studies indicate subpar FMS levels (Kelly et al., 2019; O'Brien et al., 2016a). One Irish study indicated that just over 50% of Irish children between the ages of 5-12 years old (n=2,048) displayed proficiency across locomotor and object-control skills (Behan et al., 2019). A ceiling effect of FMS performance may occur among Irish cohorts, which may further explain the findings of Lester et al., (2017). Among Irish adolescents, less than 40% of participants displayed proficiency in two locomotor skills (vertical and horizontal jump), and four object-control skills (kick, dribble, strike, throw), by the end of their third year of post-primary school (ages 15-16 years old), indicating a stagnation in skill development in adolescence (Lester et al., 2017). The low levels of physical education participation among students in Irish primary school settings, in addition to a lack of specialist physical education teachers at the primary school level may be a critical factor in the low skill levels reported in childhood and adolescence (Bolger et al., 2018). Insufficient pedagogical knowledge from non-specialist teachers, and minimal physical education time may negatively be impacting on FMS development throughout childhood and into adolescence in Irish students, with poorer quality physical education negatively impacting on skill acquisition (Bolger et al., 2018). Furthermore, a lack of time in physical education may undermine FMS development in the primary years, with 18% of Irish children receiving less than 30 minutes of physical education per week (Woods et al., 2018). To nurture both FMS proficiency,

and PA levels, both functional movement and perceived motor competence could be deemed essential ingredients for consideration (O'Brien et al., 2018).

Functional Movement, refers to the capacity to move with adequate muscle and joint functioning (Coker, 2018). While research on functional movement and its association with PA or perceived motor competence (PMC) is limited, an association between FMS and functional movement is theoretically informed. Critical elements of functional movement assessments, including shoulder mobility, and postural stability are essential to a higher level of performance in a number of FMS, such as vertical jumping, running, and throwing (Kraus et al., 2014; Papaiakovou et al., 2007; Salles et al., 2011). Motor Competence (MC) has been defined as a term to describe goal-directed human movement (Robinson et al., 2015). Both functional movement and FMS fit this description and their associations indicate assessing both elements in an assessment battery would be highly pertinent. By diversifying both the range of movements assessed, and assessment batteries used in MC testing through the inclusion of functional movement, a more rounded perspective of MC would be gathered, which reflects the greater diversity of PA opportunities available to an individual across their lifespan (Kavanagh et al., 2020; O'Brien et al., 2018).

The Functional Movement Screen™ (FMS™) is the pre-eminent assessment tool within the field of functional movement patterns, and this instrument seeks to detect asymmetries, or pain when performing these critical movements (Cook et al., 2006a). Irish studies indicate that adolescents possess poor levels of functional movement (Lester et al., 2017; O'Brien et al., 2018). These figures are lower than previously cited global figures found among Indian adolescents (Abraham et al., 2015), and in American populations (Coker, 2018; Kramer et al., 2019). These Irish results are marginally above the well-established critical composite score of 14, with a score below 14 frequently theorised as being associated with increased risk of injury (Kiesel et al., 2011). Minimal research examining the association between FMS and functional movement exists, though some recent publications have noted a link between stability and functional movement (Kramer et al., 2019; Silva et al., 2019).

Perceptions of ability across both fundamental and functional movement are considered likely factors in guiding actual movement abilities, either directly, or in a mediating capacity (Rogers et al., 2018). Perceived Motor Competence (PMC) refers to a person's own belief in how competently they can execute a particular skill (Van Veen et al., 2020). PMC is formulated through numerous factors, including but not limited to: (i) previous experience (ii) task difficulty, (iii) persuasion and interaction with others (iv) intrinsic motivation (v) vicarious experience (Bandura et al., 1999; Harter, 1978). PMC is rooted within Harter's Competence Motivation theory, which suggests that competence (i.e. mastering FMS or functional movement) is related to PMC, with PMC further impacting on PA (Barnett et al., 2008; Harter, 1978). Further research in motor development has proposed a theoretical model, highlighting a positive spiral of engagement between PMC, FMS (or general motor skills competence), and PA (Stodden et al., 2008)

A systematic review found that PMC and PA have a bidirectional relationship, as they both act as an outcome and a determinant of one another (Babic et al., 2014), which is further supported across international studies (Bolger et al., 2019; Khodaverdi et al., 2016; Visser et al., 2018). Interestingly, PMC has also been found to have an association with actual motor competence (AMC) (De Meester et al., 2016a; Duncan et al., 2018), however, other research has noted a lack of an association between PMC and AMC (Barnett et al., 2018; Bolger et al., 2019). Regarding PMC and functional movement, O'Brien et al., (2018) observed that Irish adolescents (N=219) have rather high perceptions of ability, in spite of their low actual levels of functional movement (O'Brien et al., 2018). Notably, these high perceptions of ability are in contrast to the theoretical expectations of lower and more realistic perception scores, emerging in adolescence due to cognitive maturity (Harter, 1999; Stodden et al., 2008).

There is a glaring need to investigate the extent of the relationship between PMC, FMS & functional movement. A greater understanding of this relationship could spur the development of effective intervention programmes centred on PA, FMS, or functional movement for adolescent populations. The purpose of this study was to

gather data on Irish adolescents fundamental and functional movement, and PMC, to determine if there was an age-related association between variables (i.e., were perceptions of ability becoming more accurate in older participants). PMC was measured as the developmental model of motor competence indicates that PMC and AMC have a reciprocal relationship, with positive PMC resulting in improvements in MC and vice-versa (Stodden et al., 2008). Furthermore, this model theorises that perceptions of movement will become more realistic as children progress through adolescence (Stodden et al., 2008).

4.3. Materials and Methods

4.3.1. Study Design and Participants or Participants and setting

This data were collected at baseline as part of a larger randomised controlled trial study of Irish adolescent youth focused on AMC and PMC. Ethical approval was granted by the Social Research Ethics Committee at University College Cork in November 2018 (UCC Ethics log code "Log 2018-169"). Prior to commencing this school-based study, the leading researchers visited the school Principal and liaison physical education teacher in each participating school, where a full briefing of the data collection process was outlined. All schools partaking in the study had a qualified post-primary physical education teacher, as recognised by the Teaching Council of Ireland, teaching a consecutive double-period (80 minutes of class time) of physical education to the participating class groups. While quality of the existing physical education programme was not assessed, the provision of qualified teachers and equal time for physical education in each school, indicates teaching experiences for the participating students was relatively equal at baseline. All students who participated came through the Irish primary school system where a generalist classroom teacher led their physical education classes. Subsequent to the granted approval from school principals, consent forms and information sheets were distributed to each respective class group. Informed parental consent and child assent were required to be eligible for participation in the study. Both schools and participants were informed that their participation was entirely voluntary, and they

were free to withdraw from participation of their own volition at any time. In terms of the research rigour inherent to school-based measurements, it is important to note that the principal investigators for this study were qualified post-primary specialist physical education teachers, as recognised by the Teaching Council of Ireland.

Consenting second-level participants from years one to three (age range: 12.23-16.37 years), across 6 schools, within suburban areas of County Cork, in the province of Munster, Ireland were invited to participate. Two all-male second-level schools, two all-female second-level schools, and two mixed lower socioeconomic status (SES) schools took part, with each pairing matched by gender and SES. This matching protocol should ensure that equality of PA experiences outside of schooling was relatively similar for students in the different SES bands, through qualitative or self-report data on accumulated PA or sporting experience outside of schooling was not collected. A total of four hundred and eighty-six students were eligible to partake in the study, with final consent and attendance provided by 373 participants (14.38 ± 0.87 years; 76.7% of full sample). Of the participants, 178 were female (47.7%), and 195 were male (52.3%); with 101 participants from 1st year (i.e., their first year of second-level schooling), 149 from 2nd year, and 123 from 3rd year.

4.3.2. Collection Methods

Prior to data collection, all field staff, who were undergraduate pre-service, or graduate physical education teachers, underwent a thorough 3-hour field researcher training workshop on the measurement protocol associated with FMS, FMS^{TM}, self-report questionnaires, and body composition. This involved an objective criteria informed process to ensure field staff applied consistency to their administration and implementation of the respective FMS and functional movement pattern (s) they were assigned. Research assistants practiced their assigned skills at the workshop, and prior to arrival of study participants on day of testing, with their procedures evaluated by the principal investigators during these evaluations. Additionally, field staff were given a descriptive research handbook detailing the protocol for them to revise prior to all data collection phases. Baseline data were

collected with participants in their respective class groups (maximum n=27) during allocated school timetable visits. All measurements (FMS, FMS^{TM}, and self-report questionnaires) were carried out during a typical physical education class (duration range 80 minutes to 120 minutes).

4.3.3. Measures

For both the FMS and FMS^{TM} objective measurements, Apple iPads placed on a fixed stanchion were used to record each participant's performance, and execution of the requisite skill/movement patterns. Camera positioning and angles were kept consistent at all times to ensure that total body movement was captured (O'Brien et al., 2016a, 2016b). While live-scoring has proven to be an acceptable method for both inter-rater and intra-rater reliability of the FMS^{TM} (Moran et al., 2016), video-recording was used to allow for more careful data processing at a later time in the University lab (O'Brien et al., 2013, 2016a). Video recordings are an essential component to motor skills data collection, as they allow for greater scrutiny and accuracy of measurement (Okely & Booth, 2004).

4.3.3.1 Fundamental Movement skills

The following 10 FMS were assessed; horizontal jump, vertical jump, run, skip (locomotor, maximum score of 34); catch, stationary dribble, overhead throw, two-handed strike, kick (object-control, maximum score of 40) and balance (stability, maximum score of 10) for a composite maximum raw score of 84. Each of the ten FMS were assessed in conjunction with the observable behavioural components from three FMS measurements (Test of Gross Motor Development, Test of Gross Motor Development-2; Get Skilled Get active resource), with established reliability and construct validity (Cools et al., 2009; Ulrich, 2000; Victoria Department of Education, 1996; New South Wales Department of Education and Training, 2000). Prior to participant performance, a trained field staff member provided an accurate demonstration and instruction of the skill to be performed. Procedures delineated in the TGMD-2 examiner's manual (Ulrich, 2000) were stringently adhered to within the

assessment of the ten FMS during the physical education period. To maintain participant consistency within skill performance, no visual or verbal feedback, from any of the trained field stuff was given during testing. Skills were performed on three occasions by participants, including a single familiarisation practice, and two performance trials, as described in other Irish adolescent movement research (O'Brien et al., 2016a, 2016b). The FMS scoring process were completed at a later date by the principal investigators.

4.3.3.2 Functional Movement Screen:

The Functional Movement Screen (FMS^{TM}) is an evaluation tool that comprises a series of movements designed to assess multiple domains of function, and the quality of movement patterns (Cook et al., 2006b, 2006a). All seven components of the FMS^{TM} were assessed: active straight-leg raise, trunk stability push-up, shoulder mobility, deep squat, rotary stability, hurdle step, and in-line lunge. The test administration measures, instructions and scoring associated with the standardised version of the test (Cook et al., 2006b, 2006a) were applied to maintain accuracy during testing and scoring (Abraham et al., 2015; Bardenett et al., 2015). Normative FMS^{TM} values have been established in adolescent school-aged children (Abraham et al., 2015). Trained field staff utilised the pre-determined verbal instructions during testing. During data collection, each participant was video-recorded, and given three attempts to perform the movement. The principal investigators scored the optimum trial rigorously at later date, as recommended in the original training workshop. The FMS^{TM} has a scoring range from zero to three, with three being the optimum score (Cook et al., 2011). If, at any juncture during the testing, the participant displayed signs of pain or discomfort, anywhere on their body, they received a score of zero and the area of discomfort was noted. An inability to complete the movement is characterised by a score of one. A score of two was awarded when the participant used a compensation in order to perform the movement. A maximum score of three was allocated to the participant where the movement was performed correctly without compensation. Bilateral scores for five (active straight-leg raise, shoulder mobility, rotary stability, in-line lunge, and hurdle

step) of the seven functional movements were also recorded, to compare imbalance and dysfunction between the left and right sides of the body. The lowest score for either side of the body within the movement contributed to the final score. For each of the seven screening items, the highest score from the three trials was recorded, and used to generate an overall composite FMS^{TM} score, with a maximum value of 21, as part of established protocol (Cook et al., 2006a, 2006b; Duncan & Stanley, 2012). FMS^{TM} scoring was completed by the principal investigators at a later juncture.

4.3.3.3. Perceived Motor Competence

The McGrane et al., (2016) physical self-confidence scale is the first valid and reliable instrument that has been developed to assess physical self-confidence in adolescents, and at a skill specific, FMS proficiency level (McGrane et al., 2016). This Likert Scale measurement tool has excellent test-retest reliability (r = 0.92) (McGrane et al., 2016). The scale demonstrates good content and concurrent validity (r = 0.72) (McGrane et al., 2016), when compared to the physical self-perception profile (Fox, 1990). The physical self-confidence scale (McGrane et al., 2016) was adapted, and used as an indicator to measure the PMC of participants' in their FMS proficiency, with the question stem altered very slightly from "how confident are you at performing" to "how well can you perform", following advice from experts and recent developments in the field (Estevan & Barnett, 2018). Referring to competence will insure better alignment with the field of PMC, and reduce a problem within PMC research of 'definitional blurring', where a lack of clarity and alignment between measurement tools and constructs leads to incorrect assumptions being made (Estevan & Barnett, 2018; Shearer et al., 2018). Participants completed the PMC questionnaire separate from other participants, after they performed the actual motor competence test of a specific skill (i.e., the participant evaluated their throw PMC after completing the TGMD-2 test for the throw skill), returning to watch the demonstration of the next skill. Within this PMC scale, participants were asked to rate their competence at performing 10 FMS, based on a Likert scale format of 1–10. A score of '1' indicated being not competent at all and a score of 10 indicated being

very competent. By using the Likert scale, and modifying the question stem, a more holistic alignment and accurate conception of PMC is obtained and collected (Estevan & Barnett, 2018). The 10 FMS selected within this instrument are pivotal to the Irish adolescent sporting culture (O'Brien et al., 2016a; Woods et al., 2018). In the current study, Cronbach's alpha coefficient showed good internal consistency for the perceived motor competence scale, with a Cronbach alpha coefficient of 0.84 overall, 0.73 for the object control subscale, and 0.80 for the locomotor subscale. Both self-report questionnaires (Perceived FMS competence and perceived functional competence) were collected with participants using pen and paper, and later inputted into a statistical programming software by the research team.

4.3.3.4. Perceived Functional Movement Competence

A previously developed tool to assess perceived functional movement competence amongst an Irish adolescent populations was employed in this study to measure the PMC of participants' in their functional movement proficiency (O'Brien et al., 2018). As per the FMS scale outlined above, small modifications were made to refer to 'how well can you perform', rather than 'how confident you are', in accordance with the recommended alignment between PMC and FMS assessment (Estevan & Barnett, 2018). Participants completed the perceived functional movement competence questionnaire separate from other participants, after they performed the actual motor competence test of a specific skill (i.e., the participant evaluated their deep squat perceived competence after completing the FMS^{TM} test for the deep squat), returning to watch the demonstration of the next skill. Similar to the McGrane et al., (2016) protocol, participants were asked to rate their competence at performing the identified seven FMS™ tasks, based on a Likert scale format of 1–10. A score of 1 indicated being not at all competent, and a score of 10 indicated being very competent. As the seven FMS™ tasks are non-sport specific, and participants may not be familiar with the movements, a visual image alongside the question was provided, similar to empirically validated pictorial instruments for assessing FMS perceived competence (Barnett et al., 2015, 2016; O'Brien et al., 2018). Previous test-retest reliability coefficients for this perceived functional

movement competence scale ranged from 0.82 to 0.93, which showed that the scores across this instrument were stable over time (O'Brien et al., 2018). Furthermore, the perceived functional movement competence scale in this current study presented with good internal consistency, with an overall Cronbach alpha coefficient of 0.85 reported across the seven items

4.4. Data Processing and Analysis

Prior to the data scoring of fundamental and functional movement, inter- and intra-rater reliability was established on 10% of the data set. Two raters double coded 10% of the data to determine intra-rater reliability, and both coded the same 10% of data to determine interrater reliability (Logan et al., 2017). The two principal investigators were required to reach a minimum of 95% inter-rater agreement for all ten FMS and seven functional movements. Questionnaire data for PMC were collated and inputted into SPSS version 25.0 for windows.

The FMS and FMS™, and PMC data sets were analysed using SPSS version 25.0 for Windows. Descriptive statistics and frequencies for FMS and FMS™ at the skill and composite score levels were calculated. For both FMS and FMS™, mastery was defined as correct performance of all components across two trials (O'Brien et al., 2016a). Differences in performance by year group in overall and individual FMS/FMS™, and PMC performances were analysed using one-way between groups analysis of variance (ANOVA), with post-hoc tests. Pearson product moment correlation coefficients were calculated to analyse the strength and direction of the association between PMC scores and AMC scores across both FMS and FMS™, differentiated by school year group as observed in prior PMC studies (McGrane et al., 2016; Rogers et al., 2018). The strength of the relationship (i.e. small, moderate, large) was determined using the Cohen (1988) guidelines (Cohen, 1988). A correlation coefficient of r = 0.10 – 0.29 denoted a small correlation, r = 0.30 - 0.49 denoted a moderate correlation, and r ≥ 0.50 denoting a strong correlation respectively (Cohen, 1988).

4.5. Results

This section has been divided into subheadings

4.5.1. Fundamental Movement Skills

Across the 10 FMS assessed, no participant successfully mastered all skills. The percentage mastery for each FMS by year group is shown in figure 4.1, while the actual FMS proficiency by year group is given in table 4.1. The highest performed skill was the run (60.4% mastery in 1st year, 70.3% in 2nd year, and 62.6% mastery in 3rd year respectively). For 1st and 2nd year students, the poorest performed skill was the horizontal jump (14% mastery and 7.7% mastery respectively), however, for the 3rd year cohort, the poorest performed skill was the kick (10.3%).

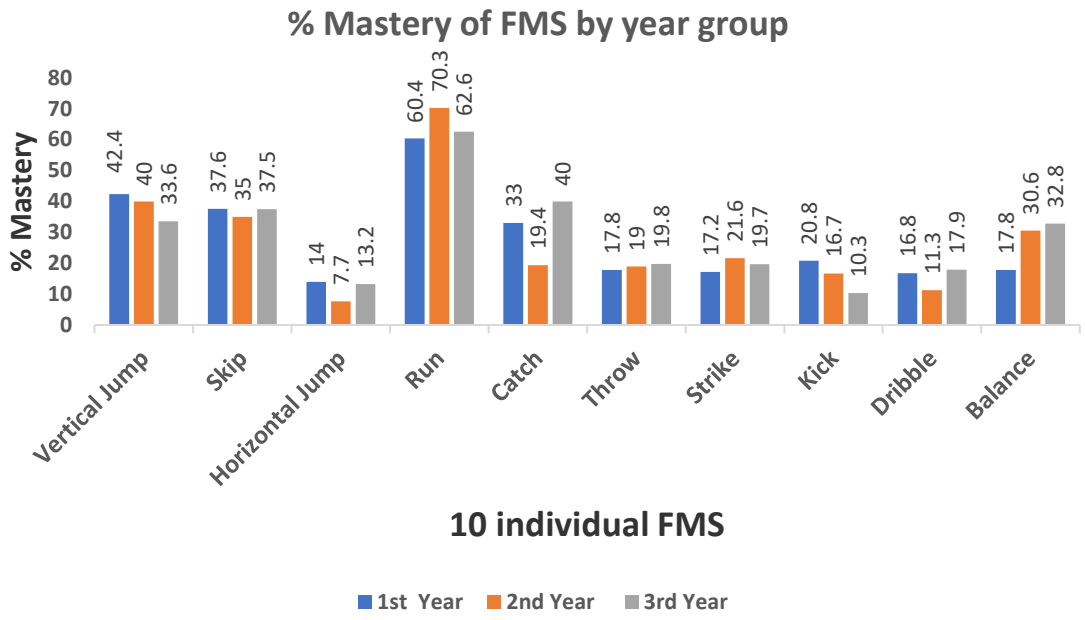


Figure 4.1. The prevalence of FMS mastery by school year group among participants.

A one-way ANOVA (table 4.1) revealed no significant differences in gross motor FMS competence across the three-year groups. At the individual skill level, a significant decrease in horizontal jump proficiency was evident from 1st year (5.19 ± 1.75) to 2nd year only (4.99 ± 1.8) ($p<.001$). Participants' catching proficiency increased significantly from 2nd year (4.5 ± .95) to 3rd year (4.94 ± 1.01) ($p<.001$).

Table 4.1. Actual FMS & FMSTM proficiency by year group (ANOVA results).

FMS Skills (Max raw score)	Year 1 (Mean ± SD)	Year 2 (Mean ± SD)	Year 3 (Mean ± SD)	p value	Post-Hoc Tests
Gross Motor Skill (84)	65.03 ± 6.43	64.73 ± 5.99	64.98 ± 6.28	.93	N/A
Locomotor Skill (34)	27.55 ± 3.66	26.85 ± 3.43	26.79 ± 3.71	.24	N/A
Object Control Skill (40)	29.53 ± 4.24	29.5 8± 3.67	29.90 ± 3.85	.75	N/A
Vertical Jump (12)	10.40 ± 1.82	10.2 ± 1.91	10.14 ± 1.87	.56	N/A
Skip (6)	4.69 ± 1.24	4.43 ± 1.44	4.52 ± 1.45	.34	N/A
Horizontal Jump (8)	5.19 ± 1.75	4.64 ± 1.58	4.99 ± 1.8	.04*	Y1>Y2
Run (8)	7.28 ± .99	7.38 ± 1.11	7.13 ± 1.27	.20	N/A
Catch (6)	4.8 ± .98	4.5 ± .95	4.94 ± 1.01	.001*	Y2<Y3
Throw (8)	5.18 ± 2.1	5.35 ± 2.06	5.1 ± 2.19	.60	N/A
Strike (10)	7.66 ± 1.77	8.08 ± 1.53	7.77 ± 1.64	.10	N/A
Kick (8)	6.15 ± 1.31	5.85 ± 1.38	5.74 ± 1.32	.08	N/A
Dribble (8)	5.75 ± 1.53	5.80 ± 1.23	6.05 ± 1.29	.20	N/A
Balance (10)	7.92 ± 1.66	8.23 ± 1.73	8.22 ± 1.65	.30	N/A
Functional movements	**Year 1 (Mean ± SD)**	**Year 2 (Mean ± SD)**	**Year 3 (Mean ± SD)**	**P value**	**Post-Hoc**
Active Straight Leg Raise (3)	1.72 ±. 70	1.66 ± .56	1.69 ± .67	0.78	N/A
Deep Squat (3)	1.48 ± .63	1.52 ± .63	1.48 ±. 60	0.82	N/A
Hurdle Step (3)	1.69 ±. 49	1.73 ± .55	1.80 ± .53	0.34	N/A
In-Line Lunge (3)	1.69 ± .46	1.74 ± .45	1.78 ± .46	0.41	N/A
Rotary Stability (3)	1.72 ± .45	1.84 ± .37	1.80 ± .40	0.09	N/A

Shoulder Mobility (3)	1.94 ± .73	2.06 ± .69	1.95 ± .73	.0.31	N/A
Trunk Stability Push Up (3)	1.47 ± .66	1.45 ± .58	1.63 ± .66	0.06	N/A
FMSTM Overall (21)	11.78 ± 1.19	12.06 ± 1.88	12.14 ± 2.12	0.40	N/A

Note: *p<.05. The mean difference is significant at the .05 level. **p<.01. The mean difference is significant at the .01 level.

4.5.2. Functional Movement

No student attained mastery across all seven functional movement assessments (maximum score of 3 per test). Figure 4.2 displays the prevalence of functional movement mastery among participants by year group. Shoulder Mobility was the best performed movement pattern across all 3-year groups, with 23.8%, 26.9%, and 24% mastery across the 1st, 2nd, and 3rd year groups respectively. The poorest performed movement pattern was the rotary stability, with 0% of participants obtaining mastery across all 3-year groups.

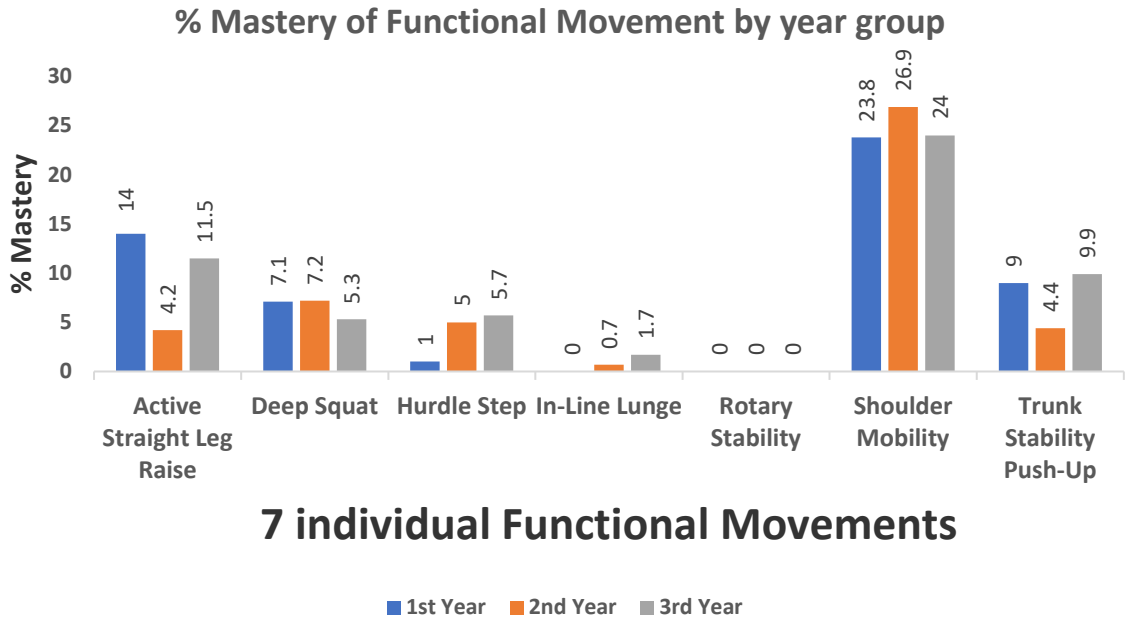


Figure 4.2. The prevalence of functional movement mastery by school year group among participants.

When broken down by year group, a one-way ANOVA (Table 4.1) revealed no significant differences in functional movement performances at the gross or at the individual movement pattern level.

4.5.3. Perceived Motor Competence

A one-way ANOVA broken down by year group revealed no significant differences in PMC levels across the 10 FMS (see table 4.2) between year groups.

Table 4.2. Perceived motor competence of the 10 FMS & 7 functional movements by year group.

FMS PMC Rating	Year 1 (Mean ± SD)	Year 2 (Mean ± SD	Year 3 (Mean ± SD)	Year Group (p value)	Post-Hoc Tests
Vertical Jump (10)	7.27 ± 2.11	6.97 ± 1.94	7.11 ± 1.78	.52	N/A
Skip (10)	8.05 ± 2.14	7.70 ± 1.9	7.74 ± 2.02	.38	N/A
Horizontal Jump (10)	6.84 ± 2.13	6.36 ± 2.06	6.34 ± 2.09	.15	N/A
Run (10)	8.44 ± 1.67	8.09 ± 1.65	8.19 ± 1.64	.28	N/A
Catch (10)	8.98 ± 1.44	8.95 ± 1.39	8.72 ± 1.76	.38	N/A
Throw (10)	7.65 ± 1.91	7.37 ± 1.85	7.82 ± 1.70	.15	N/A
Strike (10)	6.23 ± 2.85	6.20 ± 2.46	6.42 ± 2.41	.77	N/A
Kick (10)	7.40 ± 2.24	7.18 ± 2.23	7.48 ± 1.86	.50	N/A
Dribble (10)	8.09 ± 1.89	7.87 ± 1.85	8.10 ± 1.5	.53	N/A
Balance (10)	8.46 ± 1.76	8.31 ± 1.55	8.40 ± 1.73	.81	N/A
Functional Movement PMC Rating	**Year 1 (Mean ± SD)**	**Year 2 (Mean ± SD**	**Year 3 (Mean ± SD)**	**Year Group (p value)**	**Post-Hoc Tests**

Active Straight Leg Raise (10)	6.90 ± 2.11	6.63 ± 6.76	6.76 ± 2.10	.63	N/A
Deep Squat (10)	6.95 ± 2.24	6.91 ± 2.15	6.84 ± 2.13	.94	N/A
Hurdle Step (10)	6.86± 1.96	6.71± 2.14	6.88±2.14	.76	N/A
In-Line Lunge (10)	7.27 ± 1.87	7.11 ± 1.840	6.90 ± 2.11	.38	N/A
Rotary Stability (10)	5.69 ± 2.32	4.71 ± 2.04	5.14 ± 2.05	.003*	Y1>Y2<Y3
Shoulder Mobility (10)	6.86 ± 2.33	6.55 ± 2.20	6.32 ± 2.07	.20	N/A
Trunk Stability Push-up (10)	6.93 ± 2.38	6.43 ± 2.39	6.53 ± 2.38	.29	N/A

Note: *p<.05. The mean difference is significant at the .05 level. **p<.01 The mean difference is significant at the .01 Level.

A one-way ANOVA broken down by year group (table 4.2) revealed that participants had significant differences in their perceptions of rotary stability competence, across years. Post-hoc tests revealed that there was a significant difference in their perception of this functional movement between 1st year (*m*= 5.70 ± 2.32) and 2nd year participants (*m*= 4.71 ± 2.04).

4.5.4. Relationship Actual Motor Competence (FMS and functional movements) and Perceived Motor Competence

4.5.4.1. FMS

1st Years – A small positive relationship was found between PMC scores for 1st year participants in overall gross motor FMS competence (r=. 29, p= .007), the vertical jump (r= .24, p= .02), throw (r= .27, p= .007), strike (r= .29, p= .005), and the balance (r= .27, p= .006). A moderate positive relationship was found between PMC scores for 1st year participants in the object control composite subset (r= .38, p <.001) and the kick (r=.38, p= <.001).

2nd Years – A small positive correlation was found between PMC scores for 2nd year participants in overall gross motor competence (r=.28, p= .006), the throw (r=.25, p=.004) strike (r=.2, p= .03), and kick (r=.18, p= .05). A moderate positive correlation was found between PMC scores for 2nd year participants in the object-control composite subset (r= .36, p<.001) and the balance (r.30, p= <.001).

3rd Years – Small positive correlations were found between PMC scores for 3rd year participants in the skip (r= .24, p= .008), horizontal jump (r= .22, p= .02), strike (r= .27, p= .003), and the balance (r= .29, p = .001). A moderate positive correlation was found between PMC scores 3rd year participants in overall gross motor competence (r= .41, p <.001), the locomotor composite subset (r= .33, p <.001), the object-control composite subset (r= .4, p <.001), throw (r=. 35, p <.001), and kick (r=.31, p= .001).

4.5.4.2. Functional Movement

1st Years – Small positive correlations were found between PMC scores for 1st year participants in the overall composite functional movement score (r=.25, p= .03), the in-line lunge (r= .28, p= .008), and the shoulder mobility (r=.26, p= .01). Moderate positive correlations were found between PMC scores for 1st year participants in the deep squat (r= .31, p= .002), and the trunk stability push up (r= .38, p <.001)

2nd Years - Small positive correlations were found between PMC scores for 2nd year participants in the active straight-leg raise (r= .23, p= .008), deep squat (r= .20, p= .03), hurdle step (r=.23, p= .01), shoulder mobility (r=.23, p=. 01) the trunk stability push-up (r= .23, p= .01), and the overall composite functional movement score (r= .26, p= .01).

3rd Years - Small positive correlations were found between PMC scores for 3rd year participants in the hurdle step (r= .20, p= .03), and the trunk stability push-up (r= .28, p= .003). Moderate positive correlations were found between PMC scores for 3rd year participants in the shoulder mobility assessment (r= .37, p <.001).

4.6. Discussion

The intention of this study was to derive findings on FMS, FMS^{TM}, and PMC to see if an age-related association existed among adolescents. To the author's knowledge, this is only the second study of its kind to combine both actual and perceived fundamental and functional movement assessments among a general adolescent population. Within the current study, no participant across the age range of 12-16 years old demonstrated overall mastery across all seventeen assessed FMS and functional movements. This overall lack of proficiency may suggest that Irish children and adolescents are transitioning to more sport-specific games and skills, without acquiring basic motor competencies (Gallahue et al., 2019; O'Brien et al., 2016a). These movement skill and pattern deficiencies may also help explain the steep decline in both PA and community sport participation among Irish teenagers (Lunn et al., 2013; Woods et al., 2018) as adolescents may be 'dropping out' due to lower skill levels. The high and misaligned perceptions of movement do not appear to be a mediating factor on skill ability, high perceptions which are not reflective of actual ability may in fact be a contributing factor to activity withdrawal, as adolescents look to maintain the illusion of ability to themselves and their peers (Schmidt et al., 2013a).

Data from figure 4.1. would suggest low overall FMS proficiency among participants. Mastery of object-control skills in this study were demonstrably lower than previously published figures among Irish adolescents (Lester et al., 2017; O'Brien et al., 2016a) and Irish children (Behan et al., 2019; Kelly et al., 2019). While performance in the locomotor skills of the run and horizontal jump were below previous Irish standards, both the vertical jump and skip were comparable, or higher than other Irish childhood and adolescent research (Behan et al., 2019; Farmer et al., 2018; Kelly et al., 2019; Lester et al., 2017; O'Brien et al., 2016a). In comparison with global studies, performances in the kick, dribble and balance were lower than previously reported values in British children (Bryant et al., 2014). Participant performance in both the horizontal jump and catch from this study were lower than the previously reported values among Belgian 8-year old children (Bardid et al.,

2016b). In terms of overall gross motor skill proficiency, all FMS scores in the current study were lower than published values among Australian children (Cliff et al., 2012).

The values from table 4.1 indicate that there is no significant age-related association in the growth of FMS. Older individuals often exhibit improved FMS due to increased access to practice, coaching, corrective feedback and greater physical stature, however, FMS improvements are not always age-determined (Charlesworth, 2016; Gallahue et al., 2012). This study's findings are supported by previous Irish research which found an age-related decline in object-control proficiency across the post-primary school years (Lester et al., 2017). More recent Irish findings indicate a 'plateau' of skills from the age of ten, with no further growth in FMS for children aged eleven and twelve (Behan et al., 2019). This is aligned with critical principles of motor development, which suggest motor skills require purposeful practice, and are not a product of maturity (Clark, 2007; Clark & Metcalfe, 2002).

This troublesome lack of growth in FMS will be detrimental to long-term PA and global health, given the aforementioned association between FMS and PA in addition to other markers of health (Cohen et al., 2015; Stodden et al., 2008). Seefeldt's motor proficiency barrier theory similarly affirms this by noting how those who fail to become competent in motor skills will disengage from PA, and demonstrate lower physical fitness capacity (Seefeldt, 1980). This theory has been affirmed in young adult populations (Stodden et al., 2013), and recent research on a cohort of Belgian children has suggested this barrier exists in later childhood (De Meester et al., 2018).

This study presented lower overall composite and individual functional movement values, when compared to previous research conducted among Irish adolescents (Lester et al., 2017; O'Brien et al., 2018), and global adolescent populations (Abraham et al., 2015; Coker, 2018; Kramer et al., 2019). The overall mean value of approximately 12 across the three-year groups is lower than the score of 14. This score of '14' or lower has previously been cited as evidence of movement dysfunction, which may increase propensity for injury (Alemany et al., 2017; Kiesel et al., 2011). The lack of any significant age-related effects on functional movement is notable (table 4.1), given the fact that age has been cited as being a moderate

predictor of performance on the FMS^{TM} among childhood populations (Garcia-Pinillos et al., 2019). The lack of strong functional movement capacity may be due to additional factors, such as postural instability, resulting from extended static periods during schooling (Lester et al., 2017). As functional movement has been linked with improvements in PA behaviour (Duncan & Stanley, 2012; Karuc & Mišigoj-Duraković, 2019), these low values are troublesome and indicate it is imperative to focus on growing functional capacities in physical education and sporting environments to promote efficient and safe movement among adolescent populations. Functional movement exemplifies the definition of MC, as presented by Robinson et al., (2015), in addition to its theorised links with FMS skills (Papaiakovou, 2013; Salles et al., 2011) The strength and mobility elements of the FMS^{TM}, typify movements which are often unaccounted for in MC testing batteries, but ones which warrant inclusion in a broader definition of MC (Hulteen et al., 2018).

Table 4.2 highlights the high PMC values for FMS across all three-year groups. All 10 FMS presented with a mean PMC value above 6 (out of 10). While lower than previously documented Irish values of PMC (McGrane et al., 2016; O'Brien et al., 2018), Table 4.2 further highlights the high PMC values and the lack of significant change in these PMC values across different year groups. A comparable study in Belgium presented moderate relationships between PMC and AMC (De Meester et al., 2016b) . While in the current study, the correlational analysis between object control PMC and object control AMC met the moderate threshold across all years, no other composite score (i.e., overall gross motor or locomotor), or skill did, suggesting that Irish adolescents may possess lower accuracy of assessment, compared to their Belgian counterparts. The 3rd year group did possess slightly more moderate correlations than both other year groups in terms of AMC and PMC associations, however, these findings suggest that there is little consistency in cognitive maturity, and that realistic and accurate perceptions do not emerge as adolescents age, as has been previously theorised (Harter, 1999; Stodden et al., 2008).

Regarding actual functional movements and PMC alignment (table 4.2), lower, aligned, and realistic PMC functional movement values were expected, as the success criteria for performance were shared with participants during assessment, in

accordance with the FMS^{TM} protocol (Cook et al., 2006a). As such, participants may have a greater understanding of what constitutes successful performance for the specific functional movement patterns, and therefore, may be more aware when evaluating their work (Brian et al., 2018; Niemistö et al., 2019). Mean perceived functional movement scores over 6 (out of 10) were found for all patterns, bar the rotary stability. These perceived functional movement values were lower than previous values in the literature (O'Brien et al., 2018), however, there were no significant changes across year groups between actual functional movement proficiency and PMC scores, albeit with the exception of rotary stability. A significant change was found in rotary stability between year groups, with second years possessing significantly lower actual and perceived values than 1st years, and 3rd years, respectively. An expected decline in PMC values with aging is expected (Stodden et al., 2008), which did not generally occur to a statistically significant level across the other movements.

The theoretical assumption of cognitive growth (Harter, 1999; Stodden et al., 2008) suggests a greater degree of alignment between PMC and AMC should emerge across the adolescent years, with greater correlation coefficients emerging across each year group. The 'veridicality' of PMC, i.e. the degree of alignment between perception of ability and actual ability (Schmidt et al., 2013b) does not appear to show linear improvement as participants age, contrary to conventional theories in the field of PMC (De Meester et al., 2016a; Harter, 1999). The lack of improvement in veridicality in this study appears to be consistent across PMC and FMS assessment, and PMC and functional movement assessment respectively.

This study's findings, and those of previous Irish (McGrane et al., 2016, 2018; O'Brien et al., 2018) and international work (De Meester et al., 2016a; Utesch et al., 2018; Van Veen et al., 2020) suggest that high PMC values are common in later childhood and early adolescence. Furthermore, these values may even remain stable with aging, a study of Dutch and German children (n=198; male=110; female- 88; mean age = 9.35± 0.67 years) found no significant differences in their perception of ability a year after their initial assessment, with values still remaining high (Van Veen et al., 2020). This potentially indicates that the theoretical assumption of greater

accuracy of assessing one's PMC as children age, may be flawed. The reasons for this are innumerable, it has been suggested enhanced awareness and social comparisons of their peers may interfere with self-assessment among adolescents (McGrane et al., 2018). The potential for social desirability bias impacting on self-report data should be noted, this is a common problem in PA research, where a disconnect between reported behaviour and actual behaviour exists (Brenner & DeLamater, 2014; Shephard, 2003).

A veridical, i.e. aligned and accurate perception is more desirable as recent research indicates that accuracy in assessment of PMC may be associated with engagement in PA (Utesch et al., 2018). Harter's work within competence motivation theory suggests that high perceptions are quite important, but actual ability and realistic perceptions must remain a key focus when working with youths (Harter, 1982). Interventions designed to boost PMC and nurture accuracy of perception often prioritise developmentally appropriate exercises that focus on FMS deficiencies and enable all participants to achieve success at a level commensurate with their abilities (Bardid et al., 2016a; Lander et al., 2019). A similar approach could be advocated for FMS^{TM} exercises, given that improvements in functional capacity have been shown in as little as six weeks, when incorporated into warm-up exercises for students (Coker, 2018). Furthermore, increased knowledge of the FMS^{TM} testing criteria, as would happen in an intervention with a specific purpose and focus on improving functional movement, has been shown to boost FMS^{TM} capacity (Frost et al., 2015). Improvements in MC, veridicality, and levels of perception have been achieved through effective pedagogy styles taking a student-centred approach (i.e. purposeful, student-led goals, opportunities for reflection, positive reinforcement, appropriately challenging tasks) (Schmidt et al., 2013a, 2013b).

A focus on skill improvements through student-centred activities which promote engagement and understanding are pivotal to increasing AMC and accuracy of PMC among childhood and adolescent populations (Lander et al., 2019; Schmidt et al., 2013a, 2013b). The student-centred approach will nurture actual skill improvements, while promoting the cognitive engagement necessary for students to form a better understanding of skill performances, potentially resulting in more

realistic and accurate PMC scores (Chan et al., 2019; Schmidt et al., 2013b). Veridical and realistic perceptions of ability are critical to accruing PA and improving movement quality, as they are associated with sustained motivation and fulfilment of goals, programmes designed to ameliorate deficiencies in AMC and PMC must take these ideas into account (Horn, 2008; Schmidt et al., 2013b; Utesch et al., 2018). Reducing actual skill deficiencies in addition to promoting veridical perceptions must become a central tenet of future movement programmes predicated on motor development principles.

4.7. Limitations and directions for future research

A potential limitation of this study is that it is cross-sectional in nature. While the sample size, is large, and data were collected from a representative mixture of single sex, mixed-sex and disadvantaged area school populations, all participants were selected from one county in the south of Ireland which may not be representative of Irish adolescents in rural settings or other regions. The use of valid and reliable tools for both perceived and actual motor competence is a strength of the study, however self-report data of perceived motor and perceived functional competence may result in positive response bias or overestimation. The current study does not provide evidence of a causal relationship between motor competence and perceived motor competence. To gain greater insight into this relationship and how it evolves as individuals age, longitudinal or intervention studies with a greater sample size will be required.

4.8. Conclusions

The low level of AMC in both fundamental and functional movement among the Irish adolescent population indicates the need for developmentally appropriate activities, and effective teaching strategies that would ameliorate these movement deficiencies. Continued focus on FMS in both primary school and across the early

second-level school years may be necessary, as deficiencies in FMS are apparent throughout the first three years of second-level school. The use of specialist physical education teachers in primary school physical education or in after-school physical education programmes at the primary level may need to be considered to ensure student enter second level with appropriate FMS ability with current practice of generalist classroom teachers teaching physical education, proving ineffective in developing FMS. High levels of PMC across both FMS and functional movement exist, however there does not appear to be a strong association between PMC and FMS or functional movement among Irish adolescents, nor does there appear to be an age-related association between PMC and AMC. Teaching strategies that clearly elucidate to students how to execute movement skills and patterns will be critical to improving their actual abilities, in addition to their cognitive capacities, and perception of their abilities. Future interventions will need to focus on addressing the movement deficit that is abundantly evident in adolescents, and further creating more realistic perceptions of ability among Irish adolescent youth. Further studies examining the association between PMC and AMC are warranted to explore the presence or absence of cognitive growth as children age, as this current study found no substantial age-related link between PMC and AMC.

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Chapter 5

Effects of an 8-week Intervention Targeting the Veridicality of Actual and Perceived Motor Competence Among Irish Adolescents in Project FLAME

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5.1. Abstract

High levels of perceived motor competence and low levels of actual motor competence in youth populations have been reported world-wide. Both perceived and actual motor competence have been deemed independent correlates of health and physical activity (PA) behaviour, and past research has indicated that their alignment may be linked to more consistent PA. Moreover, there is potential for a movement-based intervention to strengthen the alignment between perceived and actual motor competence, perhaps then guiding future health, PA, and community sport engagement globally. Thus, the objective of this study was to investigate the effectiveness of an 8-week movement-based intervention on increasing the alignment (i.e., veridicality) between PMC and AMC among Irish adolescent youth. We collected data on adolescents (*n* = 324; females= 149; *Mean age*= 14.5 ± 0.88 years) across six second-level schools in Ireland, including measurements of actual and perceived, motor competence at pre- and post-intervention. We observed low levels of actual in contrast to high levels of perceived motor competence. We found a small but significant veridical alignment between perceived and actual motor competence, but there was no intervention effect on alignment. Future research should prioritise a longer intervention duration that targets student learning and understanding in order to develop veridical perceptions in adolescents that might sustain their participation in PA.

5.2. Introduction:

Physical Activity (PA) levels remain low across the globe (Farooq et al., 2020). As low PA levels are associated with a higher degree of obesity, and increased risk of non-communicable diseases, increasing PA levels must become a core part of efforts to improve the health of future generations (Farooq et al., 2020; Mannocci et al., 2020). Within the Irish context, these trends remain prevalent and disconcerting, with only 13% of Irish children meeting current recommendations for 60 minutes of PA per day (Woods et al., 2018). Improving PA levels in adolescents may improve their mental health and bone mineral density (Faienza et al., 2020; Murphy et al., 2020). Actual Motor Competence (AMC), refers to any form of goal-directed human movement**,** and it is a crucial component to physical health and wellbeing (Bardid et al., 2019; Robinson et al., 2015). AMC is viewed as a critical contributor to long-term PA participation, and high levels of AMC have been associated with greater cardiorespiratory and health-related fitness (Cattuzzo et al., 2016; Lubans et al., 2010). There is also strong evidence that a healthy weight status is linked with improved AMC**,** and unhealthy weight status can act as an antecedent or a consequence of poor AMC (Engel et al., 2018).

While AMC proficiency levels vary by region, common findings indicate that young children currently possess below par movement skills compared to children of previous generations (Bolger et al., 2021)**.** Mean scores for AMC in global research are consistently close to the mid-way point for targeted expectations, in China (*n* = 282; *Mean age=* 8.4 ± 0.56 years, Chan et al., 2018), and cross-culturally (*n* = 358; 191 males; 167 female; Mean age= 8.35 ± 0.65 years), based on a study conducted in Germany and Australia (Tietjens et al., 2020). Weaker results were found in Brazil (*n* = 2,337; 1,194 male, 1,183 female*;* Mean age= 7.4 ± 1.9 years), where less than half of the children between the ages of 3 to 10 years demonstrated proficiency across all locomotor skills (run, gallop, hop, leap, jump, slide) and object-control skills (strike, stationary dribble, catch, throw, underhand roll) (Valentini et al., 2016). In contrast to children, global studies of adolescents are not widespread; however, there is recent troubling evidence of subpar AMC proficiency among adolescents

(Lander et al., 2017a; O'Brien et al., 2016) who would be expected to possess higher AMC levels (Barnett et al., 2016).

Philpott et al (2020) recently examined age-related AMC associations in Irish adolescents (*n* = 373; Mean age = 14.38 ± 0.87 years) and further supported the stagnation of basic AMC with proficiency levels above 40% only evident for two skills - the run and the catch (Philpott et al., 2020). Undeveloped AMC among Irish adolescents may contribute to declines in their PA behaviour in both their adolescence and adulthood (Lester et al., 2017; Lunn et al., 2013).

The influence of perceived motor competence on AMC and PA habits must also be considered, especially in light of emerging evidence of their connection (Tietjens et al., 2020). Perceived Motor Competence (PMC) refers to a person's belief in their ability to perform goal-directed human movement (i.e., their estimation of their own level of AMC) (Estevan & Barnett, 2018). In early theoretical constructs of PMC and physical perceptions (i.e. Competence Motivation theory) higher levels of perceived competence were desirable, as high perceptions were associated with greater task persistence and motivation for PA (Harter, 1978). High self-perception levels have been associated with greater motivation and PA engagement, and greater motivation for physical education participation in recent studies (Estevan et al., 2020; Harter, 1978). While there is some evidence that higher levels of overall PMC are associated with PA (Visser et al., 2020), stronger associations were found specifically between object-control related PMC and PA (Slykerman et al., 2016). Notably, in global research, overestimation of personal competence has been commonplace among children and adolescents (Rogers et al., 2018; Van Veen et al., 2020), and it has been problematic, as it may lead to dangerous risk taking culminating in injury, and has been associated with lower levels of PA, compared to accurate estimations of ability (Schmidt et al., 2013b; Utesch et al., 2018). Irish children and adolescents have similarly been found to have high PMC**,** despite their low levels of AMC (O'Brien et al., 2018; Philpott et al., 2020) with similar findings reported globally across different physical self-perception toolkits such as the Physical Self-Perception Profile, the Self-Perception Profile for Children, and the Pictorial Movement Scale for Children (Barnett et al., 2008; Rogers et al., 2018; Vedul-Kjelsås et al., 2012).

Consistent findings of high levels of perceived competence across these toolkits have led researchers to question the alignment between perception toolkits and AMC tests (Estevan & Barnett, 2018). New research examining this alignment of PMC and AMC values, known as 'veridicality' has now emerged (Clark et al., 2018).

Veridicality, in this context, relates to the accuracy or alignment of perceived and actual motor competence (Schmidt et al., 2013a, 2013b). Concurrent research has suggested that the accurate estimation of AMC may form a key role in consistent PA participation (Morano et al., 2020; Utesch et al., 2018). Veridical perceptions have also been associated with higher levels of achievement motivation (i.e., a desire to meet goals) and persistence toward success (Horn, 2008).

Researching the accuracy of PMC in relation to AMC has been cited as a critical new need (Clark et al., 2018; Morano et al., 2020). Given a relative paucity of research on adolescents in relation to PMC (De Meester et al., 2020; Lander et al., 2019), applying veridicality research to this age group is also important, as the adolescent period is fraught with frequent dropouts from sport and PA participation (Bryant et al., 2014; Lunn et al., 2013). Adolescent cognitive development has led some to predict greater accuracy of PMC (De Meester et al., 2020; Stodden et al., 2008), but overestimation of personal AMC within this age group has been very common (Philpott et al., 2020; Rogers et al., 2018). In this context, our purpose, in this research, was to investigate the effectiveness of an 8-week movement-based intervention on increasing the veridicality between PMC and AMC among Irish adolescents. We hypothesised that adolescents' enhanced cognitive development would contribute to their improved veridicality.

5.3. Materials and Methods

5.3.1 Study design and participants

Data were collected pre- and post-intervention as part of a larger randomised controlled trial (RCT) with Irish adolescents focusing on AMC. Ethical approval for this study was granted by the Social Research Ethics Committee at University College Cork (UCC Ethics log code "Log 2018-169", November 2018). Post-primary schools were

invited based on the following minimal inclusion criteria: (a) qualified physical education teachers on staff; (b) first-year, second-year and third-year classes of adolescents (age 12–16 years old); (c) participants taught physical education for a minimum of 80 consecutive minutes each week; and (d) all schools had access to a gymnasium hall. One class from years 1 to 3 across each school was randomly selected by the school principal and physical education teacher(s) for participation. Schools were pair matched (Belton et al., 2019) prior to data collection on the following criteria: socioeconomic status (disadvantaged; non-disadvantaged); gender (single-sex boys; single-sex girls, mixed gender); facilities (physical education hall and outdoor pitches) and school size (small: 0–299 students, medium: 300–599 students, and large: 600+ students).

This process resulted in three school pairs equally matched, two large single-sex boys non-disadvantaged schools, two medium single-sex girls non-disadvantaged schools, and two small mixed-gender disadvantaged schools across Cork city, in the province of Munster in Ireland. A randomisation process was conducted following participation agreements from the school. From the resulting pairs, one school in each pair was randomly allocated to either the control group or the intervention group prior to pre-test participation using a random number generator (Belton et al., 2019). As other variables were kept constant, any differences in the constant variables between these groups was likely to be caused by the intervention (Hariton & Locascio, 2018).

Subsequent to the approval granted by school principals and teachers, consent forms and information sheets were distributed to each respective class group. Informed parental consent and child assent were required before any adolescents could partake in the study. Both schools and participants were informed that participation was entirely voluntary, and they were free to withdraw of their own volition at any time. In terms of the research rigour inherent to school-based measurements, it is important to note that the principal investigators for this study were qualified post-primary school specialist physical education teachers, as recognised by the Teaching Council of Ireland.

Consenting post-primary school students from years 1 to 3 (age range: 12.23-16.37 years), participated in the project. Across the six schools a total of 488 students were eligible to participate. Final consent and full attendance were provided by 324 participants at pre-intervention testing (females= 45.9%; Mean age 14.5 ± 0.88 years; 66.4% of full sample) and by 243 at post-intervention testing (retention rate of 75%).

5.3.2. Intervention design

Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) is a multi-component school-based movement-oriented intervention targeting AMC and functional movement. FLAME is theoretically underpinned by the developmental model of motor competence which proposes that PMC, AMC, and PA are interconnected and work in a spiral fashion to promote positive or negative health outcomes (Stodden et al., 2008). In this theoretical model, improving AMC will develop PMC, and PA and ensure a continuous positive spiral culminating in the attendees' healthier weight status and better levels of physical fitness. More veridical perceptions of motor competence may also emerge when targeting AMC, as may the association between improved veridicality and sustained PA (Stodden et al., 2008; Utesch et al., 2018). The Project FLAME intervention consists of four critical components designed to develop AMC and improve veridicality (see Figure 5.1): (a) Teacher component, (b) Student component, (c) Whole-School component and (d) Digital component.

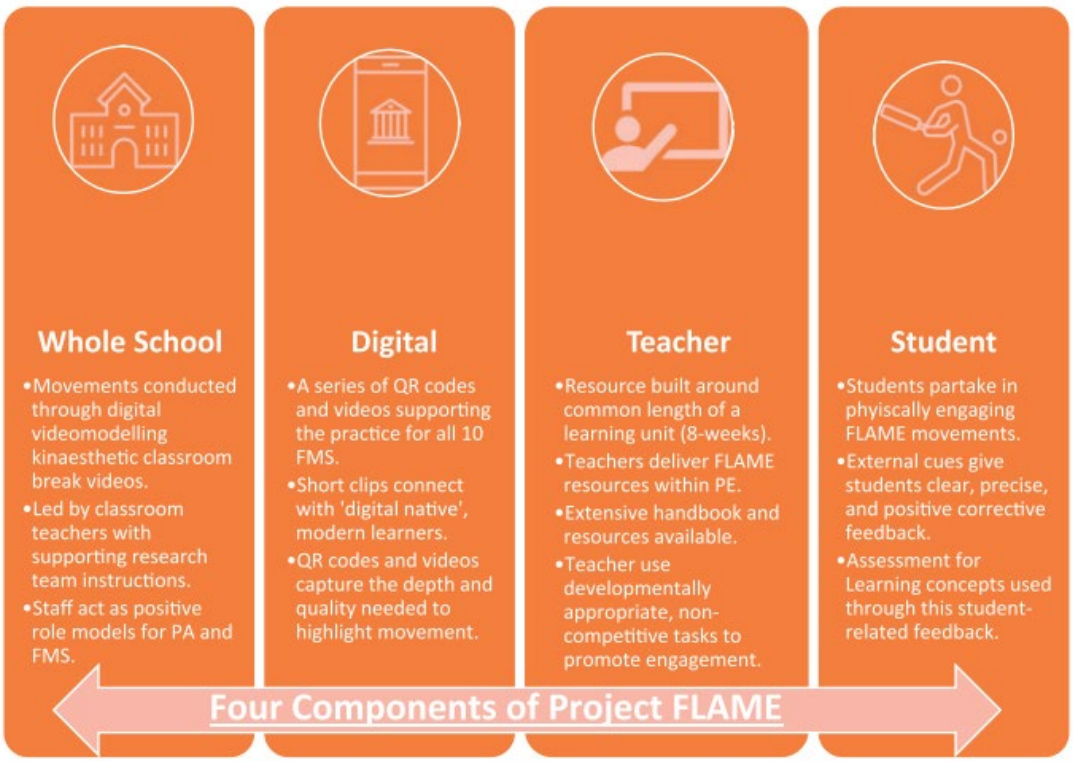


Figure 5.1: Four Components of Project FLAME: Whole-school, Digital, Teacher, and Student

5.3.3. Teacher component

Prior to the intervention, specialist physical education teachers received a total of four hours of professional development from the research team in how to deliver the intervention within the physical education class. The comprehensive training encompassed many different aspects. Information was shared to teachers on the importance and benefits of FMS, as well as some practical demonstrations of how to use the FLAME exercises and showcasing the FLAME training videos and what they looked like in practice as well as how they could be utilised with a large group of students. Further training was designed to illustrate to teachers how Assessment for Learning principles could be utilised through positive constructive feedback being implemented and utilised within the classroom. Finally, a copy of the Project FLAME handbook was provided to teachers in addition to a thorough overview on how to utilise it and how it could assist planning during the intervention and for further

planning in physical education. The handbook contained meticulous details on how to use the resources, an activity planner section, and details of how each movement aligns to the physical education curriculum. Critically, this training provided regular support (mid-intervention meetings, in addition to WhatsApp messaging threads and email conversations with all intervention schools) for physical education teachers during the intervention process. The training sessions aimed to find the correct balance between consuming too much of the teachers' time and providing sufficient detail for teachers to lead the intervention and utilise the handbook materials confidently.

FLAME activities were designed for 20-minute sections to permit seamless integration into standard 80-minute physical education lessons. The research team recommended that activities be incorporated at the start of lessons, but teachers could integrate them as they saw fit. As FLAME was devised by practicing physical education teachers (research team), there was high importance given to creating a practical and sustainable intervention to implement in physical education without extensive oversight from the researchers. The 8-week intervention duration was selected to make the project feasible for teachers to operate as a learning unit, as this is the maximum length of learning unit that was recommended to physical education teachers during previous continuous professional development work (Department of Education and Skills, 2018). This rationale is supported in systematic reviews which deemed the ecological validity and sustainability of interventions in schools without researcher support to be a key consideration of AMC and PA-related school projects (Lai et al., 2014; Ma et al., 2021).

5.3.4. Student component

Students serve as active components of Project FLAME through their participation in its activities and games, while student-centred pedagogical tools are also employed to assist learning and development. The FLAME element of external cues is a novel and effective way of developing skills in young children and athletes (Abdollahipour et al., 2017; Pascua et al., 2015). External cues were provided for each of the movements assessed in the project. An external cue focuses less on the inner

mechanics of a movement (i.e., Knee flexed at 90 degrees), and relates instead to the effect (i.e., 'act like you are balancing a cup of tea on your knee, try not to spill it!') or the outcome of the movement (Wulf, 2013). External learning cues have been shown to be effective for developing numerous motor skills, including throwing, underarm rolling, sprinting, jumping, and balancing (Abdollahipour et al., 2017; Pascua et al., 2015; Wulf, 2013). This external emphasis also recalls elements of Assessment for Learning (AfL), as it allows teachers to provide students with simple, positive, constructive feedback on how to improve their AMC with such assessment critical to post-primary Irish curricula and modern physical education classes (Black & Wiliam, 2010; Department of Education and Skills, 2015; Tolgfors, 2018).

Students' improved AMC and increased knowledge of their own movement ability achieved through providing informed feedback was expected to improve veridicality. Increased knowledge and understanding of a topic has been linked to improved levels of actual ability and greater ability to engage in self-evaluation in many diverse fields (Dunning & Helzer, 2014; Kruger & Dunning, 1999).

5.3.5. Whole-School Component

A whole-school interdisciplinary approach to learning is deemed best practice in current Irish post-primary education (MacPhail et al., 2018). In keeping with this theme in this study, teachers and principals were encouraged to collaborate and connect with physical education colleagues to foster positive attitudes towards PA and motor competence development through a series of 'kinaesthetic classroom' videos that utilised digital video modelling by members of the research team to promote AMC. General classroom teachers could use these videos, of the research team partaking in different activities, in any classroom setting to provide support and encourage students to participate in motor skill related activities and improve their skills. This video modelling concept has previously demonstrated success in boosting AMC with younger children (Bulca et al., 2020).

5.3.6. Digital component

The electronic/hardcopy handbook contained 50 videos and activities across all 10 AMC skills assessed by the project with unique QR codes (i.e., Quick Response codes, serving as weblinks to activities and games) and visual external learning cues for each movement. The QR codes were situated alongside activity diagrams in the handbook, providing practical examples of activity development tasks and games. QR codes provided physical education teachers with immediate access to the suite of skill development tasks and games through a smartphone or tablet which could then be projected onto a large screen in the physical education hall if desired.

5.3.7. Data Collection Methods

Prior to data collection, all undergraduate, pre-service or graduate physical education teachers underwent 3-hour field researcher training on the AMC and PMC measurement protocol. This training involved an objective, criteria-informed process to ensure that field staff were consistent in administering the measurements. On data collection days in various schools, research assistants demonstrated their ability to comply with the AMC and PMC protocols to the principal investigators prior to the arrival of study participants. Additionally, field staff were given a descriptive research handbook detailing the protocols associated with all data collection phases. Pre- and post-intervention test data were collected with participants in their respective class groups (maximum n = 27). All measurements (AMC, self-report PMC questionnaires) were completed during a typical physical education class (duration range 80 minutes).

5.3.8 Measures

For the AMC measurements, Apple iPads on a fixed stanchion recorded each participant's execution of the requisite skill. Camera positioning and angles were kept consistent at all times to ensure capture of total body movement (O'Brien et al., 2016). Pre-testing (i.e., baseline data before the intervention) commenced in Jan/Feb 2019, and post-intervention data collection occurred in May 2019. Between January and May, students in the control schools continued with their regular physical education lessons, independent of Project FLAME, while students in the intervention schools participated in physical education lessons with a Project FLAME focus on the three active FLAME components (digital, teacher, and student) within a whole-school context with the kinaesthetic classroom.

5.3.8.1 Actual Motor Competence (AMC)

AMC is a frequently cited global or umbrella term that reflects a variety of previously published terms in relation to human movement (Robinson et al., 2015), including fundamental movement skills (FMS) (Logan et al., 2018). Ten FMS, the "building blocks" of sporting engagement and lifelong PA (Logan et al., 2018), were assessed in this study in three separate categories: locomotor (i.e., vertical jump, horizontal jump, run, skip, maximum score = 34), object control (i.e., catch, kick, two-handed strike, overhand throw and stationary dribble maximum score = 40) and stability (i.e., balance, maximum score = 10).

The Test of Gross Motor Development (TGMD) (Ulrich, 1985), TGMD-2 (Ulrich, 2000) and skills from the Get Skilled Get Active Resource (Victoria Department of Education, 1996; New South Wales Department of Education and Training, 2000) were used to assess these FMS. Moderate to excellent construct validity and reliability has been established for the TGMD-2 with children (Barnett et al., 2014; Cools et al., 2009; Rey et al., 2020). Though not commonly used with adolescents, subsequent validity work for the TGMD-2 has deemed its usage with adolescents acceptable with good-to-excellent reliability values, and a good fit

following confirmatory factor analysis reported in a previous study (Issartel et al., 2016). Skills included in the Get Skilled Get Active resource have formed a part of the Victorian FMS manual which has shown acceptable reliability and validity among both childhood and early adolescent groups, and the skills included are deemed a 'benchmark' assessment for Australian adolescents (Lander et al., 2017b; Victoria Department of Education, 1996; New South Wales Department of Education and Training, 2000). At the beginning of each data collection session, participants were informed about the FMS testing procedures (i.e., the first performance being practice and the second and third trials being recorded). Field researchers first demonstrated accurate skill technique once for participants to observe. No feedback was given during or after performances of any skill. This measurement protocol was consistent with previous Irish adolescent FMS research (O'Brien et al., 2016; Philpott et al., 2020).

5.3.8.2. Perceived Motor Competence (PMC)

The McGrane et al., (2016) Physical Self-Confidence Scale is the first valid and reliable instrument for assessing adolescents' physical self-confidence at a skill-specific FMS proficiency level. This Likert scale measurement tool has shown excellent test-retest reliability (r = 0.92) and possesses good content and concurrent validity (r = 0.72) (McGrane et al., 2016) when compared to the Physical Self-perception Profile (Fox, 1990). The Physical Self-Confidence Scale (McGrane et al., 2016) was modified in this study to measure participants' PMC for their FMS proficiency by altering the question stem from "how confident are you at performing" to "indicate how well you can perform ____ (e.g., kick)." In this modification, we followed expert advice and recent research regarding the alignment of test batteries (De Meester et al., 2020; Estevan & Barnett, 2018). Referring to competence ensured better alignment with past research in PMC and reduces a problem within PMC research of "definitional blurring" that occurs when unclear alignment between measurement tools and constructs leads to incorrect data interpretation assumptions (Shearer et al., 2018).

Within this PMC scale, participants were asked to rate their competence at performing the 10 FMS, based on a 1-10 Likert scale in which "1" indicated being not competent at all and "10" indicated being very competent. Participants completed the PMC questionnaire item by item separately and independently from other participants after they performed each FMS test. They returned to the group after completing the relevant question. The 10 FMS selected for AMC and PMC testing were selected due to their critical role in Irish sporting and physical education cultures (O'Brien et al., 2016). Among participants in the current study, a Cronbach's alpha coefficient showed good internal consistency for the PMC scale (Cronbach alpha coefficient of 0.84 overall, 0.73 for the object control subscale, and 0.80 for the locomotor subscale). The PMC questionnaire participant responses were collected via pen and paper, and later entered into statistical programming software by the research team.

5.4. Data Processing and Analysis

Prior to the FMS data scoring, we established inter- and intra-rater reliability using 10% of the data set. Two raters (principal investigators) double coded this data subset to determine both their intra-rater reliability and their interrater reliability (Logan et al., 2017). They were required to reach at least 95% intra- and inter-rater agreement for all 10 FMS. Each rater then coded half of the full dataset. All data analyses were completed with JASP (JASP Team, 2020), SPSS version 25.0 for Windows, R Software (Version 4.0.2, www.r-project.org) and RStudio Software (Version 1.3.1056, www.rstudio.com), primarily using the package *nlme* (Pinheiro et al., 2021) and *tidyverse* (Wickham et al., 2019). We set the statistical significance level at $p < .05$.

We calculated descriptive statistics for FMS at both the individual skill and composite score levels. These data were normalised on a 0-1 scoring basis and are presented in the tables below such that a score of 1 reflected a maximum score of 84 (i.e., all 10 FMS skills mastered – meeting all performance criteria - across two trials). All PMC data is presented in terms of its raw overall value with a minimum score of 10 and a maximum score of 100 across the ten movements. We calculated any differences between the control and intervention participants groups at pre-

intervention using Bayesian independent t-tests with a Cauchy prior. Bayes Factors (01) for the test of equality (i.e., no difference) indicate the ratio of the probability of no difference between control and intervention group. We determined the strength of the analysed relationships (i.e. small, moderate, large) using the Cohen's (1988) guidelines in which a standardised beta coefficient of $\beta = 0.10 – 0.29$ denoted a small correlation, $\beta = .30 - 0.49$ denoted a moderate correlation, and $\beta \geq 0.50$ denoted a strong correlation, respectively (Cohen, 1988). To analyse the effect of the main hypothesis of improved veridicality, we calculated multilevel regression models with time observations on level 1 that were nested in persons on level 2. We conducted complete cases analysis in order to examine whether between-group effects differed from the intention to treat data analysis. PMC was the dependent variable, while individual variation of children's level of PMC was allowed by adding a random intercept to the model. Different models were calculated in order to analyse the veridicality effect. First (model 1), only AMC was added to the model predicting PMC in order to analyse the strength and the direction of the association between PMC and AMC scores. Second (model 2), age and sex were added in order to control for these variables. In model 3, the treatment (intervention) interaction term with AMC was added. In model 4, we added the interaction of AMC, the treatment and time (pre-post).

5.5. Results

Overall, 486 children (48.5% female; Mean age = 14.50 ± 0.88 years) from six schools participated in at least one AMC or PMC test at pre- or post-intervention. Table 5.1 shows their demographic and pre-test characteristics by intervention or control group membership. Descriptive statistics for participant's

primary outcome measures by group at pre- and post-intervention can be found in Table 5.2. There was no significant difference at pre-test between intervention and control groups on either AMC (Bayes Factor = 7.6:1 probability of no difference) or PMC (Bayes Factor = 5.58:1 probability of no difference).

The hypothesis of improved veridicality from the intervention was analysed using multilevel models. Table 5.3 shows summaries of the modelling process. Initial veridicality data in model 1 (i.e., just AMC and PMC veridicality) indicated a significant small correlation between these variables at post-intervention (β = .24, p < .001). After controlling for age and sex in model 2, a significant and robust small effect (β = .23, p < .001) was still evident. However, model 3 revealed no significant intervention effect on the veridicality between AMC and PMC. Similarly, in model 4, there was no significant intervention*time effect. However, general veridicality was still shown by a small effect in all four models. Neither the intervention nor the 8-week time period between pre- and post-testing were associated with a greater relationship between PMC and AMC scores. As a further result, across all models, age showed no significant effect on PMC, but there was a gender effect on PMC (β = .53, p < .001).

Table 5.1. Demographic and Pre-test Participant Characteristics in Intervention and Control Groups.

						Body Mass	
Treatment	Gender	N	Age		N	Index	
Control			Mean	SD		Mean	SD
	Female	95	14.28	0.85	78	21.18	3.32
	Male	107	14.34	0.91	101	21.01	3.80
Intervention	Female	95	14.27	0.89	72	20.96	3.04
	Male	92	14.63	0.79	63	20.23	2.95

Note: N= Number of participants; M= Mean value; SD = Standard deviation

Table 5.2. Mean Actual and Perceived Motor Competence Scores at Pre- and Post-Testing for Male and Female Participants.

				Actual Motor Competence				Perceived Motor Competence			
Treatment	Gender			PRE		POST		PRE		POST	
Control	Female	N		80		33		70		35	
		M	SD	0.76	0.07	0.77	0.06	70.04	14.68	74.71	16.23
	Male	N		93		87		88		75	
		M	SD	0.78	0.07	0.81	0.06	80.48	8.97	84.95	10.41
Intervention	Female	N		69		76		74		69	
		M	SD	0.76	0.08	0.79	0.08	76.19	11.57	77.74	11.12
	Male	N		82		47		68		51	
		M	SD	0.78	0.07	0.81	0.06	77.84	11.82	78.00	14.66

Note: N= Number of participants; M= Mean value; SD = Standard deviation. Actual Motor competence scores range from 0 to 1 after normalising process, with Perceived Motor Competence ranging from 10-100.

Table 5.3. Results of the Four Multilevel Regression Models.

	Model 1			Model 2			Model 3			Model 4		
Predictors	*β*	*CI*	*p*	β	*CI*	*p*	β	*CI*	*p*	β	*CI*	*p*
Fixed Effects												
(Intercept)	-0.03	-0.13 – 0.07	<.001	-0.30	-0.45 – -0.16	<.001	-0.36	-0.54 – -0.17	<.001	-0.37	-0.55 – -0.19	<.001
AMC	**0.24***	0.16 – 0.32	<.001	**0.23***	0.15 – 0.31	<.001	**0.22***	0.11 – 0.33	<.001	**0.20***	0.09 – 0.31	.003
Sex				**0.53***	0.33 – 0.73	<.001	**0.54***	0.34 – 0.75	<.001	0.57	0.36 – 0.77	<.001
Age				-0.04	-0.13 – 0.06	.469	-0.04	-0.14 – 0.05	.370	-0.09	-0.19 – 0.01	.093
Treatment							0.09	-0.11 – 0.30	.900	0.10	-0.10 – 0.31	.931
AMC*Treatment							0.02	-0.14 – 0.17	.815	-0.01	-0.17 – 0.15	.870
Time										0.08	0.01 – 0.15	.883
AMC*time										0.01	-0.07 – 0.10	.746
Treatment*Time										0.03	-0.08 – 0.13	.629
AMC*TREATMENT*TIME										-0.03	-0.15 – 0.09	.655
Random Effects												
σ2		37.71										
τ00		107.40										

*β = Beta Coefficient; Beta values represent the strength of the relationship between variables. *= p<.001; AMC= Actual Motor Competence; Perceived Motor Competence; CI= Confidence Interval*

5.6. Discussion

The purpose of this study was to examine pre- and post-intervention veridicality between adolescents' PMC and AMC with the hypothesis that a movement-based intervention would improve it. To the author's knowledge this was the first study to focus on AMC and PMC alignment in an Irish context, and it must be noted that this randomised controlled trial highlighted a lack of AMC proficiency despite high levels of PMC among Irish adolescents. With regard to our main hypothesis, we found no significant intervention effect for improving the veridicality of the AMC / PMC relationship.

At pre-test, there was no difference between the intervention and control groups on either PMC or AMC. The veridicality between AMC and PMC in our large adolescent sample was small but statistically significant at post-intervention. While the observed value was low, correlations in the small to moderate range are commonly found within adolescent research samples (De Meester et al., 2016; Rogers et al., 2018). A previous study among Belgian adolescents, (*n* = 215; 66.0% boys; Mean age = 13.64 ± .58 years) reported a moderate correlation, while a comparable Australian study (*n* = 173; Mean age= 12.48 ± .34 years) similarly reported a small correlation between FMS and PMC (De Meester et al., 2016; Rogers et al., 2018). The intervention did not lead to statistically significant improved veridicality between PMC and AMC**,** possibly because 8-weeks was too short a period for this intervention to effect veridicality by invoking requisite changes in participants' skills and perceptions. While short-duration interventions (i.e., 6-weeks) have previously successfully developed both PMC levels (and more general physical self-perceptions) and AMC levels (as separate constructs), it would appear that greater time is needed to improve their mutual alignment (Bryant et al., 2016; Burgess et al., 2006).

Prior interventions examining improvements and/or alignments in perceptions have typically lasted between 10-12 weeks (Lander et al., 2019; Schmidt et al., 2013b). The Lander et al., (2019) intervention utilised 12 sessions of 90-minute PE lessons over

12 weeks, while the Schmidt et al., (2013b) intervention implemented 20 sessions of 45 minutes of PE over ten weeks (Lander et al., 2019; Schmidt et al., 2013b). This suggests that future initiatives of Project FLAME should aim for an increase in the number of weeks of the programme and the number of sessions. An additional 4 weeks to the current 8-week programme should be the minimum target set based on insight from this research (Lander et al., 2019; Schmidt et al., 2013b). While intervention tasks in this study prioritised engagement in PA and AMC, further intervention refinement may be necessary to include more fun and social interaction which might precipitate greater autonomy, and self-reflection. Such tools have proven effective in previous AMC and PMC-related interventions among adolescent youth (Morgan et al., 2012). A change in pedagogical methods might also be necessary in order to invoke the realistic self-perceptions that are essential to longer-term sport and PA participation (Lander et al., 2019; Schmidt et al., 2013b).

Given the minimal influence of age on veridicality of PMC and AMC among participants in this and previous studies, it seems possible that self-perceived motor competence (though remaining high) stabilises developmentally when approaching adolescence (Philpott et al., 2020; Van Veen et al., 2020). More data from adolescent samples is required to examine whether AMC / PMC alignment improves during this juncture, though a recent meta-analysis reported no significant effect of age on this relationship or on other measures of physical self-perception (De Meester et al., 2020). It seems possible that young people reach a 'plateau' of self-perception, whereby perception values remain consistently high and are hard to change during the adolescent period (Philpott et al., 2020; Rogers et al., 2018).

As PMC levels have been consistently high and alignment between PMC and AMC across studies has remained in the small to moderate range, it seems to remain essential to target improvements in AMC with intervention programs (De Meester et al., 2020). Studies that have examined AMC / PMC alignment following intervention are limited in number. However, an AMC focus with strong student-centred learning methods successfully improved the relationship between measures of strength and physical self-

perceptions among Swiss adolescents (n = 246; Mean age = 11.00 ± .56 years) through a teaching method known as the individualised teacher frame of reference (Schmidt et al., 2013b). This pedagogical style included positive feedback, student journaling, self-reflection, and self-directed learning for muscular strength and endurance work (Schmidt et al., 2013b). The intervention had a significant effect in improving veridicality between physical self-concept and actual strength among both over-estimators and under-estimators from baseline to post-test (Schmidt et al., 2013b). It would appear that improved ability combined with greater participant understanding and learning, developed through more student-centred approaches, could be key to improving AMC / PMC veridicality (Lander et al., 2019; Schmidt et al., 2013b).

A gender effect for PMC (see Table 5.3), with males recording higher values than females was found, and greater AMC / PMC veridicality was reported among males in comparison to females. It has been common in past studies too for males to report higher PMC, with such findings reported in Chinese, Finnish, and cross-cultural (i.e., German-Australian) studies (Chan et al., 2018; Niemistö et al., 2019; Tietjens et al., 2020). Reasons for disparate gender perceptions are believed to be primarily sociological (Tietjens et al., 2020). Female PA is often less prioritised or promoted by society than male PA, resulting in lower social support (from peers or family), encouragement, and opportunities for girls to be active, to develop competence, and to experience positive feelings that might spur sport participation (O'Brien et al., 2021). Differing social priorities often mean that females bond and socialise in non-sporting or physically active settings, when compared to males, for whom sport settings appear pivotal in the formation and identification of peer relationships (Timler et al., 2019). These influences on female perceptions may account for females feeling more marginalised and less capable of performing motor skills (Horn, 2018).

High levels of PMC and other forms of physical self-perception are common among adolescents (Lander et al., 2019; O'Brien et al., 2018), and this pattern was found in this study, with mean PMC values across pre- and post-intervention measures among both males and females above 70 (on a scale with a maximum score of 100). While

participants' PMC values were exceptionally high, no participant in our sample at pre- or post-intervention testing actually mastered all 10 of our measured FMS even though separate research showed these capacities to be evident from the age of six (Gallahue et al., 2019). Low AMC and high PMC findings from this and other studies suggest that overestimation of AMC (i.e. high levels of perception, not matched by actual skill ability) is an important contributor to the lack of AMC / PMC veridicality (O'Brien et al., 2018; Philpott et al., 2020). High levels of perception are quite common across the globe, with this 'overestimation' issue reported among childhood and adolescent studies across different measures of perception in regions such as Norway, Australia, and Spain (Estevan et al., 2020; Lander et al., 2019; Vedul-Kjelsås et al., 2012).

High PMC values can be beneficial and have been associated with greater inclinations for PA, participation in physical education, and higher levels of well-being (De Meester et al., 2020; Estevan et al., 2020; Visser et al., 2020). The sensitive adolescent period, fraught with personal, social, and biological changes, may account for this tendency to overestimate personal motor competence as adolescents seek to preserve a confident image in front of peers (Estevan et al., 2021). Promoting veridical alignment with high levels of PMC and high AMC would appear to be critical. High levels of PMC unsupported by actual competence can have negative consequences in that this non-veridicality has been associated with lower levels of PA (Utesch et al., 2018).

Examining future trends and directions in the area of PMC and veridicality, it seems probable that developing a greater understanding and knowledge about movement and skills may be inherent to more aligned perceptions (Lander et al., 2019). Improved accuracy in alignment has long been theorised to be a pivotal component of improved motivation towards PA (Harter, 1982; Stodden et al., 2008). To develop more realistic perceptions, knowledge and understanding would appear to be critical as informed by the Dunning-Kruger Effect (DKE). The DKE suggests that those lacking competence are often unaware of their ability level or falsely assume they possess greater ability than their actual capacity (Kruger & Dunning, 1999). The poor AMC levels recorded in this study, and others globally suggests that children and adolescents do not

clearly understand what it means to perform various skills at the optimal level. While not yet researched within the AMC / PMC field, it is possible that the DKE is influencing findings of high PMC and low AMC. Study participants with low levels of AMC may be unable to accurately quantify and understand what constitutes a high movement ability, leading them to overrate their actual skills. Thus, improving participants' movement awareness, knowledge and understanding may be an alternate route toward improved AMC / PMC veridicality, as those with higher ability are more realistic in their evaluations of their own skills (Kruger & Dunning, 1999). Additionally, a focus on the DKE may be pivotal for further refinements within the Project FLAME intervention (Lander et al., 2019; Philpott et al., 2020).

5.7. Limitations and Directions for Further Research

A limitation of this study is that all participants were selected from a single county in the south of Ireland in an urban setting making them potentially unrepresentative of Irish adolescents (and adolescents in other countries) from rural backgrounds. Secondly, we did not monitor the fidelity of the FLAME intervention in the schools during the practice sessions because we sought to mimic an authentic school environment. Though we did use a follow-up questionnaire completed by teachers, possible insufficient adherence to our intervention protocol is a limitation that should be corrected in future research. Additionally, PMC self-report data in this study and in others may have been susceptible to a positive response bias that was not managed through instrument validity scales. Future investigators might utilise social desirability scales to help determine the influence of this variable. This study indicates that longer duration interventions (aiming for a minimum of 12 weeks, with 1 session a week) with a key focus on skill development are required to positively impact veridicality among adolescent youths. Further implications for future research include the need to increase intervention length, provide greater student autonomy and responsibility to improve their engagement and motivation in intervention participation. Finally, the cross-sectional nature of this research limits the ability to make inferences regarding causal

relationships between the variable of interest. To gain greater insight into the relationship between PMC and intervention-manipulated AMC, longitudinal research designs would be ideal.

5.8. Conclusion

In this study it was documented that Irish adolescents, like those from other countries, tend to exhibit low levels of AMC and high levels of PMC. Our hypothesis was that overestimation of motor competence relative to actual motor competence, rife among adolescents, might be ameliorated with a targeted physical education intervention in Project FLAME. The intervention did not result in significant improved veridicality between PMC and AMC values possibly because of its length. In the discussion, the possibility of developmental stabilisation of high PMC during adolescence, possible bases for gender differences in AMC / PMC, and the possible role of a distorted awareness and understanding of personal movement skills among adolescents that might be an alternate or adjunct intervention target for future investigators, and several specific limitations of this study are all outlined.

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Chapter 6

Validity and Reliability of the Project FLAME Perceived Movement Competence Scale in Irish adolescents.

6.1. Abstract:

This study aimed to establish the reliability and validity of the Project Flame Perceived Movement Competence Scale, a new tool, targeting Irish adolescents in post-primary physical education classes aged between 12-16. Concurrent validity and internal consistency between the Project FLAME Perceived Movement Competence scale (PF-PMC) and the pictorial scale of Perceived Movement Skill Competence (PMSC) was assessed with a sample of 147 participants (63 female; mean age 13.61 ± .93 years). A subsample of 106 participants (n= 54 female) partook in the 7-day test-retest reliability of the PF-PMC scale. Concurrent validity reported a positive association between overall PF-PMC and PMSC scores, with a strong overall relationship between both measures observed ($r = 0.83$, $p<.001$) suggesting the tool may be fit and appropriate measurement tool for use among Irish adolescents. An excellent internal consistency score of 0.85 was reported at the overall PF-PMC level. An excellent intra-class correlation value was reported across the 7-day test-retest reliability of the PF-PMC measures at the overall level with an ICC value of 0.87. Findings support the validity and reliability of the PF-PMC scale for measurement among Irish children within physical education settings. The PF-PMC scale may be an appropriate tool for future research, with further cross-sectional and longitudinal research among different adolescent groups warranted to support its usage.

6.2. Introduction

Fundamental Movement Skill (FMS) competence, referring to the ability to perform rudimentary movements such as jumping, running, and kicking, have frequently been theorised and reported to be a precursor to long-term participation in physical activity (PA) (Graham et al., 2022; Lubans et al., 2010; Stodden et al., 2008). FMS are often thought of as either a subset of motor competence (MC), or a synonymous term to MC, which refers to displaying proficiency in movements and actions within one's environment (Logan et al., 2018; Lopes et al., 2021; Robinson et al., 2015). Systematic review evidence strongly supports high levels of FMS and MC being essential to reductions in weight status, and higher levels of physical fitness (Barnett et al., 2022; Cattuzzo et al., 2016; Lubans et al., 2010). Despite their positive role in promoting positive health-related behaviours and contributing to lower anxiety and social distress, FMS among children are characterised as below average, with modern standards below normative standards established in the late 20th century (Bolger et al., 2021; Eddy et al., 2021b; Ulrich, 2000). Actual FMS levels among Irish youth have been perennially cited as low (Behan et al., 2019; Duncan et al., 2022; Philpott et al., 2021). This is a worrying trend in the face of the alarmingly low levels of PA, and high degree of obesity recorded in Ireland (Belton et al., 2016; Belton et al., 2019a; Daly et al., 2021). While evidence for adolescent populations is not extensive, several Irish studies have noted a plateau or decline in FMS performance beginning from the age of 12 (Behan et al., 2019; Lester et al., 2017). Further international studies, have additionally observed low FMS levels among adolescent groups (De Meester et al., 2016; Lander et al., 2017; Rogers et al., 2018).

One key personal factor contributing to FMS growth and participation in PA is known as perceived motor competence (PMC), which is the belief one has in the ability to perform goal-directed human movements (including FMS) (Estevan & Barnett, 2018). While theorised to be a mediating factor for both FMS and PA, there remains some conflicting evidence on the importance of PMC to these variables (Barnett et al., 2022;

Stodden et al., 2008). A recent systematic review and meta-analysis of 13 studies (covering typically developing children aged between 2 and 18 years old) examined pathways from PA to MC, with PMC analysed as a mediating variable. Indeterminate evidence from PA to MC with PMC as mediating influence was reported, and no evidence for the MC to PA relationship with PMC as a mediating influence was reported (Barnett et al., 2022). The high PMC levels recorded among younger children may be a contributing factor to the lack of evidence for this pathway, as some evidence in later childhood has emerged indicating that higher levels of PMC can contribute to willingness to partake in PA, and in physical education (Bardid et al., 2016; Estevan et al., 2021a; Visser et al., 2020).

These pathways seem to be more probable to exist in later childhood and early adolescent groups, though there is a need for appropriate instrumentation to assess adolescents which contributes to the difficulty in gauging PMC levels among this age cohort (Barnett et al., 2022; De Meester et al., 2020; Estevan & Barnett, 2018). Examining PMC levels during the adolescent period is of critical importance, and there is currently a 'gap' in research among this group (Barnett et al., 2022; De Meester et al., 2020). Adolescence is a sensitive time period of great change and transition, where negative levels of self-perception and self-esteem are quite common (Bandura, 2005; Estevan et al., 2021b; McGrane et al., 2017). The movement and PA habits that adolescents develop during adolescence appear to track to adulthood, further establishing how critical it is to assess PMC and its role in skills and PA habits (Jaakkola & Washington, 2013; Lopes et al., 2021; Van Sluijs et al., 2021).

The majority of previous Irish research under the guise of 'PMC', has been conducted with an instrument referred to as the 'self-confidence scale' (McGrane et al., 2016). While papers using the self-confidence scale have been included in a comprehensive meta-analysis and systematic review of PMC papers (De Meester et al., 2020), it cannot be viewed purely as a measure of PMC (Estevan & Barnett, 2018). The self-confidence scale is aligned with an FMS testing battery (the Test of Gross Motor Development-2); however, PMC and self-confidence differ conceptually. PMC more

commonly relates to self-efficacy, which pertains to context-specific performance i.e. how good is someone at a task, such as running in a straight line (Bandura et al., 1999). Self-confidence differs, by measuring an individual's belief in their willingness or capacity to execute a task at a skill-specific level (Bandura et al., 1999; McGrane et al., 2016; Stewart et al., 2000). The degree of alignment and accuracy between scales and what they purport to measure, and between scale and skill ability is critical to future research into PMC (De Meester et al., 2020; Estevan & Barnett, 2018; Utesch et al., 2018).

The predominant PMC toolkits in use are child-centred, with limited measurement tools available for adolescents that specifically relate to PMC, as opposed to confidence (De Meester et al., 2020; Estevan & Barnett, 2018). Child-centred toolkits are often conducted in one-to-one settings, utilising a structured alternative response format, and a low scale scoring method, with typically between 1-4 item response options provided (Barnett et al., 2015, 2016; Harter, 1982). A greater number of response items in a PMC scale may be more preferable when examining perception among the adolescent cohort (Alan & Atalay Kabasakal, 2020; González-Betanzos et al., 2012). The greater amount of response items have recorded improved reliability metrics in prior studies in the area of self-esteem, which PMC is closely associated with (Leung, 2011). PMC has previously been identified as a component of the global model of self-esteem or self-concept, suggesting insights from self-esteem studies may be pertinent to PMC research (Estevan & Barnett, 2018; Fox & Corbin, 1989; Leung, 2011). A study of 1,217 adolescents in Macau (age range 13-18 years old) examined the use of the Rosenberg Self-Esteem Scale, comparing the psychometric properties on a 4, 5, 6, and 11-point version of the scale (Leung, 2011; Rosenberg, 1965). The 6 and 11-point scales presented with greater psychometric properties, with both 6 and 11-point scales presenting with reduced skewness and the 11-point scale also registering the smallest kurtosis (Leung, 2011). The ease of comprehension for scales with higher response items may partially account for the improvement in psychometric properties among adolescents, as it could illustrate their developed cognitive faculties compared to younger children (Leung, 2011).

A greater insight on how PMC impacts on skill and other exercise habits, and methods of developing PMC is vital to assisting practitioners such as teachers and coaches. It will allow them to deliver appropriate interactions and activities for students and players to improve their skill and perception (Niemistö et al., 2019; Philpott et al., 2021). The debilitating effects of Covid-19 on PA, and FMS illustrate the gravity and importance of analysing and exploring how PMC has been impacted by the pandemic (Eddy et al., 2021a; Murphy et al., 2021; Pombo et al., 2021). With these perspectives in mind (i.e., lack of adolescent research, lack of tools, increasing item response numbers, and need to assist both coaches and teachers), an adolescent toolkit was developed; the 'Project FLAME Perceived Movement Competence (PF-PMC) scale from which validity and reliability needed to be ascertained. The primary aim of this study was to assess reliability and validity of the PF-PMC scale among Irish adolescents, as there is limited research among adolescents using PMC-specific measurement tools. Test-retest reliability for this measurement instrument was assessed with a subsample of 106 participants (*n*= 54 female). A secondary aim of the study was to examine some preliminary PF-PMC data for adolescent youth to explore some potential emerging trends in PMC among adolescents following the Covid-19 pandemic.

6.3. Materials and Methods:

6.3.1. Study Design and Participants

Minimal inclusion criteria from prior iterations of this project, and previous Irish research were adapted for use (Belton et al., 2019b; Philpott et al., 2020, 2021) in this study. In order to participate, schools required (a) qualified physical education teachers on staff; (b) first-year, second-year, and third-year classes of adolescents (age 12–16 years old); (c) participants received physical education for a minimum of 80 consecutive minutes each week; and (d) availability of indoor facilities for physical education classes during the 2021/22 school year (August-May in Ireland). A total of seven schools

(randomly selected) were issued with an invitation for participation during October and November 2021, having met the minimal inclusion criteria. Four schools declined, citing logistical challenges and a lack of suitable venues to conduct the data collection during the Covid-19 pandemic. Participants were, therefore, recruited from three secondary schools within Cork city, Ireland. Of the three included schools, one was a single-sex boys school, one was a single-sex girls school, and one was a mixed-sex school. Out of a total sample of 164 participants, 147 participants (63 female; mean age 13.61 ± .93 years) provided full consent (parental consent and participant assent) and participated in the study (89.6% of full sample). Ethical approval was granted by the Social Research and Ethics committee at University College Cork (Log 2018-169, November 2018).

6.3.2 Data Collection Methods

Prior to completion of both questionnaires, the process and purpose of the study was explained to students, and they were encouraged to be as truthful and honest as possible in completing their answers. Questionnaires were completed independently in the same order, PF-PMC first, by participants (i.e. participants completed answers separately in their own personal space in Physical Education class) via pen and paper, as per previous iterations of the questionnaire, and later inputted into a statistical programme for analysis (Philpott et al., 2020, 2021). All data provided was anonymised and stored in accordance with University College Cork protocol, and compliant with European Guidelines for general data protection regulation.

6.3.3. Collection Measures

The PF-PMC scale utilised the term movement instead of motor to keep terminology simplified for adolescent-aged participants, with motor and movement often viewed as synonymous within FMS research, and aided by the fact that previous

PMC toolkits have used the term movement in their description (Barnett et al., 2016; Logan et al., 2018; Robinson et al., 2015). Adapted from the McGrane self-confidence scale (containing 15 skills), the current PF-PMC scale contains 10 skills, which are the most pertinent to both Irish and British Physical Education, and sporting culture (McGrane et al., 2016; O'Brien et al., 2016). A total of 7 of the 10 skills assessed in the PF-PMC (run, skip, horizontal jump, catch, throw, kick, strike) selected match the skills contained in the Test of Gross Motor Development-2 (TGMD-2) (Ulrich, 2000). The other 3 skills (skip, balance and vertical jump) selected were based on the original TGMD, and skills central to the Victorian FMS manual, and the Get Skilled Get Active resource from New South Wales (Victoria Department of Education, 1996; Ulrich, 2000; New South Wales Department of Education and Training, 2000). These skills were divided into the locomotor subset (i.e. skills of moving/transport) or object-control (utilising or manipulating an implement) subsets (Logan et al., 2018). Locomotor skills included the vertical jump, horizontal jump, skip, and run. Object-control skills included the strike, dribble, catch, throw, and kick.

Participants rated their abilities on a scale of 1-10. A competence question was asked of participants, with the question referring to the following: "Use the scale below to indicate how well you can perform __ (e.g., throw)". By referring to competence, the PF-PMC scale refined its PMC alignment, following current best practice recommendations by experts within the field (De Meester et al., 2020; Estevan & Barnett, 2018). Additionally, while the question stem of the McGrane scale refers to confidence of your skill ability e.g. "How confident on a scale of 1–10 are you at the following skill: Catch a tennis ball with two hands?" (McGrane et al., 2016), the PF-PMC explicitly refers to performance and execution of the task which are crucial elements of PMC measurement (Estevan & Barnett, 2018). This differentiates the PF-PMC scale from the McGrane self-confidence scale, and other PMC-related toolkits through its more explicit focus on execution of the task. In the PF-PMC, participants rated their skill competence in different FMS on a 1-10 Likert scale, in which "1" indicated being not

competent at all ("not well") and "10" indicated being very competent ("very well"). The 1-10 element was utilised with the aim of catering for greater breadth of answering (Hodge & Gillespie, 2007; Leung, 2011). The use of "well" was deemed important during consultations within the research team, being synonymous with competence and a term familiar to adolescent participants that they could grasp (Philpott et al., 2020, 2021). Participants completed the PF-PMC scale twice in 7-days, with the same guidelines and protocol adhered to during both data collection periods. A 7-day period was utilised as a best practice measurement in accordance with previous work conducted in relation to self-perception instruments (Barnett et al., 2015, 2016; Estevan et al., 2018).

To fulfil concurrent validity guidelines, participants completed the Perceived Movement Skill Competence (PMSC) during the data collection session to compare their ratings on both scales. The PMSC is a highly regarded tool which has previously been utilised across Europe, Asia, and Australia (Bolger et al., 2019; Diao et al., 2017; Rogers et al., 2018). The PMSC was initially designed for children, and the childhood version utilises a structured alternative response format common to self-perception measurements to assess perceptions in skills that are assessed as part of the TGMD-2 and TGMD-3 (Barnett et al., 2015; Barnett & Makin, 2018; Johnson et al., 2016). Children are first shown two images, one of a good performer, and one of a poor performer, and are asked "which child is like you?" (Barnett et al., 2015). Different questions are asked based on their response, if they choose the 'good' image, they are asked if they are "really good at", or pretty good at a particular skill (Barnett et al., 2016). If the image of the poor performer is selected, children are asked if they are "sort of good at" or "not good at" performing the skill (Barnett et al., 2016).

This childhood PMSC tool was adapted to an adolescent format, without the use of a structured alternative response, or an interview format. It has not been extensively utilised in research, but has been used among Australian adolescents (Lander et al., 2019; Rogers et al., 2018). The adolescent PMSC tool covers the same skillset as the childhood tool but only one cartoon image of a good skill performance is provided (Barnett et al., 2016; Rogers et al., 2018). Participants are asked to score their abilities

on a 1-4 basis, with the question stem remaining the same for all skills, as participants are asked “How good are you at” for all 13 skills. The following terms are utilised “really good” (i.e., score of 4), “pretty good” (score of 3), “sort of good” (score of 2), “not so good” (score of 1). Participants tick a box to reflect how they feel about their ability in the appropriate skill (Rogers et al., 2018). Thirteen PMSC skills were assessed in this current validity study: run, skip, horizontal jump, gallop, side-gallop, hop (locomotor); one-handed strike, two-handed strike, dribble, catch, kick, underhand roll, throw (Barnett et al., 2016; Diao et al., 2017). This data was also collected via pen and paper for later inputting into a statistical database (Philpott et al., 2020; Rogers et al., 2018).

The PF-PMC, and adolescent PMSC cover similar territory in terms of the skill domains, however the PF-PMC differs in its more explicit focus on skills that are inherent to both the British, and Irish sporting cultures and the respective curricula in those countries (Department of Education, 2013; National Council for Curriculum and Assessment; & Department of Education and Skills, 2016; O’Brien et al., 2016). This narrower skill focus (10 skills of PF-PMC, with 15 of self-confidence scale, and 13 of the PMSC), and explicit reference to competence in its question is a key aspect of the creation of the PF-PMC, as it is the only adolescent scale entirely PMC-centred, that aligns with essential elements of the curriculum and targeted skills, making its utilisation and adoption within the British Isles particularly apt (O’Brien et al., 2016; Philpott et al., 2020). The five skills that were removed from the McGrane scale for the PF-PMC are the roll, hop, leap, slide, and gallop, which have been omitted in previous Irish adolescent research due to their lack of relevance to Irish sporting culture, and their lack of practice in post-primary physical education settings (Lester et al., 2017; O’Brien et al., 2016).

Both scales differ in their Likert scale implementation, with PMSC opting for a four point scale, and the PF-PMC utilising a 10-point scale (Barnett et al., 2016; Philpott et al., 2020). An 11-point scale (i.e., 0-10) was considered during the development of the PF-PMC among the research team. However, it is notable that a score of 0 on a measure has been described as possessing zero acumen in the skill or attribute (Hodge & Gillespie, 2007; Leung, 2011). The desire to avoid a negative connotation of an individual self-

reporting a zero on a skill was avoided for the PF-PMC by beginning the scale with a 1, as is common for other self-perception instruments (Barnett et al., 2016; McGrane et al., 2016; Tietjens et al., 2018). Though less than the 11-point, a 10-point item response may still present with high reliability in comparison to PMC scales with fewer response items (Alan & Atalay Kabasakal, 2020; Dawes, 2008; González-Betanzos et al., 2012).

6.4. Data processing and analysis

To account for the differences in the scoring methods between scales (PF-PMC and PMSC), standardised comparative scores were prepared for both scales. Descriptive statistics for the PF-PMC scale measures were calculated. Internal consistency for this PF-PMC scale at the overall and subset (i.e. locomotor and object-control) was assessed using the Cronbach alpha measure (Diao et al., 2017; Philpott et al., 2020, 2021). Values were categorised as acceptable in the range of 0.60-0.70, good in the range of 0.70 to 0.80 and excellent when exceeding 0.80, in accordance with established protocol (Cronbach, 1989; Cronbach & Meehl, 1976). Intraclass correlations (ICC) were performed for the overall and subset categories utilising a two-way mixed effects models to assess test-retest reliability. ICC values <0.40 were deemed as poor, 0.40-0.75 as fair to good, and >.75 as excellent (Diao et al., 2017; Nunnally & Bernstein, 1994). To assess concurrent validity, a Pearson-product moment correlation was utilised for comparison between scores in the PF-PMC scale, and the adolescent version of the PMSC in accordance with precedent previously established within physical self-perception research (McGrane et al., 2016; Whitehead, 1995). Comparisons were assessed between the overall and subset levels. The strength of the relationships assessed through concurrent validity were determined using Cohen's (1988) guidelines. R= 0.1-0.29 denoted a small correlation, r = 0.3-0.49 denoted a moderate correlation, and $r \geq 0.50$ denoted a large correlation (Cohen, 1988). Data analyses were conducted with SPSS version 28.0 (SPSS Inc., Chicago, IL, USA), with statistical significance set at $p < .05$.

6.5. Results

Internal consistency

Good-to-excellent levels of internal consistency were observed in the overall study sample with an excellent Cronbach alpha coefficient of 0.85 across all PF-PMC skills, with good values of 0.78 for the object control subscale, and 0.76 for the locomotor subscale respectively.

Reliability

The results of the ICC tests are documented in table 6.1. Across all three subsets of the PF-PMC, ICC scores met the minimum threshold of excellent. At the subset level (locomotor, object-control, and overall gross motor), all PF-PMC scores were recorded as excellent (scores >0.75) values, which are listed below. The highest value observed was in overall gross motor skills at 0.87.

Table 6.1. Test-Retest Reliability Values for overall and subset values of the Project FLAME Perceived Movement Competence scale

PF-PMC FMS Skill	Mean value Week 1	Mean value Week 2	*ICC*
Object control (max 50)	38.22 (6.90)	38.42 (7.58)	0.84
Locomotor (max 40)	31.38 (5.49)	31.69 (5.91)	0.83
Overall Gross Motor (max 100)	77.51 (12.17)	78.07 (13.66)	0.87

Note: ICC= Intraclass correlation

Validity

Results of the Pearson-product moment correlations are highlighted in Table 6.2. A strong positive relationship between the overall gross PMSC score and overall gross PF-PMC score was observed (r= .83, p<.001), with further strong positive relationships observed across the subset scores in locomotor performances (r=.72, p<.001) and object control performances (r=.82, p<.001) respectively.

Table 6.2. Concurrent validity of subset items in the Project Flame Perceived Movement Competence scale (PF-PMC) and Adolescent Perceived Movement Skill Competence Scale (PMSC)

PF-PMC FMS	Overall Locomotor	Overall Object-Control	Gross Motor
PMSC Locomotor	0.72*	-	-
PMSC Object-Control	-	0.82*	-
PMSC Gross Motor	-	-	0.83*

Note: * = p<. 001

6.6. Discussion

This paper establishes the reliability and validity for the PF-PMC scale, the first PMC measurement tool designed principally for adolescents that examines perceived skill-specific levels of FMS, is aligned with the key terminology of PMC, and focuses on skills that are central to the Irish sporting and PA culture, in addition to being pertinent in British physical education (Department of Education, 2013; O'Brien et al., 2016; Philpott et al., 2020). Increasing the number of Likert scale response options compared to prior PMC tools proved successful, with strong evidence of validity, and reliability for the PF-PMC scale. Higher reliability metrics were observed here in comparison to other PMC toolkits with fewer response items (Leung, 2011; Simms et al., 2019). A 7-day test-retest window was followed in accordance with established best practice using existing PMC testing toolkits (Barnett et al., 2016; Diao et al., 2017; Estevan et al., 2018). Test-retest reliability results at the subset level was reported as excellent for the PF-PMC scale.

Excellent internal consistency for the overall PF-PMC scale was observed (0.87), with good values for the locomotor (0.78), and object-control (0.73) subsets additionally observed. These high values represent a strength of the PF-PMC scale, illustrating the high homogeneity of the scale, and suggest that the scale may be a strong representation of the PMC construct (Breakwell et al., 2006; Valentini et al., 2018). The greater number of Likert scale responses available in comparison to the PMSC does not appear to have negatively impeded the scale in terms of internal consistency measures. A high level of internal consistency that is consistent with prior thresholds was observed (Barnett et al., 2015, 2016; Lopes et al., 2016; Valentini et al., 2018).

The overall gross motor test-retest reliability value (0.87) meets the excellent threshold, which is in alignment with prior ICC values from test-retest studies (Barnett et al., 2015; Diao et al., 2017; Venetsanou et al., 2018). The excellent locomotor test-retest reliability value (0.83), and object-control value (0.84) were also in concert with prior international findings (Barnett et al., 2015; Diao et al., 2017; Estevan et al., 2018; Venetsanou et al., 2018). These ICC values provide solid evidence

for the viability of the PF-PMC scale and its ability to gauge an individual's true and accurate estimation of their FMS abilities based on the range of good to excellent test-retest reliability values recorded (Koo & Li, 2016). While it is important to note that the psychometric properties of a test are context specific, these values, which echo prior international precedent in the realm of PMC are notable. The increase in the number of Likert scale responses does not appear to have disrupted the test-retest reliability values, with the sample recording similarly high values to those observed in previous other self-perception work conducted with adolescents (Leung, 2011; McGrane et al., 2016; Venetsanou et al., 2018; Whitehead, 1995).

Comparable methods to those used in previous PMC and FMS studies were implemented to gauge concurrent validity (McGrane et al., 2016; Whitehead, 1995). As table 6.2 highlights, strong positive relationship values were reported between the PF-PMC and PMSC scales at the overall and subset level. Strong correlation values were expected given there was an element of overlap in the skills presented in both scales. The strong correlations suggests that the PF-PMC scale is an appropriate tool for measuring PMC among Irish adolescents, as it has demonstrated an ability to assess the same construct as the PMSC tool (Barnett et al., 2015; Rogers et al., 2018). The 10-item scale is a viable method for adolescent PMC measurement, with excellent values on par with prior PMC concurrent validity findings observed (McGrane et al., 2016; Whitehead, 1995). This finding of stability of PMC findings among the same cohort has also been found among participants assessed in later childhood (Van Veen et al., 2020).

Although not the primary intended purpose of this study, the PF-PMC results over 7 days are presented in Table 6.1, and they warrant some consideration in terms of how they relate to previous findings. The overall mean values (and subset values) reported for the PF-PMC scale in this study are marginally higher than those presented in previous work with Irish adolescents (Philpott et al., 2020, 2021). The key difference between the aforementioned Project FLAME studies with data collected in 2019, and this current validity study has been the onset of the Covid-19 pandemic, which has significantly disrupted PA, MC, and exercise habits of adolescents in schools, and the community setting, both in Ireland and across the

globe (Burkart et al., 2022; Pombo et al., 2021; Rossi et al., 2021). Ireland experienced some of the more prolonged and severe lockdowns in Europe throughout 2020 and 2021, which included the closure of schools and cessation of community sports for several months at a time over multiple different periods (Darmody et al., 2020; Murray et al., 2021).

Prior research has indicated that the formulation of perceptions of the self are based on 5 central pillars (i) past experience (ii) task difficulty, (iii) influence and interaction with others (iv) intrinsic motivation (v) vicarious experience (Harter, 1978). Covid-19, and distancing regulations disrupted the opportunity to partake in PA with others and gain experience within formal sports or school settings for much of 2020 and 2021 (Murray et al., 2021; Stockwell et al., 2021). In Ireland, there were documented cases of declines in PA and sport among adolescents, with similar global concerns on reduced youth sporting participation during the pandemic (Darmody et al., 2020; Murray et al., 2021; Rossi et al., 2021). Additionally, declines in youth MC have been observed in the aftermath of the pandemic and the associated lockdowns (Pombo et al., 2021). Irish adolescents during the Covid-19 pandemic reported increased levels of depression and other factors of low mental health (Murphy et al., 2021; Murray et al., 2021). Prior studies illustrate how those reporting lower issues of self-esteem and mental health commonly accumulate less PA time (Murphy et al., 2021; Visser et al., 2020). When considering the hierarchical model and multi-dimensional nature of self-perception and PMC, adolescents experiencing negative feelings of low self-worth about themselves in one facet of life would be expected to present with lower PMC scores (Harter, 1978; Visser et al., 2020).

While Irish MC data following the harshest waves of Covid-19 has not been reported among any age group yet, the lack of PA opportunities on offer during this time would indicate that a decline in MC may have occurred within childhood and adolescent populations (Pombo et al., 2021). It is possible, that a lack of understanding of movement quality is culminating in the marginally higher levels of self-perceptions among youth that are inconsistent with their level of ability, as has been observed in other areas of cognitive psychology (Kruger & Dunning, 1999; Sullivan et al., 2019). Participants lack of understanding on the quality of skill may

have been further exacerbated by decreases in PA, physical education, and social play during Covid-19, particularly when physical education often fails to adequately address the cognitive element of performance (Belton et al., 2022; Dudley et al., 2022; Stanley & Krakauer, 2013). Further research examining trends in perceptions among children and adolescents is needed to ascertain the potential ramifications of Covid-19 on PMC, and how it interacts with PA and MC respectively.

6.7. Limitations and Future Directions

Construct validity for the PF-PMC was not established during this study. Though the sample is relatively large, and diverse across age and gender, it may not be fully representative of wider Irish or global demographics due to data being collected among an urban and suburban sample within one city in Ireland. As with other self-report scales, the possibility of positive response bias when participants answer questionnaires is a possibility. A counter-balanced design (i.e., alternating the order of the completion of the PMSC and the PF-PMC measures) may have added to the strength of the validity and reliability findings recorded. Further research within Ireland, and internationally is necessary to gain a wider sense of PMC levels among adolescents, particularly in the wake of the Covid-19 pandemic.

6.8. Conclusion:

The current PF-PMC scale serves as a continuation and addition to the work of PMC with children, by providing an under researched population (i.e., adolescents) with an appropriate and aligned measurement scale for their use. It is the first skill-specific measurement for use among Irish adolescents that is aligned with the construct of PMC. The results provided give strong evidence of the reliability and validity of the PF-PMC scale for use among adolescents. An increase in the number of scale item responses has not harmed the psychometric properties of the toolkit, with comparable and excellent values to those observed among childhood groups. Construct validity must still be established for this instrument. The higher PF-PMC scale mean values reported in this study when compared to data collected prior to

Covid-19 is notable, with further data necessary to see if changes in self-perception following the pandemic have occurred in childhood and adolescent populations. Continued and longitudinal work assessing the association between perception and FMS competency is needed to appropriately assist coaches, teachers, and interventions in delivering appropriate teaching strategies to improve FMS and physical health among adolescents in the wake of the Covid-19 pandemic. Through its collection in a physical education class setting, the PF-PMC scale has demonstrated ecological validity and its ability to be utilised in a practical school environment. Though overseen by a researcher in this instance, the pen and paper format, and simple instructions provided to participants on the documents should allow data to be collected rather seamlessly without specialist research involvement in future practice.

6.9. References

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Chapter 7

Conclusions and future directions for Project FLAME

7.1. Overview of Thesis.

This PhD research study provides a detailed account of the Project FLAME intervention, a multi-component, school-centred research project targeting adolescents in the Junior Cycle classes (first three years) of post-primary schooling in Ireland. Furthermore, the research expands on the initial aims of Project FLAME through a more targeted examination of the role of PMC among adolescent youth through the examination of perception levels (at both baseline, and post-intervention), in addition to establishing the reliability and validity of a new tool for measuring PMC among adolescent youth.

This study partially fulfils the gap evident within the MC fields, by providing a greater degree of adolescent-centred research, through highlighting the movement deficiencies which permeate youth populations (Bolger et al., 2021; De Meester et al., 2020; Duncan et al., 2022; Estevan & Barnett, 2018; Rogers et al., 2018). The study also presents associations between functional movement performance and FMS, with specific research on functional movement performances in the adolescent populace currently lacking globally (Fitton-Davies et al., 2022; Karuc et al., 2020; O'Brien et al., 2022).

Chapter 1 introduces the thesis by providing information on the overall study's intended purpose, background, and significance and contribution to the area of MC and PMC.

Chapter 2 casts a critical lens on three main concepts essential to the thesis, namely FMS, Functional Movement, and PMC. The chapter provides in-depth analysis and comprehensive detail on the burgeoning and most current research in these areas through a number of sub-headings including but not limited to: intervention work, gender/sex differences, national and global levels of MC.

Chapter 3, the first data-informed study chapter within the thesis presents a novel investigation examining cross-sectional baseline data from 2019. The study

examines proficiency levels in FMS and functional movement differentiated by sex (while controlling for the effect of maturity status), dysfunctional movement performance, in addition to examining the relationship between FMS and functional movement. FMS abilities could be characterised as low across both sexes, with no significant differences observed across levels of overall gross motor abilities. Significant differences were, however, observed across both the object-control and the locomotor domains, with male superiority reported in the object-control domain, and female superiority reported in the locomotor domain. In functional movement, it was interesting to note that no significant gender differences were recorded overall, with functional movement scores below expectations for the adolescent group. While dysfunctional movement scores were found in males and females, males did possess a higher degree of dysfunction in the deep squat and the active straight-leg raise, while females showed a higher degree of dysfunction in the hurdle step, the in-line lunge, and the trunk stability push-up. Across both sexes, FMS^{TM} performance was below new global normative standards. There were, however, moderate positive associations present between gross FMS and functional movement mean scores. Encouragingly, the presence of some associations between overall FMS and functional movement performances suggests that viewing FMS and functional movement as part of a more holistic view of MC is reasonable and deserving of deeper analysis.

Chapter 4 was a further investigation of the cross-sectional baseline data providing an examination of movement skills (FMS and functional movement) and PMC, differentiated by age, as evaluated through examining differences by school year group (and sex). The study reported proficiency levels of FMS and functional movement across all three-year groups, in addition to age-related performance differences across individual, subset (locomotor and object-control) and overall levels of FMS. Movement abilities in the FMS subsets did not improve as participants aged (as theorised in the triangulated hourglass model of motor development theory). Overall, this study reported subpar FMS levels below the expectation of mastery for the adolescent cohort (Gallahue et al., 2012, 2019). Notably, a lack of consistent improvement in the association between PMC and facets of MC (i.e. PMC

and FMS, and PMC and functional movement respectively) did not occur. While the small and moderate associations observed do suggest that adolescents possess some level of cognitive understanding in MC, the lack of consistent improvements in the PMC-MC relationship across each year group is noteworthy. It may suggest that consistent cognitive growth and understanding of movement emerging throughout adolescence may not occur as consistently, which has been previously theorised (Harter, 1978, 1999; Stodden et al., 2008).

Chapters 3 and 4 described in the thesis provide a robust overview of the baseline findings from the data collected in 2019. The wide scope of these chapters, and the results included therein, support the rationale and necessity for intervention work among adolescent-aged groups, given the low level of movement proficiency presented, alongside the high levels of PMC reported, which is inconsistent with their level of ability. These two specific research studies were conducted to address some of the following research questions, which were outlined in chapter one:

- What level of perceived motor competence do Irish adolescents possess?
- What level of motor competence (fundamental movement and functional movement) do Irish adolescents currently possess?
- To what extent are there gender and age-related differences in PMC, fundamental movement, and functional movement among Irish adolescents?

Chapter 5 provides a thorough and accurate depiction of the refinement and development of the 2019 Project FLAME intervention which was enacted in 6 schools (3 intervention schools, and 3 control schools) as part of the RCT research design across Cork city, Ireland. Lessons and adaptations were made to the project in response to previous iterations of data collection as part other postgraduate work e.g. focus group work conducted in late 2018 from early-career teachers, feedback provided by teachers who partook in a proof-of-concept feasibility trial, and the experimental Project FLAME trial in the years 2016 and 2017 respectively. Additional adjustments for the current PhD study were made in response to best practice physical education advice from international research, Irish curricular changes to promote continuous assessment for learning, and newer guidelines in relation to the

recommended learning units of 6-8 weeks in physical education in Ireland (Department of Education and Skills, 2018; National Council for Curriculum and Assessment; & Department of Education and Skills, 2016). The 2019 iteration of Project FLAME was centred on 4 key pillars: The whole-school approach, digital, teacher, and student components. The intervention was designed principally with the intention of improving MC as per previous iterations of the project. Targeting actual MC in an effort to improve the alignment between PMC and MC, or boost PMC levels has previously been utilised with research as an effective strategy given the supposed bi-directional relationship between these variables (Chan et al., 2016, 2019; Lander et al., 2019; Robinson et al., 2015; Stodden et al., 2008). While shorter in duration than previous Project FLAME interventions (Lester, 2020) this current iteration was 8 weeks in duration, when compared to 13 weeks previously), with the desire for Project FLAME to be feasible and practical within a school environment (Department of Education and Skills, 2018). Though the results of the current RCT trial were not successful in improving the alignment between PMC and MC among early adolescent youth, the study provided the research team with great insight, opportunities for reflection and contemplation for future initiatives. Principally, the study answered the following key research question outlined in the opening chapter:

- Is Project FLAME currently catering to best practice in motor competence intervention research and providing a robust attempt at addressing adolescent motor competence and perceived motor competence?

Chapter 6 presented the validity and reliability findings of the Project Flame Perceived Movement Competence Scale (PF-PMC), which is the PMC toolkit utilised throughout this study. This data collection took place in October and November of 2021, owing to the inability to engage in MC and PMC data collection in the wake of the Covid-19 pandemic. A total of 147 participants (63 female; mean age 13.61 ± .93 years) participated (across three schools, one mixed-sex, one single-sex boys, and one single-sex girls) in the concurrent validity element of the study, which compared scores on the PF-PMC scale to scoring on the Perceived Movement Skill Competence

(PMSC) scale, an Australian toolkit commonly used across the world. A subsample of 106 participants (*n*= 54 female) partook in the 7-day test-retest reliability of the PF-PMC scale. Internal consistency was also gathered with the sample. The study findings were highly supportive of the utilisation of the PF-PMC, with excellent internal consistency results, excellent test-rest reliability, and strong concurrent validity findings observed at the overall and subset levels of the PF-PMC. The PF-PMC scale is fit and appropriate for use as evidenced by its strong association values with the PMSC, which highlights how both tools measure what they purport to measure, the construct of PMC. This chapter adds to the strong evidence and glaring need for research on PMC among the under-researched adolescent populace. It primarily serves to target two main research questions outlined in the introduction which were as follows:

- What level of perceived motor competence do Irish adolescents possess, and do levels change as individuals age?

- Can reliability and validity for a new PMC tool be established among Irish adolescents?

Recent evidence has emerged questioning the importance of PMC and its relationship with MC, and its influence on PA. The PA to MC pathway, with PMC as a mediating influence, reported indeterminate evidence, with no evidence for the MC to PA relationship with PMC as a mediating influence in a recent systematic review (Barnett et al., 2022). Several current studies, however, have indicated that PMC can play a prominent role in PA participation, and engagement in physical education suggesting that PMC retains a key role in the development of MC research (Britton et al., 2019; Estevan et al., 2021; Visser et al., 2020). The promotion of MC and PMC is vital in physical education and school spaces for promoting health-related behaviour such as reduced weight status and PA (Barnett et al., 2022; Behan et al., 2022). Both MC and PMC can be targeted using contextually-appropriate activities and the correct pedagogical tools (i.e. positive encouragement, activities that challenge them and are enjoyable and sociable) to promote longer-term physically

active lifestyles and a positive sense of self (Dudley et al., 2022; Engel et al., 2018; Graham et al., 2022; Lubans et al., 2017).

7.2. Strengths of the Study:

Numerous strengths have been identified in this rigorous school-based research within Project FLAME, which are outlined below:

- A wide range of assessment toolkits which capture a more holistic interpretation of MC, possess reliability and validity in youth populations, and are well established in Irish and international research (Cook et al., 2006a; Lander et al., 2017; O'Brien et al., 2018, 2021; Rogers et al., 2018; Ulrich, 2000).

- In excess of 500 students partook in this iteration of the study, making it one of the larger studies conducted among European adolescents in PMC and MC.

- The RCT phase of the project expanded Project FLAME into 6 schools (3 intervention, and 3 control schools). A diverse range of schools were included with two same-sex, two all-male, and two all-female schools participating. This breadth of schools included, and their successful implementation is key to observing how practical and feasible the project is, and whether there is scope for further regional or national expansion. While socioeconomic status was not evaluated as part of this current study, 2 schools (mixed-sex) from lower socioeconomic backgrounds (i.e. classified DEIS- Delivering equality in schooling), as designated by the government of Ireland, were included in the project. Monitoring the practicality and feasibility of implementing the project in such settings is a key concern, given the educational and social challenges that may be prevalent within such settings (Department of Education, 2022).

- Appropriate data collection procedures were adhered to at all times, as specified in the rigorous protocol devised, aligning to Irish and international research (Cook et al., 2006a, 2006b; Lander et al., 2017; Lester et al., 2017; O'Brien et al., 2016). Research assistants from the undergraduate programme in UCC partook in 3-

hours of training in data collection procedures with a separate handbook prepared for their participation and learning to ensure robust procedures were followed.

- All researchers and assistants on this project were undertaking or were graduates of teaching degrees (both primary and post-primary), who fulfilled ethical and safeguarding training for working with youth populations as mandated by the Teaching Council of Ireland.

- Openness and transparency in the reporting of the RCT procedures has been mentioned in all research conducted as part of the project in accordance with the CONSORT guidelines (Moher et al., 2010). To aid the strengths and rigour of RCT protocol, similar randomisation procedures utilised in the Youth Physical Activity Towards Health (Y-PATH) study, another Irish adolescent-centred research programme targeting MC were applied (Belton et al., 2019).

- Reliability and validity for a new tool assessing PMC in an adolescent cohort was collected during the process of this PhD study. The Project FLAME Perceived Movement Competence Tool (PF-PMC) is one of the first PMC tools to establish reliability and validity among a European and adolescent population, with the PMSC used as part of the concurrent validity process for this tool (Barnett et al., 2015, 2016). Schools of equal socio-demographic status were identified, with a reasonable sex split in the overall sample (n= 147 participants; 42.86% female; mean age 13.61 ± .93 years). Additionally, the sample size for this test-retest reliability and validity study (N=106; mean age 13.61 ± .93 years) could be considered large in comparison to many previous studies in the area of self-perception (Barnett et al., 2015; Venetsanou et al., 2018; Whitehead, 1995).

- More formalised collaboration was enacted as part of this iteration of Project FLAME. This included some critical review and progress meetings with external stakeholders (national governing bodies, local sports partnerships), in addition to reviews of the process from participating in-service teachers and schools. As part of

further research with other universities, Project FLAME partook in a Collective Intelligence programme to evaluate the implementation and sustainability of the project (Ma et al., 2021a, 2021b). The commitment to a multi-stakeholder perspective highlighted thorough the inclusion of both physical education teachers and classroom teachers, was considered as an example of best practice for collaborative approaches to FMS development during this review (Lander et al., 2020; Ma et al., 2021a, 2021b).

- Project FLAME retained its practical and feasible approach through its implementation in the physical education and classroom environment. In line with its foundational philosophy, it did not make unreasonable demands of physical education teachers throughout the 8-week intervention, and it did not necessitate a greater timetable dose (i.e. increase in number of physical education classes) or timetable duration (i.e. the intervention fit within 80 minutes of physical education, which is the common duration in Irish second-level schooling). While an intervention effect for increased alignment between PMC and MC was not achieved during these 8-weeks, a positive increase for MC was observed within a previous research study from Project FLAME (Donovan, 2020).

7.3. Limitations of the study:

Though the strengths of the study are numerous, like all research studies, the current PhD is not without its limitations, which will be outlined below.

- Parts of the data collected were cross-sectional in nature (chapters 3 and 4 specifically). Though the sample sizes of the studies in the research chapters were large and diverse (N= 373, mean age= 14.38 ± 0.87 years) across 6 schools, they were limited to the suburban area of Cork city, Ireland. Results may not be generalisable to other rural or urban regions of Ireland, or across the globe.

- Chapter 4 of this study investigated the age-related association between PMC and MC in early adolescents. Age was assessed using different school year groups

only (i.e. year of enrolment in the school). While pertinent to concerns of this research project in investigating post-primary schooling, biological age may have been a more accurate method of assessing age-related performance.

- Perception tools administered were appropriately aligned to testing batteries (i.e. the PF-PMC tool discussed in chapters 4, 5, and 6 is aligned with the TGMD-2 and Get Skilled Get Active tool, with the perceived functional tool aligned with the Functional Movement Screen^{TM}). Self-perception tools, however, by their nature are subjective. It is possible that issues such as positive response or social desirability bias, and overestimation could emerge through self-reported research (Brenner & DeLamater, 2014; van de Mortel, 2008).

- In accordance with the FMS^{TM} testing protocol, verbal instructions were issued to participants during their performance from set criteria (Cook et al., 2006a, 2006b). Prior evidence has highlighted that participants can improve in their functional movement ability through their understanding of feedback and verbal cues (Frost et al., 2015). This suggests that there is a cognitive element of the test and that it is not a simple test of one's strength, mobility, stability, and range of motion (Cook et al., 2006a, 2006b; Frost et al., 2015).

- FMS testing protocol were adhered to during the course of this study. A demonstration of the performance was provided to students before a practice performance, and two trial performances, which were graded by the researchers (Lester et al., 2017; Ulrich, 2000; van Beurden et al., 2002). The short duration between baseline and post-intervention assessment means a potential 'learning effect' in mastering the test may have occurred as has been noted previously (Longmuir et al., 2017; McGrane et al., 2018).

- Large group testing formats are common in FMS and MC assessment, however they are not without flaws (Behan et al., 2022; Lester et al., 2017). A rotating station approach was implemented to maximise efficiency in the school

setting with groups (maximum class size n= 27). Five stations were utilised with a minimum of one research assistant per station. The time elapsed from the demonstration shown by the research assistant to performance by an individual participant could be several minutes, and they may have forgotten some of the particulars of the demonstration by their time to perform. Participants completed PMC forms immediately after performance of a skill (e.g. after performing the throw, participants graded their PMC skills on the throw). This was implemented to negate young participants watching their colleagues perform a skill which could impact on either the skill performance, or their PMC self-evaluation. However, full privacy for MC assessment could not be achieved through the larger testing format. It is therefore possible that participants may have imitated the skill performance of their peers for their own performance which may have impacted on their scoring.

- A counter-balanced design for PMC data collection (i.e. collecting PMC data prior to the completion of actual movement skills testing) may have provided a different set of results, and not accounting for such elements is a limitation of this study.

- Maturation status (as discussed in chapter 3) was assessed using the Moore et al. (2015) maturity offset formula (Mirwald et al., 2002; Moore et al., 2015). This method is a validated method of assessing maturation among an adolescent population (Moore et al., 2015). More conventional and practical methods of assessing maturation, however, through the incorporation of weight and sitting height were not implemented in this study (Freitas et al., 2015; Malina et al., 2004, 2015).

- Though some retention data on a subset of pupils was collected as part of this study in late 2019, the sample size collected was not large enough to gain relevant insight and information. Enforced school closures in 2020, and in other junctures of 2021 prevented further data being collected with study participants.

The absence of larger retention, and longitudinal findings from this cohort is a limitation, and an unfortunate consequence of the Covid-19 pandemic.

- Project FLAME strives to be enacted in the natural school environment, that is practical and replicable for teachers (both physical education and classroom teachers) to adapt and utilise without extensive research oversight. Check-ins via WhatsApp communication, emails, and an end of intervention questionnaire were given to participating teachers and schools, but this study of Project FLAME lacks additional intervention fidelity data which monitors the dose, duration, and quality of the training programme delivered in the experimental groups in the PE, or classroom environment. Colleagues from Coventry University have gathered such data in relation to Project FLAME from early 2022 which is currently under review (Ma et al., n.d.).

- An 8-week intervention suited the framework of working within an Irish post-primary setting but is of a short duration. Similar length interventions have proven efficacious within research in Ireland, and globally to improve FMS, PA, or PMC (Bryant et al., 2016; Burgess et al., 2006; Costello & Warne, 2020; Kelly et al., 2021). This length, however, is below common standards of MC/PMC interventions which commonly range from 3 months up to a year (Bolger et al., 2018; Eyre et al., 2020; Lander et al., 2019; Schmidt et al., 2013).

7.4. Recommendations and future directions.

A wide number of different potential avenues for future research within this field are proposed below under the auspices of different headings.

7.4.1 Sex-related differences in school settings.

- While performance in different movement skills was examined at a sex-specific level (chapter 3), further information in this realm could be identified. A range of literature for example has observed that males and females commonly differ in their PA habits (males commonly practice more object-control activities, whereas females practice locomotor skills) (Charlesworth, 2016; Santer, Griffiths, Goodall, 2007). Given the high number of single-sex all-male, and all-female schools in Ireland (and indeed other regions), an examination of how such educational and socialisation backgrounds impacts the acquisition of FMS, and PMC would be quite intriguing.

- Additionally, continued support for targeted female-centred MC interventions will be essential given the plethora of females who dropout of sport and PA during the early adolescents years (Farmer et al., 2020; Lunn et al., 2013). Some of the key principles of successful female-centred interventions (i.e. social element, fun games, achievable targets, autonomy, diversity of tasks) must be considered for adoption in school and research settings to minimise dropout among females, and males respectively (Cowley et al., 2022; Farmer et al., 2018, 2020).

7.4.2. Maturational differences.

- This research study did examine maturation in FMS and functional movement performances, however, this was undertaken at a surface-level. Sports science has vociferously argued for research into the effects of biological maturation, and its difference from chronological age (Malina et al., 2015, 2019). A deeper analysis of biological maturation and its potential impact on FMS, and more specifically functional movement may be necessary, given the findings of this research study, and others that suggests a stagnation or regression in movement capacity may be occurring during the adolescent years (Behan et al., 2019; Ghasempoor et al., 2018; Lester et al., 2017).

7.4.3. Longitudinal studies & functional movement gaps.

- As has been stated in recent systematic reviews, a crucial next step for both PMC and MC research is the longitudinal examination of these concepts (Barnett et al., 2022; De Meester et al., 2020). Examining the key mediators and variables of both PMC and MC (i.e. PA, BMI, health-related physical fitness, sex, biological maturation) from childhood to adolescence must be considered where feasible.

- Future retention and a further follow-up of MC intervention results will be needed to gauge the effectiveness of skill performance results from maturation, BMI changes, chronological aging etc (Barnett et al., 2022; Duncan et al., 2022; Lester et al., 2017).

- Early research has suggested that functional movement may have an underlying relationship with FMS, through emergent convergent validity evidence (O'Brien et al., 2021). Further investigation into the association between functional movement performance and FMS is critical, in addition to more work examining functional movement in non-sporting adolescent populations given the current dearth of research in this group (O'Brien et al., 2022). Identifying and assessing common covariates associated with functional movement and/or FMS performances (e.g.'s BMI, PA, age, maturation status and gender) are key to examining potentially shared associations.

7.4.4. PMC and MC- Alignment and development of toolkits.

- A recent systematic review decreed that the relationship between PMC and MC was in the low-to-moderate range (De Meester et al., 2020). Similar findings in this research study were observed for PMC and MC alignment among youth (chapters 4 and 5). Continued work on validating and aligning PMC toolkits with MC and testing batteries for MC are key. Though age and sex did not appear to impact on the strength of the relationship between PMC and MC, an absence of adolescent-centred data and longitudinal studies observing perception levels clearly remains in the literature (De Meester et al., 2020; Estevan & Barnett, 2018).

- The concurrent validation and test-retest reliability process conducted in this study for the PF-PMC was an important step given that limited data exists among European adolescents in PMC. Construct validity and criterion validity may need to be established at a later date in order to further solidify the strength of the PF-PMC tool. Additional research at a national and/or international level will be necessary to further enhance this research tool's potential use amongst adolescents (Alan & Atalay Kabasakal, 2020; González-Betanzos et al., 2012). Work with childhood and adolescent groups must persist in order to understand their cognitive knowledge of MC, and how participants interpret their own performance ability. Knowledge of performance plays a key role in how participants perceive their abilities, and this element is often not effectively targeted and developed within school settings (Dudley et al., 2022; Stanley & Krakauer, 2013).

7.4.5. Qualitative research on PMC.

- Qualitative research assessing adolescent perceptions of skill qualities could add depth to this field. The current quantitative approach in PMC collection demands adolescents consider 'how good' they believe they are at performing a skill. It does not consider the 'what' element, and it is unclear what adolescents believe to be essential to the performance of rudimentary and/or other skills. Exploring a question in the vein of 'what does a good performance of a throw/catch/kick look like to you?' may be pertinent. This may help identify what adolescents see as key features of performance for specific skills. In response to this, teachers and coaches can be more effective in their design of activities to help ensure students understand the key teaching elements of the skill being developed. The cognitive element of performance is frequently not targeted by teachers, coaches and other activity stakeholders (Belton et al., 2022). Such a rounded approach may help adolescents to understand skills more roundly, which is critical to accurate self-evaluations (Dunning & Helzer, 2014; Kruger & Dunning, 1999).

7.4.6. Covid-19 impact on self-perceptions and MC.

- It may be difficult to feasibly research this topic, however, examining the impact of Covid-19 on skill self-perceptions, and MC would be highly pertinent. Longitudinal studies will be challenging to conduct as few studies would have comparative data available prior to Covid-19. A number of researchers have keenly presented information on PA, and FMS being in decline both during and after the early stages of the pandemic (Burkart et al., 2022; Pombo et al., 2021; Rossi et al., 2021; Salway et al., 2022). Additionally, some research has presented work on the increased levels of anxiety, depression and other markers of wellbeing during lockdowns and other Covid-19 enforced measures (Andermo et al., 2020; Brooks et al., 2020; Murphy et al., 2021). The combination of low FMS and PA levels, alongside lower levels of self-esteem and wellbeing would appear likely to culminate in lower markers of self-perception (Estevan & Barnett, 2018; Stodden et al., 2008).

7.4.7. Evaluation of the intervention:

- A thorough reflection and assessment of Project FLAME's intervention procedures and process evaluation protocols are being undertaken at the time of writing this PhD concluding chapter through collective intelligence data analysis. Collective intelligence utilises a structured approach combining both human and computer-integrated technology to identify problems and solutions, fostering a collaborative approach from diverse perspectives in the field (Hogan et al., 2015; Warfield & Cardenas, 1993). Issues such as fidelity and the monitoring of teacher training and dosage have arisen from Project FLAME during the completion of this process (Ma et al., 2021a, 2021b). These next stage refinements and developments will form a key role in the future of Project FLAME in the secondary-school community, and other educational capacities.

- The time of year can impact on the suitability to introduce new teaching formats and intervention programmes for teachers. Unfortunately, this

Project FLAME project had to commence in January of 2019. The start of the school year (early September in Ireland) may be a more feasible to begin future programmes due to fewer examinations and events at this juncture.

- Acknowledging the student perspective through focus groups, or post-lesson reflections would be highly beneficial. Giving the students a greater input is in line with current pedagogical best practice to increase student autonomy through leadership and decision-making (Crotti et al., 2021; Department of Education and Skills, 2015; Lubans et al., 2017).

- Project FLAME does not espouse a particular teaching philosophy, though its games and activities are designed with a student-centred approach. Emphasis on new teaching methodologies, and adaptions to games to boost inclusive philosophy and skill development may be key. Skill acquisition science (i.e. ecological dynamics and constraints-led approaches), and physical literacy research have highlighted the importance of acknowledging constraints (i.e. task, equipment, environment, participants etc.) and how they must be manipulated to provoke learning (Renshaw et al., 2022; Rudd et al., 2021; Seifert et al., 2018). Providing broader games and activities that require elements of self-discovery and challenge through game-based and natural environments could be key to developing skill ability (O'Sullivan et al., 2020; Renshaw et al., 2022).

7.4.8. Next steps for Project FLAME.

- If an 8-week duration for Project FLAME remains in place, increasing the dosage (i.e. number of physical education sessions) must be considered. It is important to note that 8 weeks is a limited time window, particularly as self-perceptions can remain consistent or static in short spans of time (Harter, 1982, 1985, 2012). Increasing the amount of physical education, however, and the opportunities to engage in MC exercises may prove pertinent for improving participants' level of skill. Greater time in physical education class should develop

their learning within class, and promote a level of understanding of skills which can boost PMC levels, or improve alignment between PMC and MC (Lander et al., 2019).

- To improve the dissemination of this project, some practical changes are necessary. This iteration of the project was led by 2 research personnel involved in coordinating all elements central to the project (i.e. primary point of contact, data management, video scoring, liaising with school principals teachers, designing intervention handbooks, etc.). An increase in staff (and external personnel, such as graphic design artists) would enhance time for creativity and innovation across all areas of the project, by generating sleeker and more modern presentations of the work.

- In collaboration with local sports governing bodies, Project FLAME is currently embarking on an initiative to upskill community sports coaches and to deliver the Project FLAME programme in this setting. Investigating the efficacy of such a project and its ability to assess and improve movement capacity among sporting populations among youth is very important. The prevalence of community sport participation in Ireland is high (80% of primary and 58% of post-primary students partake in sport), which suggests that upskilling coaches in this area may be even more crucial than physical education to combat the deficits in MC, PA, and health (Lester et al., 2017; Woods et al., 2018). In a similar vein, after-school and extracurricular settings could implement the Project FLAME programme. A collaborative approach linking parents, the school and the community would appear to be a key aspect of strengthening interventions to improve participant engagement and monitoring progress (Belton et al., 2019; Ma et al., 2021a; McGrane et al., 2018).

- Collaboration with local educational bodies should be conducted if a future expansion of the project occurs. Collaborations with larger stakeholders are essential to the field of MC (and to an extent PMC). Addressing matters at a top-down policy level has been identified as a notable strategy within future PA and health research (Volf et al., 2022; Woods et al., 2021).

- The primary school setting may offer a further viable platform to deliver Project FLAME. Earlier intervention and the development of MC has previously been

decreed as a critical point to optimally develop youth in their journey towards an active lifestyle (Dudley, 2015; Fahey et al., 2005; Gallahue et al., 2019). It would also help provide support and structure to primary school educators, who often feel unsupported, and might be lacking in confidence in their delivery of physical education programmes, which can culminate in external sporting associations teaching physical education (Ní Chrónín & Cosgrave, 2013; Parker et al., 2018; van Rossum et al., 2019).

- Project FLAME has embraced the digital learning space through its innovative kinaesthetic classroom videos of skill performances and activities, which can be performed alongside a research instructor. The use of such video platforms and technology has been advocated to boost PA, and potentially develop movement skill in youth (Bulca et al., 2020; Williams & Ayres, 2020). Retaining this element of the project should remain a key focus, with a room to expanding on activities delivered by research instructors where feasible.

- If teachers are to implement the Project FLAME intervention in practice, it is in the best interest of the research team to collaborate with teachers, and educational organisations (i.e. teacher unions, professional development bodies etc.) to develop further assessment materials which are reflective of ongoing changes in the curricula. In the Irish education system for example, physical education can be assessed (prior to 2020 this was not possible) among post-primary school students through a continuous assessment format (Department of Education and Skills, 2015, 2018). Developing Project FLAME resources that utilise the key vocabulary and terminology that reflect such assessment guidelines could be pivotal to integrating the project into a school setting, as it provides teachers with a practical guide they are familiar with (Department of Education and Skills, 2018; *Junior Cycle Physical Education Specification*, 2017).

7.4.9. Project FLAME- Towards a physical literate approach

- The role of both FMS, and functional movement in maintaining healthy weight status suggests that from a MC perspective, the skills developed in Project FLAME could positively contribute to improved physical health (Barnett et al., 2022; O'Brien et al., 2022). MC can play a role in social acceptance, and may boost elements of self-esteem and self-worth (Gallahue et al., 2019; Lopes et al., 2021; Schmidt et al., 2013; Timler et al., 2018). As Project FLAME develops MC and PMC (which is a component of self-worth/self-esteem), the role of Project FLAME in holistic personal development is clearly illustrated. (Estevan & Barnett, 2018).

- Project FLAME is not a physical literacy intervention though it contains many of its key elements, namely in the following areas: 1) in competence (going beyond FMS to a diverse skillset through the inclusion of functional movement), and 2) in knowledge (improving skill ability through understanding and learning visual cues), motivation and confidence (PMC contains elements of these, primarily with similar traits to confidence) (Roetert et al., 2018; Roetert & MacDonald, 2015). Project FLAME currently targets some key elements of physical literacy and could adjust to be more aligned with the concept. There is a great degree of potential in Project FLAME going in this direction, as physical literacy is a very broad term, which can vary and adapt to different cultural meanings depending on context (Young, et al., 2022).

7.5. Conclusion of the Thesis.

The central aim of this thesis was to investigate the relationship between PMC and MC among adolescent youth during the early post-primary years in Ireland. This process encompassed the refinement and development of the Project FLAME intervention, developing it into an RCT research design with improved resources, and a more feasible initiative that could be appealing to a wide spread of post-primary schools. The detailed intervention protocol provides openness and transparency

which could be implemented or adjusted to suit the needs of a particular school community.

The findings of this thesis in relation to PMC and MC may prove invaluable to future practice at post-primary education, as they highlight issues, such as low levels of MC, and high levels of PMC among the adolescent population. The Project FLAME intervention did successfully improve elements of movement in adolescents, as highlighted in research outside this study (Donovan, 2020). However, the findings from this study indicative that the FLAME intervention did not appear to improve the alignment between perception and skill among adolescents. Increasing student autonomy and the number of Project FLAME sessions in the intervention may be needed to promote increases in veridicality between perception and actual skill.

Though Project FLAME succeeded in its goal to boost movement skill ability in an 8-week duration, the study may require considered changes before it is ready for a larger phased rollout at a regional level in Ireland. The work of developing, refining, and enhancing the intervention programme has helped in my own personal understanding of the physical education and MC discipline, while the writing process has assisted in my research, and critical thinking skills. The research journey began as a partnership as part of a wider team, however, for much of the final two years working in isolation during Covid-19 formed a cornerstone of the studies.

Nevertheless, skills of both collaboration and independent research were fostered over the course of this thesis. As discussed previously, communal efforts between the research team and external collaborators are vital to the growth of Project FLAME within and beyond the school community. I see this shared and communal emphasis as a strategic priority to the future of the field and bridging the gap between research and practice. I hope that my research fuels a continuous journey of self-improvement as an educator, and provides further evidence, and practical information to develop both the movement skills and self-perceptions of adolescents in this country (whom I am fortunate enough to teach and work with in my everyday practice!).

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Appendices

Appendix A: Publications

A1	Published Paper- International Journal of Environmental research and public health
A2	Published Paper- Perceptual and Motor Skills
A3	Published Paper- Physical Education and Sport Pedagogy
A4	Published Paper- Sports Medicine

International Journal of
Environmental Research and Public Health

MDPI

Article

Investigating the Age-Related Association between Perceived Motor Competence and Actual Motor Competence in Adolescence

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Abstract: Irish adolescents have been found to possess high perceptions of motor competence. However, there is an evidential value to investigating the strength of the relationship between adolescent perceptions of motor competence and their low levels of actual motor competence. The purpose of this research was to gather data on the fundamental, functional, and perceived motor competence in adolescents, differentiated by year group, to discern if participants could assess their perceptions of ability. Data were collected on adolescents (N = 373; mean age: 14.38 ± 0.87 years; 47.7% female) across six second-level schools in Ireland, including measurements of fundamental movement skills, functional movement, and perceived motor competence. Poor levels of fundamental and functional movement were observed, with significant differences between year groups detected. Participants in 1st year scored the highest in overall fundamental movement skills; however, for overall functional movement, 3rd-year participants scored highest. High levels of perceived motor competence were reported across the entire sample. These scores did not align with actual motor competence, nor did any alignment between these measurements improve with aging, countering theorized age-related associations. Future research should target low levels of actual motor competence while emphasizing the cognitive aspects of movement to ensure greater accuracy between actual and perceived motor competence.

Keywords: functional movement; fundamental movement skills; motor competence; cognition; motor skills

Article

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Effects of an 8-Week Intervention Targeting the Veridicality of Actual and Perceived Motor Competence Among Irish Adolescents in Project FLAME

Conor Philpott[1], Till Utesch[2], Sarahjane Belton[3], Brian Donovan[1], Fiona Chambers[1], Diarmuid Lester[1], and Wesley O'Brien[1]

Abstract

High levels of perceived motor competence and low levels of actual motor competence in youth populations have been reported world-wide. Both perceived and actual motor competence have been deemed independent correlates of health and physical activity (PA) behavior, and past research has indicated that their alignment may be linked to more consistent PA. Moreover, there is potential for a movement-based intervention to strengthen the alignment between perceived and actual motor competence, perhaps then guiding future health, PA, and community sport engagement globally. Thus, the objective of this study was to investigate the effectiveness of

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Motor competence assessment in physical education – convergent validity between fundamental movement skills and functional movement assessments in adolescence

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ABSTRACT

Background: The meaningful assessment of motor competence is well positioned for school-based curricular emphasis, through the integration of motor skills and movement patterns in both primary, and second level school physical education. Aligned with the growing interest in holistic motor competence assessment in physical education, the aim of this study was to assess the convergent validity between fundamental movement skills and functional movement assessments in a large cohort of adolescent youth.

Method: A sample of 583 adolescents, aged between 12 and 16 years old participated in the study. Ten fundamental movement skills were assessed in line with the behavioural components from the Test of Gross Motor Development, and the Get Skilled Get Active resource. Seven specific functional movements were also assessed, using the existing protocol from the widely established Functional Movement Screen. All data were analysed using Bayesian procedures, in which the Bayes factors provided information about the probability of a hypothesis being true.

Findings: The results indicate that it is very probable ($BF_{10} > 10{,}000{:}1$) that boys show higher actual motor competence levels in the object control subset of fundamental movement skills, when compared to girls. Moreover, a positive association between the total scores of the Functional Movement Screen and the locomotion subset of fundamental movement skills was found to be very probable ($BF_{10} = 7.737$).

Discussion: This study provides evidence of convergent validity between functional movement and fundamental movement skill assessments in adolescence. This study presents an evidence-informed rationale for physical education pedagogues to move beyond traditional perceptions of movement as being exclusively pertaining to physical skills, to a more holistic concept of motor competence comprising of both movement skills and movement patterns.

Conclusion: The current study broadens the assessment perspectives of motor competence within physical education, by specifically heightening physical education teachers' awareness towards the possible complementarity of both locomotion and movement patterns in the psychomotor domain of adolescent learning in physical education.

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Movement; children; measurement; school; locomotion

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The Assessment of Functional Movement in Children and Adolescents: A Systematic Review and Meta-Analysis

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Abstract

Background The Functional Movement Screen™ (FMS™) is an assessment of human movement that may signal potential deficits that could predispose an otherwise healthy person to injury risk. FMS™ scores are well reported in both athletic and adult samples. However, to date, there has been no comprehensive systematic review and meta-analysis of FMS™ data among school-aged children and adolescents.

Objective We aimed to systematically review and analyse functional movement proficiency of children and adolescents, specifically when assessed using the FMS™, and to establish initial normative values for the FMS™ in this population group and to further estimate differences in functional movement proficiency between the sexes, by school level (i.e., between primary and secondary school-level children and adolescents), and based on differences in child and adolescent body mass index (BMI).

Methods In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, prospective studies were identified from searches across eight databases (MEDLINE, SPORTDiscus, CINAHL, Web of Science, EMBASE, ERIC, PsychINFO and PubMed), without any date restrictions, up to December 2020. The primary meta-analysis estimated the overall FMS™ score for school-aged children and adolescents across published studies. An additional three subgroup meta-analyses estimated comparisons for FMS™ data with school level, sex, and BMI across published studies. FMS™ data were meta-analysed using a number of different meta packages (Schwarzer et al. in Meta-Analysis with R, 1st ed, Springer International Publishing, Berlin, 2015), available in R Studio.

Results A total of 19 articles were included in the systematic review. Meta-analysis revealed a weighted FMS™ mean score of 14.06, with a standardised *Tau* value of 0.56, signalling a moderate-to-large degree of variability in FMS™ means between studies. The difference in FMS™ means between samples of males (weighted FMS™ mean 13.91) and females (weighted FMS™ mean 14.56) was compatible with a possible small effect size (standardised mean difference − 0.27). The variability in FMS™ means between studies was approximately five times greater in samples of secondary school children (factor difference in *Tau* values 5.16). The final meta-regression identified a negative association between BMI and FMS™ scores ($r = -0.42$), which signalled a moderate-to-large difference in FMS™ scores between healthy weight and overweight children/adolescents.

Conclusion This systematic review and meta-analysis represents a novel and important synthesis of published FMS™ data from groups of children and adolescents. The study signals possible sex- and age-related differences in FMS™ scores, as well as a clear negative relationship between BMI and functional movement proficiency. More longitudinal research is needed to better understand the developmental trajectory and the effects of maturation milestones on FMS™ proficiency. Additional research is also needed to identify the types of interventions that could improve functional movement proficiency among 'at risk' groups, who are susceptible to functional movement deficiency, and whether changes in body composition mediate the relationship between these interventions and the improvement of FMS™ scores.

Appendix B: Information Letters for schools and principals

B1	Information Letter for school and participant teachers
B2	Information Letter for school principals and plain language statement (2019)
B3	School information letter (2021)

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Dear [redacted]

The School of Education's, Sports Studies and Physical Education Programme at University College Cork (UCC) is currently expanding its motor skills, and physical activity initiative, Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency). As part of our Masters of Education, Mr. Brian Donovan and Mr. Conor Philpott, qualified Physical Education teachers, as registered by the Teaching Council of Ireland, would like to invite [redacted] to take part in a controlled trial assessing student movement competence, across basic movement skills and patterns, seen in every day activities.

Research in Ireland has indicated low levels of movement competence and physical activity across adolescent populations (O'Brien et al., 2018; Lester et al., 2017). Our project aims to assist schools, in particular the Physical Education teachers, in reducing these movement-problems, by upskilling students to provide further opportunities for physical activity across the lifespan. Improvements in these basic movement skills and patterns are associated with increased physical activity, and reductions in overweight, obesity, screen time, and sedentary behaviour.

Project FLAME, has already been trialled in 3 schools, since its development in 2016, within the sub-urban Cork area, and has demonstrated significant benefits for Irish adolescents in Junior Cycle. In this iteration of the project, we are seeking to expand the evidence-base, so this programme may benefit post-primary school students in your school and beyond, furthering the cause of student 'Wellbeing', while developing healthy and physically active youth in the future.

Participation in this study would require one class from each of the Junior Cycle classes in [redacted] who have given their assent and parental consent to partake in the project. During a typical Physical Education class, students will be invited to undertake 10 fundamental movement skills (kick, throw, jump, run etc.) and 7 functional movement patterns (flexibility, mobility, stability) in a controlled environment, preferably in the school's sports hall.

Additional data, a Likert scale questionnaire based on student's perceived movement competence (i.e. their perception of ability to complete tasks) will also be collected on these assessment days. If feasible for the school, the full battery of movement tests will be carried out on a full class group, within three consecutive class periods, minimizing class disruption.

The intention for this project is to collect all student movement-data, during a single day school visit by the research team, at two separate time points during the current academic year, with a follow-up test scheduled early in the 2019/2020 academic year to investigate whether or not students have maintained their movements long-term. Following the initial testing period day one, set for January 2019, students will receive a 10-week movement-oriented intervention for a duration of 15 minutes during their timetabled Physical Education class, as administered by each group's respective class teacher.

All equipment for this testing will be brought to the school by the research team, and as the sports hall will be required, we are kindly asking if the school hall could be made available for a full day, on two separate occasions throughout the current academic year. All participating schools and Physical Education teachers involved in this study will receive a resource pack to utilize during the movement-oriented intervention. The Physical Education Department in the school will be provided with detailed descriptive results of how their students performed, which will be an invaluable asset in terms of long-term planning at both departmental, and school level. However, please note that no information of individual student performances will be provided in line with ethical considerations for the project, as approved by the Social Research Ethics Committee (SREC) in UCC. Furthermore, no reference to your school will be made on any future publications arising from the data collected, again in line with ethical considerations.

We would be grateful if you could inform the PE teachers in the school of this project and consider [redacted] involvement. Please find some additional information, including dates and a timeline for the intervention, attached on the following page. We appreciate that there is a lot of information in this letter, so with that in mind, we would be more than willing to meet with you in the near future to discuss your potential involvement in this project. We would be very pleased to meet with you and/or your staff to discuss any details that may be outstanding. Alternatively, please do not hesitate to contact us via phone or email.

Kind Regards,

Brian Donovan & Conor Philpott

Masters of Education Candidates, UCC.

Email: xxxxx (Brian Donovan)

Email: xxxxx Conor Philpott)

Telephone: [redacted] (Brian Donovan)

Telephone: [redacted] Conor Philpott)

Project FLAME 2018-19

Title: Project FLAME: Fundamental and Functional Literacy for Activity and Movement Efficiency

Principal Investigators: Dr. Wesley O' Brien, Mr. Brian Donovan, & Mr. Conor Philpott

University Programme: School of Education, Sports Studies and Physical Education

Dates for Testing 1: **One date only required.**	Week beginning Monday 21th January 2019 Monday 21st January, Tuesday 22nd January, Wednesday 23rd January, Thursday January 24th , Friday January 25th

	. We will also be undergoing testing the week beginning Monday 28th January. Please select your preferred date: we will try to arrange school preferences, where possible:
Intervention Programme	12-Week Intervention Intervention Start Date Week of Monday January 28th
Dates for Testing 2 (Post): One date only required.	Week of May 6th 2019 (Provisional Time slot allowing for Mock Exams using Hall)





I. Project Title

School Principal Consent form

Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'

II. Clarification of the purpose of the research

Culturally relevant research by O'Brien et al. (2016), found 'alarming' evidence that Irish adolescents entering post-primary school did not display competence across nine basic movement skills. Project FLAME was introduced, specifically to assess the levels of 1) fundamental and 2) functional movement at post-primary level, and to create a tailored movement-oriented intervention to ameliorate the life-limiting effects of movement deficiencies in Irish adolescents.

Van Beurden et al. (2002) suggest that children's Fundamental Movement Skill proficiency underpin active lifestyles. PE specialist teachers have been identified as a key factor in the successful implementation of interventions to help improve young people's motor development. (Belton et al. 2014).

In this element of the study, we hope to examine the viewpoints of both PE teachers and students pre and post participation in the Project FLAME intervention. It is hoped that this will allow us to gain valuable insights into participant's views on the intervention, so that we may develop the programme to be more practically workable and effective.

Involvement in the research is completely voluntary. Participants may choose to withdraw from the study at any time. There shall be no penalty for withdrawing before all stages of the research project have been completed**.** Confidentiality is an important issue during

data collection. Participant's identity, or other personal information, will not be revealed or published. Participants will be assigned an ID number, or a pseudonym, under which all personal information will be stored in a secure file and saved in password protected file in a computer at UCC. The investigators alone will have access to the data. Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions.

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project

Participant's Signature: _____

Name in Block Capitals: _____

Date: _____

III. Plain Language Statement – Principal

Project Title: Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency)

Principal Investigator: Dr. Wesley O'Brien

University Department: Sports Studies and Physical Education

Involvement in the Research Study:

- My school is involved in a study of movement entitled Project FLAME – (Fundamental and Functional Literacy for Activity and Movement Efficiency).
- The research is being carried out by University College Cork.
- Dr. Wesley O'Brien, Mr. Brian Donovan and Mr Conor Philpott will be carrying out the study in my school.

Primary Investigators and Contact Details:

Title	First Name	Surname	Phone	Institution	Email
Dr.	Wesley	O'Brien	[redacted]	Sports Studies & Physical Education Programme, UCC.	[redacted]
Mr.	Brian	Donovan	[redacted]	Sports Studies & Physical Education Programme, UCC.	xxxxx
Mr.	Conor	Philpott	[redacted]	Sports Studies & Physical Education Programme, UCC.	[redacted]

IV. Confirmation of particular requirements as highlighted in the Plain Language Statement.

Participant – please complete the following (Circle Yes or No for each question)

Have you read or had read to you the Plain Language Statement
Yes/No

Do you understand the information provided?
Yes/No

Have you had an opportunity to ask questions and discuss this study?
Yes/No

Have you received satisfactory answers to all your questions?
Yes/No

Are you aware that any interviews will be audio/video-taped?
Yes/No

If you have any queries regarding the conduct of this project you can contact:

Office of the Vice President for Research & Innovation, [redacted], UCC.

Tel: [redacted] ***Email:*** xxxxx

2021 School Information sheet

The, Sports Studies and Physical Education Programme in the school of education at University College Cork (UCC) is currently expanding its motor skills, and physical activity initiative, Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency). As part of my Doctorate of Philosophy in the field of Education, I would like to invite____(School)_____ to take part in a non-randomised controlled trial assessing student levels of perception in their skill development, through a new questionnaire tool.

Research in Ireland has indicated high levels of perception which are not matched by actual skill levels (O'Brien et al., 2018; Philpott et al., 2020). This mismatch between perception of skill, and actual skill can result in dangerous or adverse risk taking and may contribute to lower and poorer quality of physical activity (Utesch et al., 2018). This project aims to trial a new questionnaire, assessing students' level of perception, and improve their understanding and performance through targeting their skill development through PE and in-class setting. By developing students' knowledge and understanding of skills and physical activity, our aim is to develop physically literate individuals who recognise the importance of effective movement and physical activity across their lifespan. Improvements in their basic movement skills and physical activity are associated with reductions in overweight, obesity, screen time, and sedentary behaviour.

Our work in Project FLAME has already been trialled in 9 schools, since its development in 2016, within the sub-urban Cork area, and has demonstrated significant benefits for Irish adolescents in Junior Cycle. Cognisant of the current ramifications of COVID-19 in the Irish education system, this iteration of the project is seeking to further the cause of student 'Wellbeing', through examining their cognitive understanding of skill and exercise, helping them maintain and improve on their healthy and physically active lifestyles in the future.

Participation in this study would require **one class group** from two Junior Cycle year groups, who have given their assent and parental consent to partake in the project. During a typical Physical Education class, students will be invited to **complete a questionnaire using pen and paper** on 10 fundamental movement skills (kick, throw, jump, run etc.), and a smaller questionnaire on similar skills. This questionnaire would be **completed twice in the span of 2-3 weeks** to verify and assess its reliability and validity for further usage in Cork, Ireland or across the globe. This questionnaire collection sessions should take **no more than 20 minutes** of a standard Physical Education lesson.

I would be grateful if you could inform the PE department in your school of this project and consider the school's involvement. Please find some additional information, including dates and a timeline for the project, attached on the following page. I appreciate that there is a lot of information in this letter so with that in mind, I would be more than willing to meet with you (in person or virtually through a videoconferencing platform is of your choosing) in the near future to discuss your potential involvement in this project to discuss any details that may be outstanding. Alternatively, please do not hesitate to contact me via phone or email.

Kind Regards,

Conor Philpott

PhD Candidate



Contact info:

Teaching Council Number [redacted]

Email: xxxxx

Tel: [redacted] (Conor Philpott)

Project FLAME 2021

Title: Project FLAME: Fundamental and Functional Literacy for Activity and Movement Efficiency

Principal Investigators: Dr. Wesley O' Brien, & Mr. Conor Philpott

University Programme: School of Education, Sports Studies and Physical Education

Dates for Testing 1: **One date only required.**	Provisional timeline: Week beginning We will do our best to work around the schedule of your PE class timetable and staff, and will negotiate a suitable timetable for work preferably during this week. Flexibility around your school's schedule and ours is paramount.
Dates for Testing 2 (Post**): One date only required.**	Provisional Week of Flexibility and suitability will be prioritised around the PE staff we will be working closely with, school events, and most importantly the students

Appendix C: Project FLAME Information Sheets and consent forms for parents and adolescent participants

C1	Informed participant consent form (2019)
C2	Focus group information and consent form (2019)
C3	Informed participant consent form (2021)- PMC Data collection

January 2019

Dear Parent/Guardian,

Please find overleaf an informed consent form for your child's participation in a movement study entitled 'Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'. This study is being carried out by University College Cork in your child's school. The study aims to gather information on the movement vocabulary and physical activity levels of students in the school and develop a plan to help improve these levels, and then to assess whether or not activity levels have been improved.

In order for your child to participate in this study, please read the attached form. If you do not wish your child to be involved, then you need to take no further action. If you DO wish your child to participate in the study, then I kindly request that both you and your child sign and return Option 2 at the bottom of the form.

Thank you for your time.

Yours sincerely,

Wesley O' Brien

Wesley O' Brien. Ph.D.
Principal investigator

Informed Consent Form

Project Title: Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'

Investigators: Dr. Wesley O' Brien, Mr. Brian Donovan, and Mr. Conor Philpott.

Introduction to the study:
The ability to move with fundamental and functional competence has been shown to be extremely beneficial to youth in enabling them to move well and move often and is a key determining factor in physical activity participation. In order to develop effective physical activity programmes for your (child's) age group, it is important that researchers understand the factors that influences adolescents in Ireland to become and remain active.

This is what will happen during the research project:

- Your child may complete a physical activity and movement-based questionnaire. This questionnaire will be filled out in class with the help of the class teacher and Mr. Conor Philpott.
- Your child may have their height and weight measured.
- Your child may be recorded using a video camera in PE class to measure how well they can:
    - run; horizontal jump; strike; stationary dribble; skip; vertical jump; static balance; catch; kick and; overhand throw.
- Your child may be recorded using a video camera in PE class to assess the following:
    - deep squat; hurdle step; in-line lunge; shoulder mobility; active straight leg raise; trunk stability push-up and; rotary stability test.

A small subset of students will be selected to take part in two focus groups based on their experiences of movement and the Project FLAME programme before and after taking part in the project for the purpose of improving the project by listening to young people's experiences. If you would like your child to be eligible to take part in these focus groups, please tick the following box:

☐

All information gathered will be treated in the strictest of confidence. To ensure this, your child's name will be removed from all data and replaced with an ID number. Only the researchers will know your child's ID number, and only the researchers will have access to the information.

Please read Option 1 and Option 2 below and complete as appropriate.

Option 1: Child to be removed from the study
I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I request that my child is **not** included in the study. I understand that my child will not be penalised in any way for doing this.

ACTION: No further action necessary. Please file this consent form for future reference.

Option 2: Child to be included in the study
I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I understand that all students, including my child, are included in this study.

ACTION: To advise the research team of your decision please sign and return this form to your child's PE teacher for attention of Dr. Wesley O' Brien. Please use the envelope provided.

Parent/Guardian Signature: _____

Name in Block Capitals: _____

Child's Signature: _____

Child's Name in Block Capitals: _____

Date: _____

For further information please contact Mr. Conor Philpott or Mr. Brian Donovan

Mr. Conor Philpott

Email: [redacted]

Tel: [redacted]

Mr. Brian Donovan

Email: [redacted]

Tel: [redacted]

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Project FLAME

Focus Group Information and Consent Form

Purpose of the Study. As part of the requirements for the Master by Research degree at UCC, I have to carry out a research study. The study is concerned with evaluating the effectiveness of and developing the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention on motor competence development in adolescents.

What will the study involve? The study will involve taking part in two focus groups with approximately 5 participants. The focus groups will discuss the topics of motor competence and the Project FLAME intervention. These focus groups will take approximately one hour on each occasion.

Why have you been asked to take part?

You have been asked to take part in this focus group because your school has been selected to take part in the Project FLAME intervention and you are between the ages of 12-16.

Do you have to take part?

No, you are under no obligation to take part in the study. Participation is voluntary. If you would like to take part in the study, you must sign and return the consent form overleaf. If you agree to participate but change your mind before the study begins, you will be able to withdraw without giving any reason. If you have taken part in the study but would like to withdraw your information, you will have up to two weeks after the focus group takes place to do so. If a participant wishes to withdraw, all efforts will be made to extract their individual comments. However, it can be difficult to identify specific individual's comments on an audio-recording and also can be difficult to disentangle the comments of one person from the overall group dynamic.

Will your participation in the study be kept confidential?

Yes. Confidentiality is an important issue during data collection. Participant's identity, or other personal information, will not be revealed or published. Participants will be assigned an ID number, or a pseudonym, under which Due to the group discussion nature of a focus group, it will not be possible to ensure that other participants will keep information they hear confidential, however this will be explicitly discouraged in the focus group meeting.

What will happen to the information which you give?

All personal information will be stored in a secure file and saved in password protected file in a computer at UCC. The investigators alone will have access to the data. Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions. On completion of the project, data will be retained for minimum of a further ten years and then destroyed as specified by the UCC research guidelines.

What will happen to the results?

The results obtained may be presented in a thesis. They will be seen by my supervisor, a second marker and the external examiner. The thesis may be read by future students on the course. The study may also be published in research journals.

What are the possible disadvantages of taking part?

I don't envisage any negative consequences for you in taking part.

What if there is a problem?

While there are no negative consequences of taking part in the study envisaged, if a participant has any problem arising from taking part in the study you can contact the UCC Office of the Vice President for Research & Innovation, [redacted] UCC.
Tel: [redacted] Email: [redacted]

Who has reviewed this study?

This study has been reviewed and approved by the Social Research Ethics Committee of University College Cork.

Any further queries? If you need any further information, you can contact either:

Brian Donovan [redacted] *Conor Philpott* [redacted] *Wesley O'Brien* [redacted]

If you agree to take part in the study, please sign the consent form overleaf.

Focus Group CONSENT FORM

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

I……agree to participate in Mr. Brian Donovan and Conor Philpott's research study.

The purpose and nature of the study has been explained to me in writing.

I am participating voluntarily.

I give permission for my focus group with Mr. Brian Donovan and Mr. Conor Philpott to be audio-recorded.

I understand that I can withdraw from the study, without repercussions, at any time, whether before it starts or while I am participating.

I understand that I can withdraw permission to use the data within two weeks of the focus group, in which case the material will be deleted.

I will respect the confidentiality of other members of the focus group.

I understand that anonymity will be ensured in the write-up by disguising my identity.

I understand that disguised extracts from my interview may be quoted in the thesis and any subsequent publications if I give permission below:

(Please tick one box:)

I agree to quotation/publication of extracts from my interview ☐

I do not agree to quotation/publication of extracts from my interview ☐

Parent's/Guardian's Signatures: 1: …… PRINT: …….

2: …… PRINT:……..

Participant's Signature: ……. PRINT: …….

Date: …….

Project FLAME Information and consent sheet: PMC Data collection (2021)

October 2021

Dear Parent/Guardian,

Please find overleaf an informed consent form for your child's participation in a movement study entitled 'Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'. This study is being carried out by University College Cork in your child's school. The study aims to gather information on the movement vocabulary and physical activity levels of students in the school and develop a plan to help improve these levels, and then to assess whether or not activity levels have been improved.

In order for your child to participate in this study, please read the attached form. If you do not wish your child to be involved, then you need to take no further action and may dispose of the form. If you DO wish your child to participate in the study, then I kindly request that both you and your child sign and return Option 2 at the bottom of the form.

Thank you for your time.

Yours sincerely,

Wesley O' Brien

Wesley O' Brien. Ph.D.

Principal investigator

Informed Consent Form

Project Title: Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'

Investigators: Dr. Wesley O' Brien and Mr. Conor Philpott.

Introduction to the study:

The ability to move with fundamental and functional competence has been shown to be extremely beneficial to youth in enabling them to move well and move often and is a key determining factor in physical activity participation. In order to develop effective physical activity programmes for your child's age group, it is important that researchers understand the factors that influences adolescents in Ireland to become and remain active. This study will involve collecting information on adolescent perceptions of their skill and its influence on their actual skill.

This is what will happen during the research project:

- Your child may complete a physical activity and movement-based questionnaire. This questionnaire will be filled out in class with the help of the class teacher and Mr. Conor Philpott.

All information gathered will be treated in the strictest of confidence. To ensure this, your child's name will be removed from all data and replaced with an ID number. Only the researchers will know your child's ID number, and only the researchers will have access to the information collected.

Please read Option 1 and Option 2 below and complete as appropriate.

Option 1: Child to be removed from the study

I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I request that my child is not included in the study. I understand that my child will not be penalised in any way for doing this.

ACTION: No further action necessary. Please file this consent form for future reference.

Option 2: Child to be included in the study

I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I understand that all students, including my child, are included in this study.

ACTION: To advise the research team of your decision please sign and return this form to your child's PE

teacher for attention of Dr. Wesley O' Brien. Please use the envelope provided.

If you are happy to partake in this questionnaire study in University College Cork. Please tick this box. ☐

Parent/Guardian Signature:_____

Name in Block Capitals: _____

Child's Signature: _____

Child's Name in Block Capitals: _____

Date: _____

Appendix D: Data Collection Material:

D1	Researcher's Handbook
D2	Perceived Movement Competence Questionnaire- PF-PMC Questionnaire 2019 & 2021
D3	Perceived Functional Movement Competence Questionnaire.

Project FLAME Researcher's Handbook (containing skill criteria)

Data Collection Checklist – Project FLAME

GENERAL GUIDELINES:

Press RECORD at the start of each group and STOP the camera at the end of each group.

Call out the ID CODE of the student at the start of each skill/movement, for example, 'AA131 Practice'; 'AA131 Trial 1'; 'AA131 Trial 2'.

Give NO FEEDBACK to students during any of the FMS tests.

Ensure the camera is in a fixed position i.e. on a tripod, on a table etc. DO NOT hold the camera by hand as it can be difficult to assess the skill/movement if there is any disturbance/shaking.

Ensure that you follow the list of the participants within their group in ORDER of their ID code.

If there are any issues or problems call over the FLOATING RESEARCHER (Wesley, Brian or Conor) for help**.**

FUNDAMENTAL MOVEMENT SKILLS (FMS):

3 attempts at each skill (1 practice followed by 2 trials)

It is very important that the DEMONSTRATION of the skill is performed correctly by the researcher and that ALL students are paying attention to the demonstration. Instruct the students to repeat/copy exactly what the researcher has demonstrated.

Be strict with students to a degree by not allowing them to begin the practice or trial until you have given them the signal etc.

Ask students if they are LEFT HANDED for the THROW and STRIKE and if they use with their LEFT FOOT for the KICK. If so move the camera to the opposite side. Note that the use of the baseball grip can be confusing so let students feel it out themselves and only adjust the camera if students position themselves in that way.

TWO HANDED CATCH – Ensure the researcher is the one who throws the tennis ball to the student for this skill. Throw the ball underarm and slightly in front of the student to allow them to reach to collect it as opposed to throwing the tennis ball directly at/to them. Advise that it's always a TWO-HANDED catch!

DRIBBLE – Advise that it's FOUR BOUNCES in total using the same hand and then catch.

HORIZONTAL/VERTICAL JUMP – Begin with feet side by side and shoulder width apart. Use a line on the floor as the mark.

THROW – Instruct students to throw the beanbag as HARD as they can at the target wall.

Fundamental Movement Skill Testing Descriptions (courtesy of TGMD-2 Manual)

Run-

Skill	Materials	Directions
1. Run	60 feet of clear space, and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial.

Striking a stationary ball

Skill	Materials	Directions
1. Striking a Stationary Ball	A 4-inch lightweight ball, a plastic bat, and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial.

Catch

Skill	Materials	Directions
3. Catch	A 4-inch plastic ball, 15 feet of clear space, and tape	Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial.

Kick

Skill	Materials	Directions
4. Kick	An 8- to 10-inch plastic, playground, or soccer ball; a beanbag; 30 feet of clear space; and tape	Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the bean-bag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.

Horizontal Jump

Skill	Materials	Directions
5. Horizontal Jump	A minimum of 10 feet of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he or she can. Repeat a second trial.

Overhand Throw

Skill	Materials	Directions
5. Overhand Throw	A tennis ball, a wall, tape, and 20 feet of clear space	Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.

Stationary Dribble

Skill	Materials	Directions
2. Stationary Dribble	An 8- to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat, hard surface	Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial.

Victorian FMS Manual- Balance



1 2 3 4 5



1 3 4

Balance:

Participants are asked to balance on one leg with arms stretched out to the sides of their body.

Vertical Jump

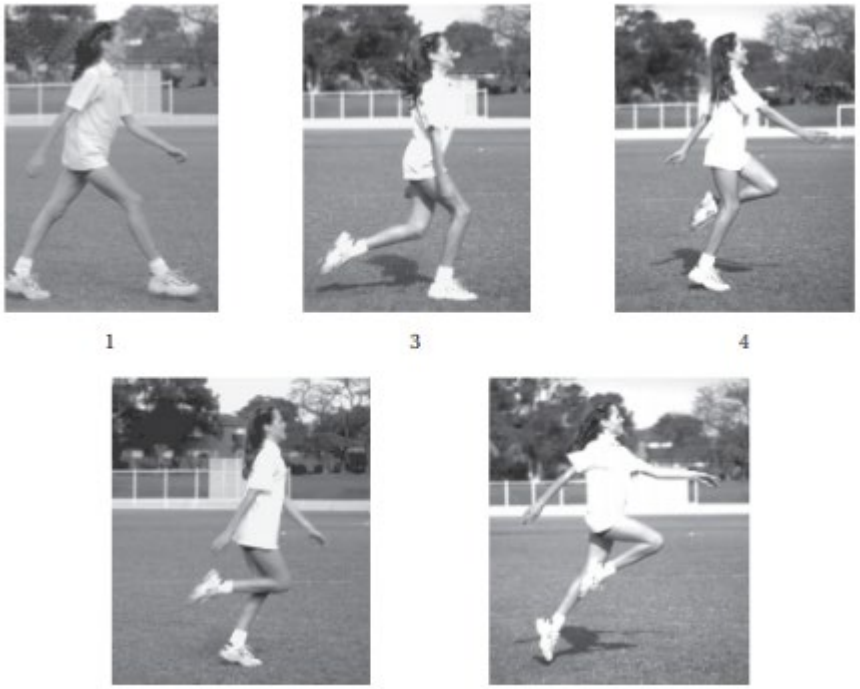


1 2 3 4 5 6

Vertical Jump:

Participants stand side on to the camera and are told to jump upwards as high as they can.

Skip-TGMD-1 (PHOTO credit- Get Skilled Get Active)



1 3 4

Skip:

The Skip is performed on the same 20m length track as the Run. In your demonstration, ensure that your arms and legs move in opposition.

Camera Positions for FMS (Front; Side):

Balance = Front	Catch = Side
Dribble = Front	Horizontal Jump = Side
Kick = Side	Run = Side
Skip = Side	Strike = Side
Throw = Side	Vertical Jump = Side

Fundamental Movement Skills (FMS)

Performance Criteria – Simplified Language

BALANCE [GET SKILLED: GET ACTIVE]
(1) Standing leg still, foot flat on the ground.
(2) Non-standing leg bent back behind at the knee, not touching the standing leg.
(3) Head stable, eyes focused forward.
(4) Body stable and upright.
(5) Arms stretched out wide at the sides with no excessive movements.
CATCH [TGMD-2]
(1) Preparation phase where hands are in front of the body and elbows are bent.
(2) Arms reach out for the ball as it arrives.
(3) Ball is caught by both/two hands only.

DRIBBLE [TGMD-2]
(1) Contacts ball with one hand at about waist level.
(2) Pushes ball with fingertips (not a slap).
(3) Ball contacts surface in front of or to the outside of foot on preferred side.
(4) Maintains control of ball for four bounces in a row without having to move the feet to retrieve it.

HORIZONTAL JUMP [TGMD-2]
(1) Preparatory movement includes bending of both knees with arms stretched out behind body.
(2) Arms reach forcefully forward and upward with full extension above the head.
(3) Take off and land on both feet together.
(4) Arms thrust downward during landing.
KICK [TGMD-2]
(1) Rapid continuous approach to the ball.
(2) An elongated stride or leap immediately prior to ball contact.
(3) Non-kicking foot placed even with (to the side) or slightly behind the ball.
(4) Kicks ball with instep of preferred foot (shoelaces) or toe.
RUN [TGMD-2]

(1) Arms alternately moving in opposition to legs, elbows bent.
(2) Brief period where both feet are off the ground.
(3) Narrow foot placement landing on heel or toe.
(4) Non-standing leg bent approximately 90 degrees.
SKIP [TGMD]
(1) A rhythmical repetition of the step-hop on alternate feet.
(2) Foot of non-standing leg carried near surface during the hop phase.
(3) Arms alternately moving in opposition to legs at about waist level.

STRIKE [TGMD-2]
(1) Dominant hand grips bat above non-dominant hand (as the bat is pointing up).
(2) Non-preferred side of body faces the imaginary thrower with feet shoulder width apart.
(3) Hip and shoulder rotate/turn during swing.
(4) Transfers body weight to front foot.
(5) Bat contacts ball.
THROW [TGMD-2]
(1) Wind-up is initiated with downward movement of hand/arm.

(2) Rotates hip and shoulder to a point where the non-throwing side faces the wall.
(3) Weight is transferred by stepping with the foot opposite the throwing hand.
(4) Follow-through with hand beyond ball release diagonally across the body towards the nonpreferred side.
VERTICAL JUMP [GET SKILLED: GET ACTIVE]
(1) Eyes focused forward or upward throughout the jump.
(2) Crouch with knees bent and arms behind the body.
(3) Forceful forward and upward swing of the arms.
(4) Legs straighten in air.
(5) Land on balls of feet and bend knees to absorb landing.
(6) Controlled landing with <1 step any direction.

FUNCTIONAL MOVEMENT SCREEN (FMS™):

3 attempts at each movement.

The researcher is NOT required to DEMONSTRATE the movement, however, do show them the starting position to save time and explain what they will be doing from there to successfully complete the movement.

Note that FIVE of the seven tests of the Functional Movement Screen must be assessed on both right and left sides of the body, namely the Active Straight Leg Raise, Hurdle Step, In-Line Lunge, Rotary Stability and Shoulder Mobility.

ROTARY STABILITY – Get students to adjust the side of their body facing the camera for right and left sides accordingly as opposed from the tester adjusting the camera. Begin with the score of ‘2’ movement and if successful instruct students to attempt the ‘3’ (i.e. same arm same leg) and 6 inches or so off the ground is sufficient.

The Functional Movement Screen (FMS™)

Performance Criteria adopted from FMS™ – Simplified Language

ACTIVE STRAIGHT LEG RAISE (Right and Left)
(1) Knee on floor remains touching the ground.
(2) Leg on floor does not turn outwards at the hip.
Testing Protocol: • Lay flat with the back of your knees against the 2x6 with your toes pointing up. • Place both arms next to your body with the palms facing up. • Pull the toes of your right foot toward your shin. • With the right leg remaining straight and the back of your left knee maintaining contact with the 2x6, raise your right foot as high as possible.
DEEP SQUAT
(1) Dowel fully pressed overhead and aligned over feet.
(2) Toes point forward.
(3) Knees aligned over feet and knees do not go passed the toe line.
(4) Thighs break parallel with the floor on the way down.

Testing Protocol: Stand tall with your feet approximately shoulder width apart and toes pointing forward. • Grasp the dowel in both hands and place it horizontally on top of your head so your shoulders and elbows are at 90 degrees. • Press the dowel so that it is directly above your head. • While maintaining an upright torso, and keeping your heels and the dowel in position, descend as deep as possible. • Hold the descended position for a count of one, then return to the starting position. • The participant can perform the move up to three times total if necessary. If a score of three is not achieved, repeat above instructions using the 2 x 6 under the client's heels.
HURDLE STEP
(1) Hips, knees and ankles aligned.
(2) Maintains a stable body with minimal to no movement in lower back.
(3) Dowel and hurdle remain parallel.
(4) Foot and/or heel touches the floor while standing leg remains in extended position.
(5) No contact between foot and hurdle.
Testing Protocol: • Stand tall with your feet together and toes touching the test kit. • Grasp the dowel with both hands and place it behind your neck and across the shoulders. • While maintaining an upright posture, raise the right leg and step over the hurdle, making sure to raise the foot towards the shin and maintaining foot alignment with the ankle, knee and hip. • Touch the floor with the heel and return to the starting position while maintaining foot alignment with the ankle, knee and hip.
IN-LINE LUNGE
(1) Dowel remains in contact with head, [middle] back and backside.
(2) Dowel remains vertical.
(3) No body movement (i.e. balance is maintained).
(4) Knee touches board behind heel of front foot.
(5) The front heel remains in contact with the board and the back heel touches board when returning to starting position.

Testing Protocol:
• Place the dowel along the spine so it touches the back of your head, your upper back and the middle of the buttocks.
• While grasping the dowel, your right hand should be against the back of your neck, and the left hand should be against your lower back.
• Step onto the 2x6 with a flat right foot and your toe on the zero mark.
• The left heel should be placed at _____mark. This is the tibial measurement marker.
• Both toes must be pointing forward, with feet flat.
• Maintaining an upright posture so the dowel stays in contact with your head, upper back and top of the buttocks, descend into a lunge position so the right knee touches the 2x6 behind your left heel.
• Return to the starting position.

ROTARY STABILITY
(1) Ankles with toes tucked under (i.e. dorsiflexion).
(2) Back remains flat/parallel to board).

Testing Protocol:
• Get on your hands and knees over the 2x6 so your hands are under your shoulders and your knees are under your hips.
• The thumbs, knees and toes must contact the sides of the 2x6, and the toes must be pulled toward the shins.
• At the same time, reach your right hand forward and right leg backward, like you are flying.
• Then without touching down, touch your right elbow to your right knee directly over the 2x6.
• Return to the extended position.
• Return to the start position.

SHOULDER MOBILITY
(1) Does not walk hands towards each other (i.e. one single motion).
(2) Head remains in neutral position (i.e. looking straight ahead).

Testing Protocol:
• Stand tall with your feet together and arms hanging comfortably.
• Make a fist so your fingers are around your thumbs.
• In one motion, place the right fist overhead and down your back as far as possible while simultaneously taking your left fist up your back as far as possible.
• Do not “creep” your hands closer after their initial placement.

TRUNK STABILITY PUSH-UP
(1) Body lifts as a unit with no delay in lower back when performing the push-up.

(2) Ankles with toes tucked under (i.e. dorsiflexion) in both the preparatory and performance phases of the movement.
Testing Protocol: • Lie face down with your arms extended overhead and your hands shoulder width apart. • Pull your thumbs down in line with the ___ (forehead for men, chin for women). • With your legs together, pull your toes toward the shins and lift your knees and elbows off the ground. • While maintaining a rigid torso, push your body as one unit into a push up position.

Camera Positions for FMS™:

Active Straight Leg Raise = Side

Deep Squat = Side

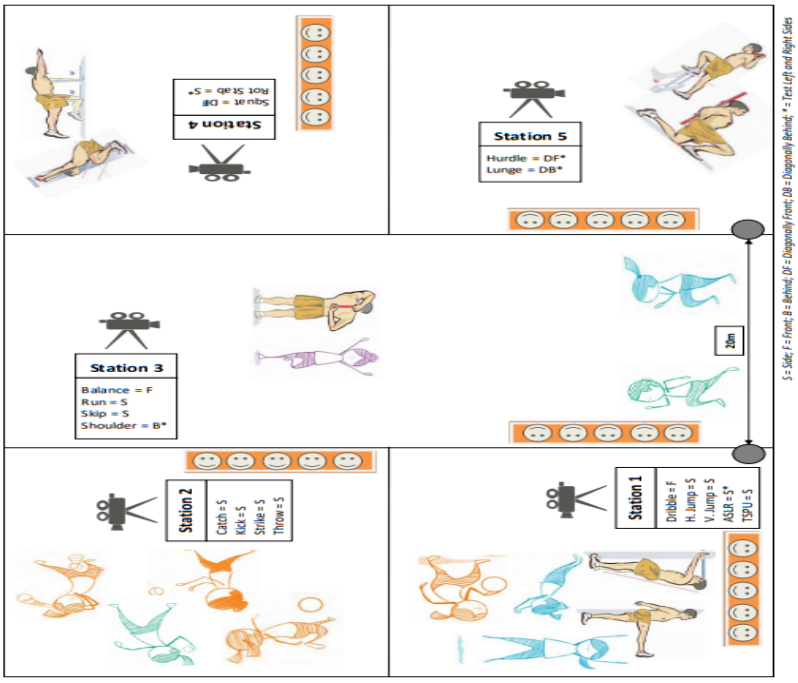
Hurdle Step = Diagonally Front

In-Line Lunge = Diagonally Behind

Shoulder Mobility = Behind

Rotary Stability = Side

Trunk Stability Push Up = Side



Data Collection Questionnaires: 2019 and 2021 Project FLAME PMC Questionnaire:

Perceived Movement Competence Questionnaire- Project FLAME

The picture(s) alongside each movement show a perfect performance of the movement.

Based on your experience of performing these movements and how hard you think they may be to do use the scale below (1-10) to indicate how well you can correctly perform each movement.

After the Question you will see a photo of the image to remind you of the skill. Read the questions carefully!!!

1 = not well at all,

5 = reasonably well

10 = very well

Please also add your name and/or your student code, and your date of birth (DOB) in the spaces below

Name _____

Student Code_____

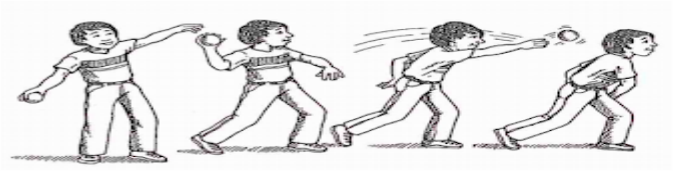
DOB:_____

1. Throw

Use the scale below (1-10) to indicate how well you can throw a beanbag overarm, on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Throw



2. Catch

Use the scale below (1-10) to indicate how well you can catch a tennis ball with two hands on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Catch

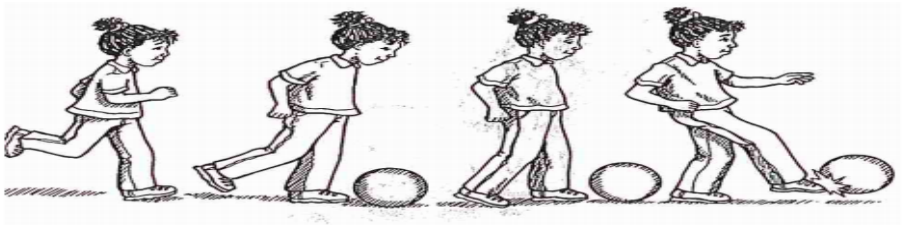


3. Kick

Use the scale below (1-10) to indicate how well you can kick a large ball placed on the floor scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Kick



4. Dribble

Use the scale below (1-10) to indicate how well you can bounce a ball (dribble) with your hand four times in a row while standing on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Bouncing a ball (Dribble)



5. Strike

Use the scale below (1-10) to indicate how well you can strike a non-moving ball placed in front of you at hip height with a bat (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Strike



6. Balance

Use the scale below (1-10) to indicate how well you can balance on one foot scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at All	○	○	○	○	○	○	○	○	○	○	Very Well

Balance



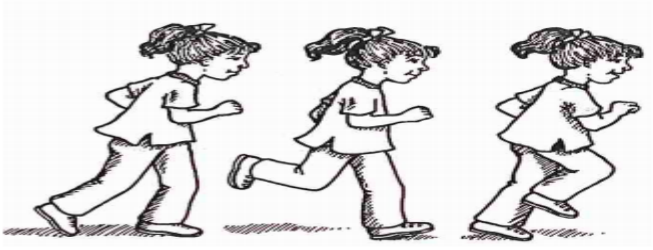


7. Run

Use the scale below (1-10) to indicate how well you can run forward in a straight on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at All	○	○	○	○	○	○	○	○	○	○	Very Well

Run

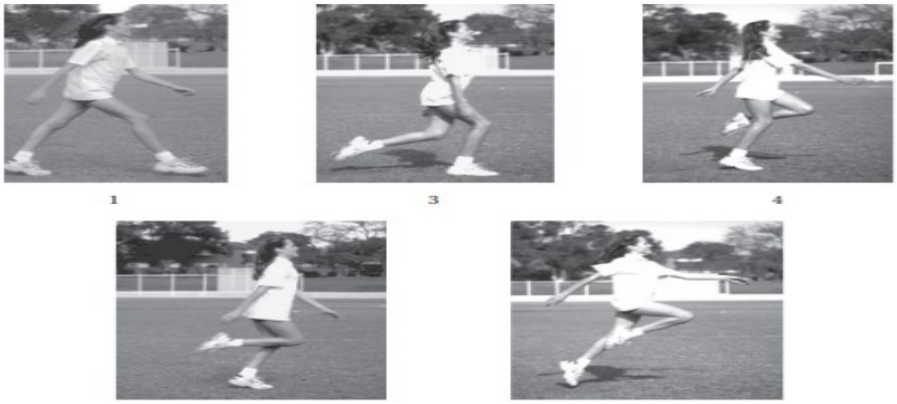


8. Skip

Use the scale below (1-10) to indicate how well you can Skip in a straight line on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Skip



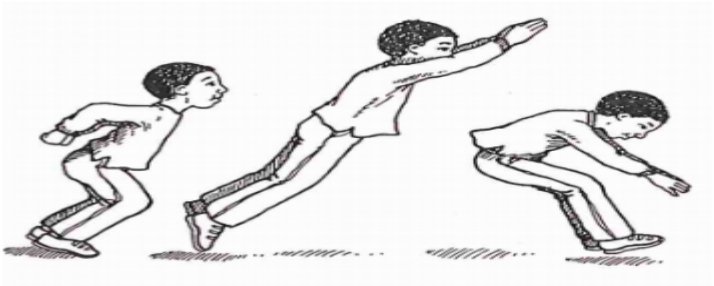
1 3 4

9. Horizontal Jump

Use the scale below (1-10) to indicate how well you can jump for distance (Horizontal Jump) from standing still on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well at all	○	○	○	○	○	○	○	○	○	○	Very Well

Horizontal Jump (Jump for Distance)



10. Vertical Jump

Use the scale below (1-10) to indicate how well you can jump for height (Vertical Jump) from standing still on a scale of 1-10 (with 1 = not well at all, 5 = reasonably well, 10 = very well) *

	1	2	3	4	5	6	7	8	9	10	
Not Well	○	○	○	○	○	○	○	○	○	○	Very Well

Vertical Jump (Jump for height)







Perceived Functional Movement Competence Questionnaire

1 2 3 4 5 6 7 8 9 10

Active Straight Leg Raise



Deep Squat





1 2 3 4 5 6 7 8 9 10

Hurdle Step

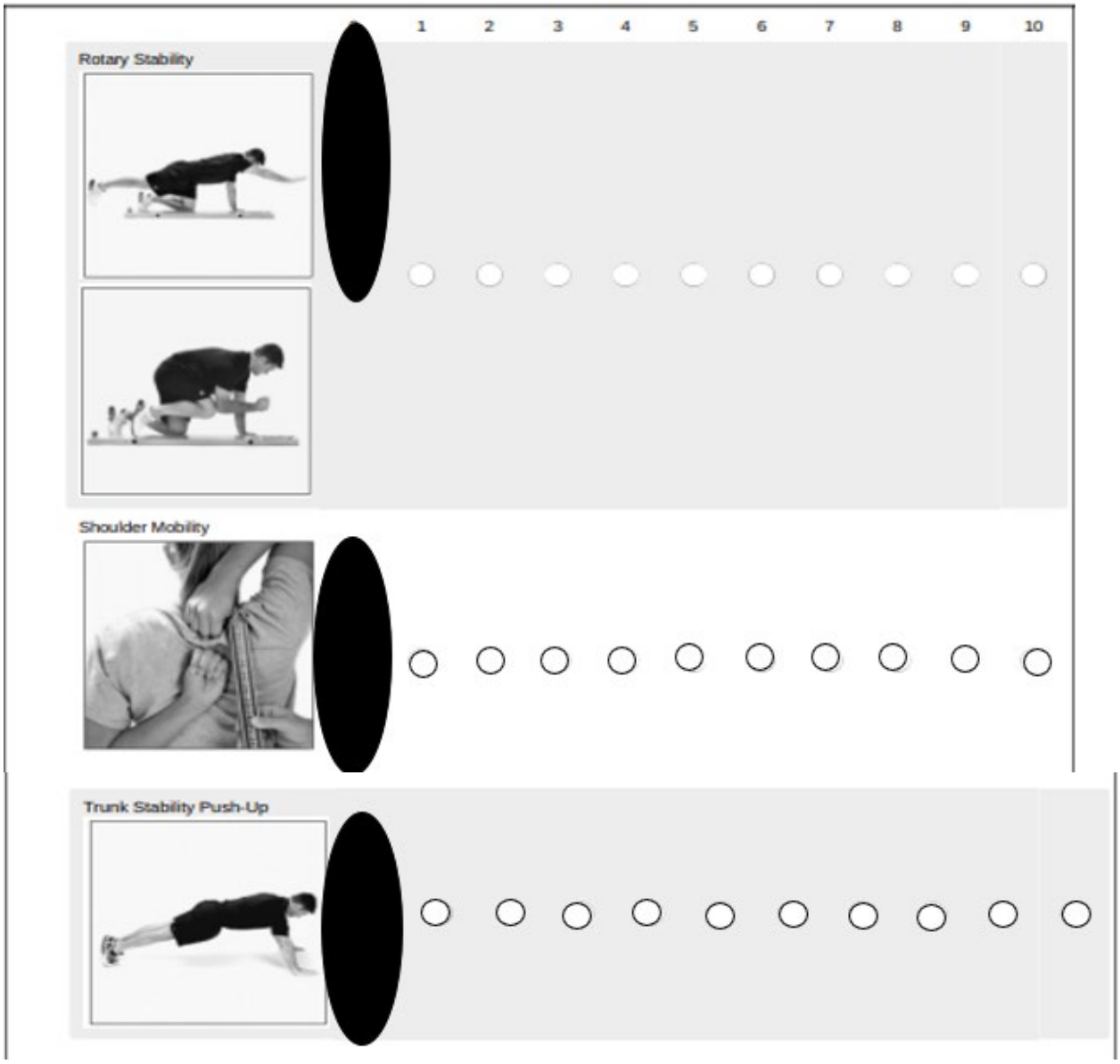




In-Line Lunge






1 2 3 4 5 6 7 8 9 10
Rotary Stability
Shoulder Mobility
Trunk Stability Push-Up

Appendix E: Project FLAME Resource Materials:

E1	**Project FLAME- How to use our resource pack**
E2	**The Project FLAME intervention teacher guidelines**
E3	**Sample 8-week intervention programme**
E4	**Project FLAME Practitioner's handbook**
E5	**Project FLAME Activities- Youtube Links**

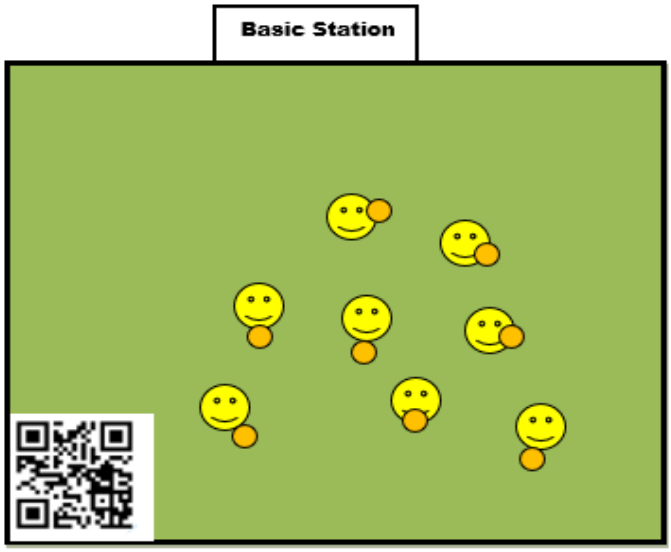
Project FLAME- How to use our resource pack

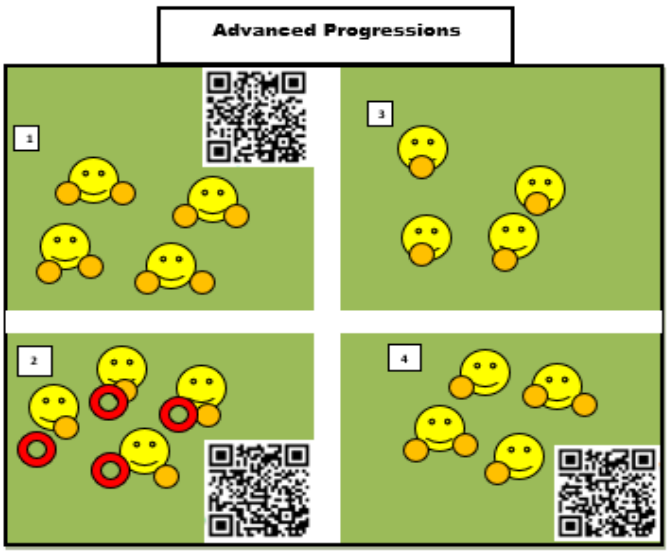
This resource pack contains 17 movement patterns across a range of locomotor, object, and functional movement skills. The pack is comprised of one card for each of the seventeen movements, each card has two sides. The first page contains suggested activities to develop the skill, while the second page contains visual and written elements of the key cues associated with the skill and suggested activities and sports in which the skill is relevant.

Each card has a minimum of two activities for use in activity settings (e.g. PE Lessons or Coaching Contexts), which move from basic to more advanced progressions of the movement. The basic stage focuses on the essential elements of the skill which are practiced in a low-intensity paired or individual performances. The advanced progressions typically contain activities at a greater intensity and are suited to larger work in groups. The fundamental aim of this intervention is to increase movement proficiency from basic to advanced for all learners, in the interests of improving their physical competence and activity levels.

The ideas outlined in this resource pack are not a prescriptive programme to be administered, rather they are guidelines which can improve movement capabilities. The activities outlined serve as the medium through which the key skill cues can be taught, practiced, and developed. Alterations depending on environmental context and the pedagogical strategies of the instructor are welcomed.

Activities Page: On the first page of the card, the activities page, sample diagrams of activities for the movement are provided. For each of the suggested activities, there is a QR code link to a YouTube video of the activity in practice. iPhones and iPads that have been updated to iOS 11 (or more recent updates) will allow your camera app to scan a QR code directly and bring you to the video. Android users may require a QR code reader from the Google Play store. In developing this pack, our research team utilised the Q.tk scanner developed by Q Inc, 2.3.135, which is freely available. A sample image of the Dribble activity page with QR codes is shown below.





Basic Station Explanations:

Explore the dribble using a range of the following:

- What different parts of the hand can you use to dribble the ball?
- How soft can you dribble the ball or how hard?
- How low can you dribble the ball or how high?
- How close to the body can you dribble the ball or how wide?

Advanced Progressions:

1) Dribble two balls at the same time.
2) Dribble around the area and each time a student comes to a cone they do a full circle around the cone while maintaining control of the ball.
3) KING OF THE HILL (NEW VIDEO REQUIRED)
4) Dribble the ball while sitting flat using one ball or two.

The second page on each card, the skill cues page, is pivotal to the project. As outlined earlier, our activities will be beneficial, but are not prescriptive. When teaching these skills, focusing on the key movement pointers is of critical importance to the development of the participant's movement proficiency. Both the written and visual elements serve to communicate these movement cues to both instructors and students. The criteria for mastering the movement are also outlined on the card. A sample of the Dribble card, which also outlines sports and activities that relate to this movement is presented below.

Sample second page of Card (Visual and Written Skill Cues)



DRIBBLE [TGMD-2]
(1) Contacts ball with one hand at about waist level.
(2) Pushes ball with fingertips (not a slap).
(3) Ball contacts surface in front of or to the outside of foot on preferred side.
(4) Maintains control of ball for four bounces in a row without having to move the feet to retrieve it.

Activities & Sports for this skill:

-Basketball - Gaelic Football (Hop)



A portion of the class will be devoted to work on these skills and patterns in each week. Here is a sample programme we have devised. It is not prescriptive, merely suggestive. To emphasise movement and skills in general, we encourage you to introduce movements that may not necessarily be associated with the sport or activity you are covering in PE lessons (e.g. at the start of a lesson for soccer, you could have a throwing element in the warm-up phase). In this sense, you are creating a movement skills phase of a lesson, which students can be made aware of. The purpose of this phase is to develop the students' cognitive knowledge of the movement (i.e. skill cues) and improve psychomotor capabilities (i.e. improve skill performance). Some of these skills/patterns are implicit in many elements of activity, as such the key cues can be repeated across the weeks. (e.g. run and skip are central to many forms of activity). The first time you engage in a skill/movement pattern we recommend using our basic stations, or similarly aligned activities.

Sample 8-Week Intervention Programme

Week	**Skills/Patterns to Work on**
Week 1	Throw/Catch, Balance
Week 2	Trunk Stability Push-Up, Shoulder Mobility, & Rotary Stability
Week 3	Deep Squat, Vertical Jump & Horizontal Jump,
Week 4	Hurdle Step, Run, & Skip
Week 5	Active Straight Leg Raise, Kick, & In-Line Lunge
Week 6	Dribble, Rotary Stability, & Trunk Stability Push-Up
Week 7	Strike, Throw & Deep Squat
Week 8	Vertical Jump & Horizontal Jump, Active Straight Leg Raise,

Project FLAME Practitioner's Handbook



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Project FLAME

Instructions

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SPORT IRELAND

UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland

Project FLAME

Project FLAME - How to Use the Resource Pack

This resource pack contains 17 movement skills patterns across a range of locomotor skills, object control skills, and functional movement patterns. The pack is comprised of one card for each of the seventeen movements, each card has two sides. The first page contains suggested activities to develop the skill, while the second page contains visual and written elements of the key cues associated with the skill and suggested activities and sports in which the skill is especially relevant.

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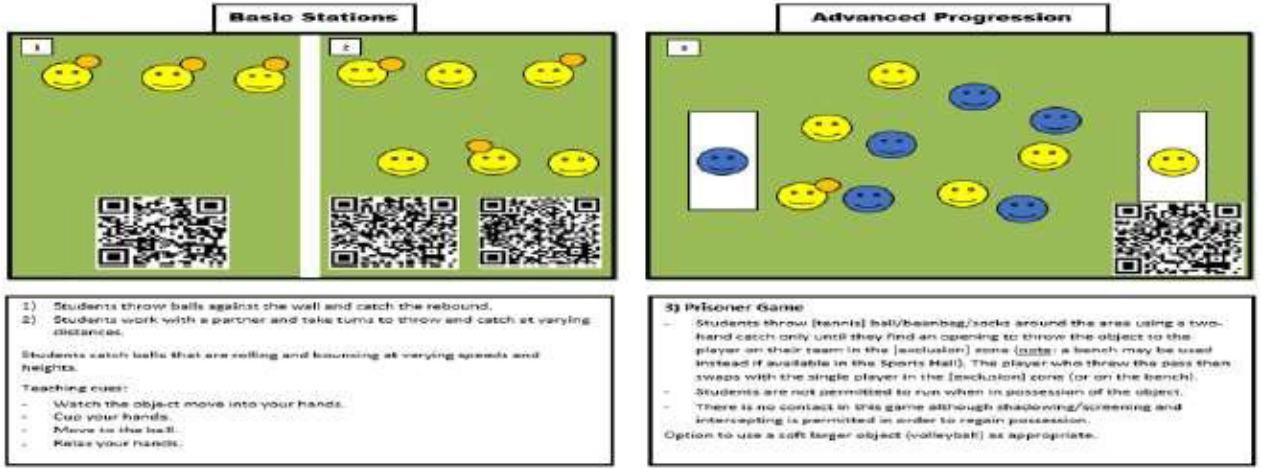
5

Instructions

Project FLAME - How to Use the Resource Pack

Activities Page:

On the first page of the card, the activities page, sample diagrams of activities for the movement are provided. For each of the suggested activities, there is a QR code link to a YouTube video of the activity in practice. iPhones and iPads that have been updated to iOS 11 (or more recent updates) will allow your camera app to scan a QR code directly and bring you to the video. Android users may require a QR code reader from the Google Play store. In developing this pack, our research team utilised the Q.tk scanner developed by Q Inc, 2.3.135, which is freely available. A sample image of the Catch card's activity page with QR codes is shown below.



6

Instructions

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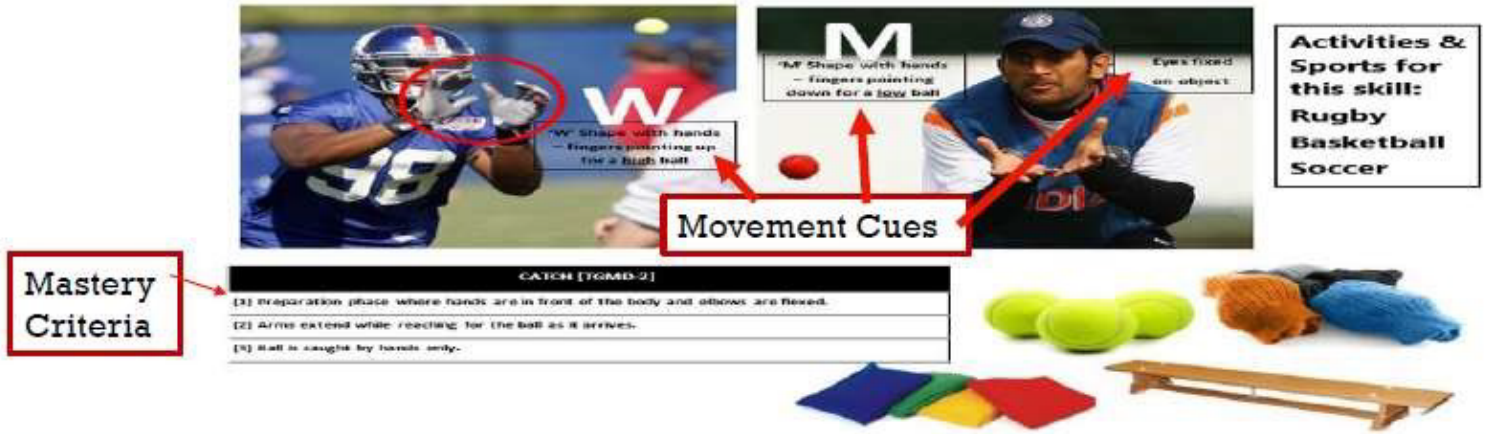
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Project FLAME

Project FLAME - How to Use the Resource Pack

Movement Cues Page:

The second page on each card, the skill cues page, is pivotal to the project. As outlined earlier, our activities will be beneficial, but are not prescriptive. When teaching these skills, focusing on the key movement pointers is of critical importance to the development of the participant's movement proficiency. Both the written and visual elements serve to communicate these movement cues to both instructors and students. The criteria for mastering the movement are also outlined on the card. A sample of the Catch card, which also outlines sports and activities that relate to this movement is presented below.



Health Related Fitness Activities

Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V-Jump	H-Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Gymnastics						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yoga & Pilates						✓					✓	✓	✓	✓		✓	✓
Strength & Conditioning						✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Flexibility /Mobility									✓	✓	✓	✓	✓	✓		✓	✓

Related Activities - Net/Divided Court Games

Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V-Jump	H-Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Badminton			✓			✓	✓		✓			✓		✓			✓
Volleyball	✓	✓			✓	✓	✓	✓	✓			✓		✓			
Tennis			✓	✓		✓	✓		✓			✓		✓			✓
Table Tennis			✓			✓					✓	✓		✓			
Spikeball	✓	✓				✓	✓	✓	✓		✓			✓			✓

Related Activities -Invasion Games

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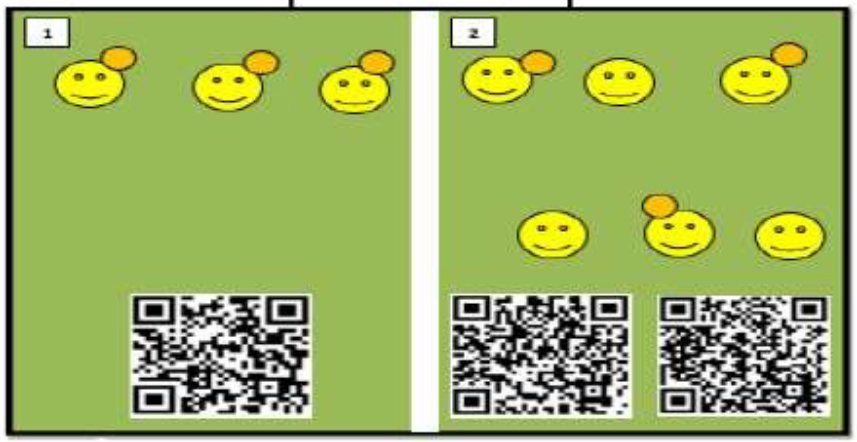
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Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V -Jump	H -Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Basketball	✓	✓			✓	✓	✓	✓	✓		✓			✓			
GAA	✓			✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	
Soccer	✓	✓		✓		✓	✓	✓	✓			✓	✓				
Rugby	✓			✓		✓	✓	✓	✓		✓		✓	✓		✓	✓
Olympic Handball	✓	✓			✓	✓	✓	✓	✓	✓				✓			✓
Ultimate Frisbee	✓	✓				✓	✓	✓	✓	✓				✓			✓
Hockey			✓			✓	✓	✓			✓	✓	✓	✓			✓

Catch

Basic Stations



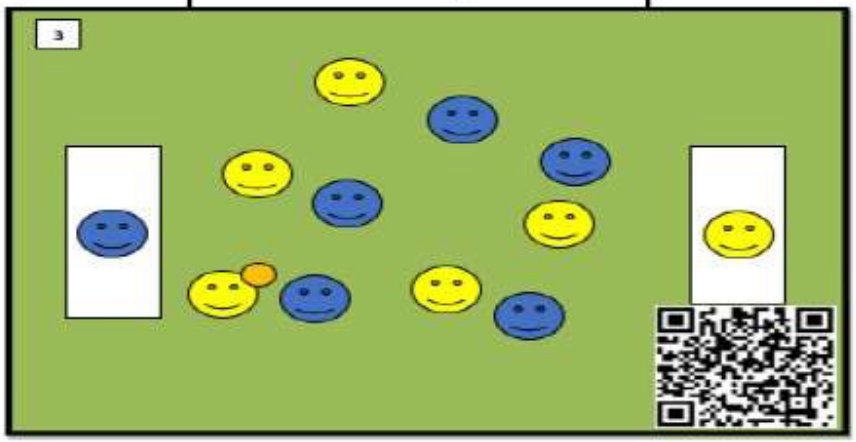
1) Students throw balls against the wall and catch the rebound.
2) Students work with a partner and take turns to throw and catch at varying distances.

Students catch balls that are rolling and bouncing at varying speeds and heights.

Teaching cues:

- Watch the object move into your hands.
- Cup your hands.
- Move to the ball.
- Relax your hands.

Advanced Progression



3) Prisoner Game

- Students throw [tennis] ball/beanbag/socks around the area using a two-hand catch only until they find an opening to throw the object to the player on their team in the [exclusion] zone (note: a bench may be used instead if available in the Sports Hall). The player who threw the pass then swaps with the single player in the [exclusion] zone (or on the bench).
- Students are not permitted to run when in possession of the object.
- There is no contact in this game although shadowing/screening and intercepting is permitted in order to regain possession.

Option to use a soft larger object (volleyball) as appropriate.

11

Catch





Activities & Sports for this skill:

Rugby

Basketball

Soccer

CATCH [TGMD-2]
(1) Preparation phase where hands are in front of the body and elbows are flexed.
(2) Arms extend while reaching for the ball as it arrives.
(3) Ball is caught by hands only.



12

Throw

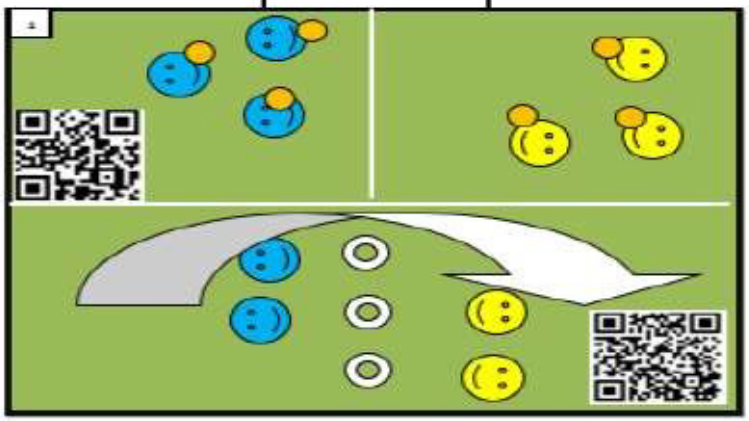
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Basic Station

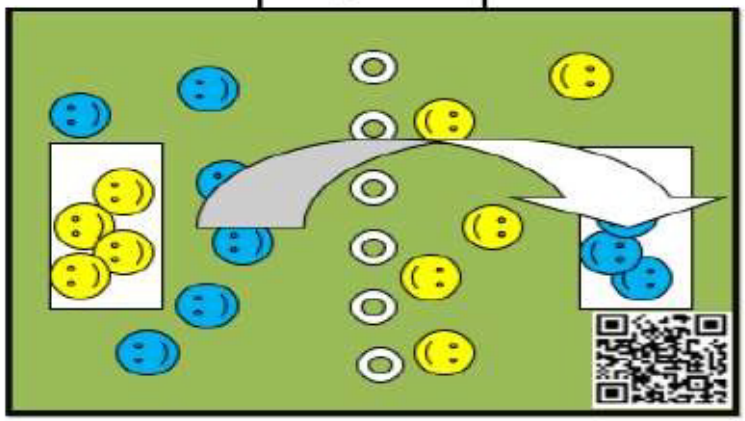


1) Students throw beanbag/socks/ball against a wall.
2) Students throw beanbag/socks/ball from one side to another for distance
- The speed and distance of the throw is determined by the follow-through.

Explore the throw using a range of the following:

- experiment with different hip, shoulder and feet movements as they throw.
- stand facing towards the target, keeping their hips and feet still.
- stand side-on and rotate their shoulders but not their hips.
- stand side-on and rotate hips and shoulders.
- take a small step as they throw to transfer their body weight.
- identify which position is the most efficient for distance and speed.
- Have students practice the throw from a sitting and kneeling position (optional).

Progression



- Students throw beanbag/socks from one side to the other trying to reach a member of their own team on the opposite side. This will free them from the box and allow them to rejoin their team.
- Students on the opposing team are not allowed into the box.
- Students may however also throw beanbag/socks at a member of the opposing team (below the waist) similar to the game of dodgeball.
- If hit, that student will then join their teammates in the box on the opposite side.

13

Throw



THROW [TGMD-2]
(1) Wind-up is initiated with downward movement of hand/arm.
(2) Rotates hip and shoulder to a point where the non-throwing side faces the wall.
(3) Weight is transferred by stepping with the foot opposite the throwing hand.
(4) Follow-through with hand beyond ball release diagonally across the body towards the non-preferred side.



Activities and Sports for this Skill:

- Olympic Handball
- Rounders
- Basketball

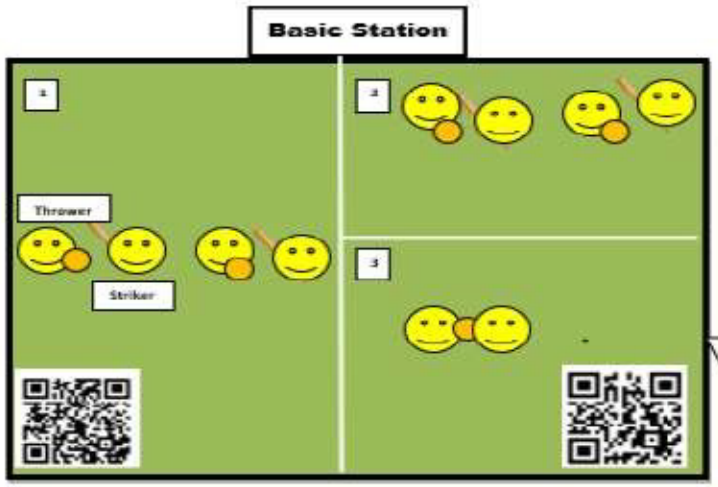
Show me the Nike logo using your arms

The most successful slogan in the world – 'Just Do It'

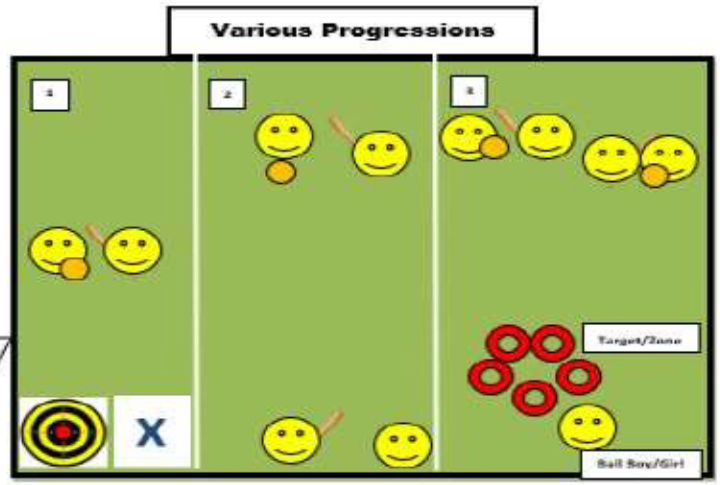


14

Strike



1) Strike the object as hard as possible at wall, partition or fence.
2) Strike the object as hard and as far as possible.
3) Partner Rotational Twists
   Explore the strike using a range of the following:
- swing with both arms bent.
- swing with both arms straight.
- make a 'half swing' with no follow-through.
- try a full swing and follow-through.
- -Work on swinging through the strike by passing to a partner, developing both sides in a twisting motion. (Activity 3)



1) [Wall] Strike the object forcefully at a target placed on the wall.
2) [Field] Strike the object to a partner standing at a distance (i.e. to encourage forceful striking). The striker on one side is partnered with the catcher on the opposite side (who then becomes the thrower on that side) and swap roles.
3) [Field] Strike the object forcefully at a target/zone placed on the ground at a distance (note: the aim is to land the object in the target/zone rather than have the object roll/bounce into the target).

Strike





Activities and Sports for this Skill:

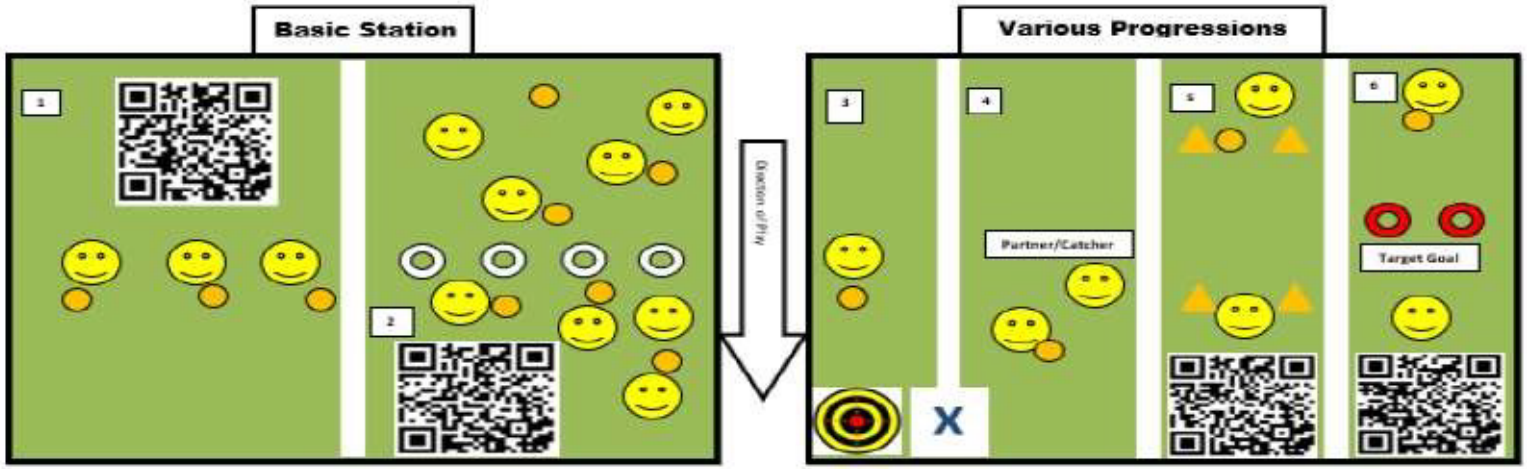
- Rounders
- Hurling
- Badminton

Ensure bats have a large surface area to facilitate successful attempts.
Use soft/larger objects to encourage forceful striking without the risk of injury.



STRIKE [TGMD-2]
(1) Dominant hand grips bat above non-dominant hand (as the bat is pointing up).
(2) Non-preferred side of body faces the imaginary thrower with feet shoulder width apart.
(3) Hip and shoulder rotate/turn during swing.
(4) Transfers body weight to front foot.
(5) Bat contacts ball.

Kick



1) Kick the ball as hard as possible at wall/partition or fence.

2) Kick the ball as hard and as far as possible from one side to the other. The aim is to kick the ball passed the group on the other side.

Explore the kick using a range of the following:
- approach the ball from directly behind and from an angle (i.e. from the side) to enable the kicking foot to follow through and touch the opposite hand.

3) [Hall] Kick the ball forcefully at a target placed on the wall.
4) [Hall] Kick the ball forcefully at the wall and attempt to land the rebound in the hands of a partner who cannot move their feet.

5) [Hall/Field] Kick the ball to partner's goal standing at a large distance apart (i.e. to encourage forceful kicking and accuracy as opposed to a short pass).

6) [Hall/Field] Kick the ball forcefully through a target goal on the ground at a distance

Kick

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Use soft balls to encourage forceful kicking without risk of injury. These balls won't travel very far.





Place ball on top of cone to encourage kicking with instep or shoelaces



Fast forward on approach to ball



Kick foot to opposite hand on follow-through

KICK [TGMD-2]
(1) Rapid continuous approach to the ball.
(2) An elongated stride or leap immediately prior to ball contact.
(3) Non-kicking foot placed even with (to the side) or slightly behind the ball.
(4) Kicks ball with instep of preferred foot (shoelaces) or toe.

Activities and Sports for this Skill:

- Soccer
- Gaelic Football
- Rugby

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Dribble

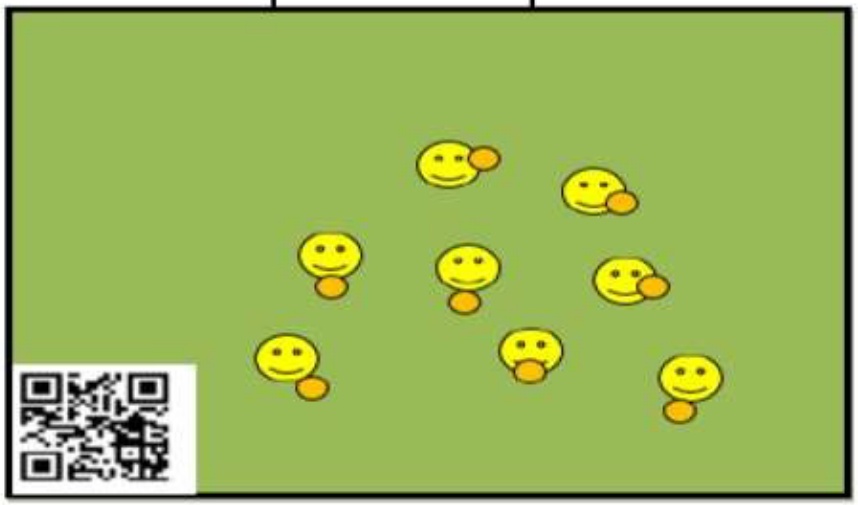
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Basic Station

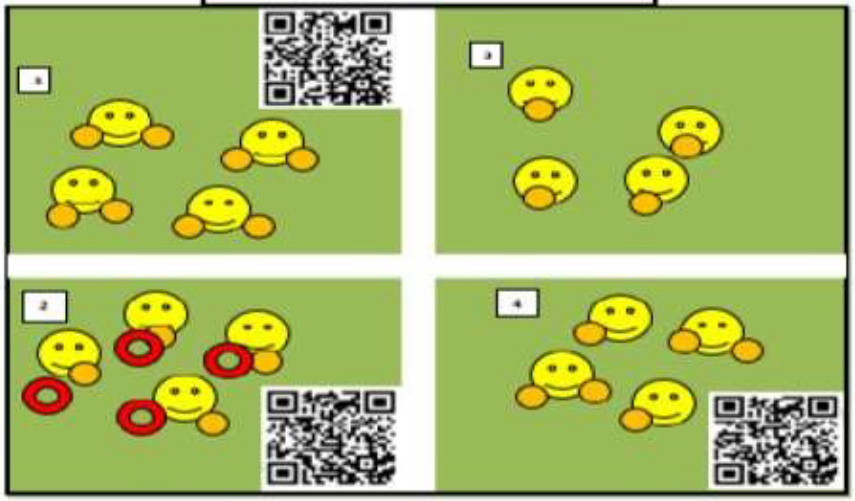


Basic Station Explanations:

Explore the dribble using a range of the following:

- What different parts of the hand can you use to dribble the ball?
- How soft can you dribble the ball or how hard?
- How low can you dribble the ball or how high?
- How close to the body can you dribble the ball or how wide?

Advanced Progressions



1) Dribble two balls at the same time.
2) Dribble around the area and each time a student comes to a cone they do a full circle around the cone while maintaining control of the ball.
3) King of the Ring: Each player dribbles a ball around the zone. The player must try to knock all other player's balls out of the zone while continuing to dribble and protect their own ball until they are the only remaining player.
4) Dribble the ball while sitting flat using one ball or two.

Dribble



DRIBBLE [TGMD-2]
(1) Contacts ball with one hand at about waist level.
(2) Pushes ball with fingertips (not a slap).
(3) Ball contacts surface in front of or to the outside of foot on preferred side.
(4) Maintains control of ball for four bounces in a row without having to move the feet to retrieve it.

Activities & Sports for this skill:

-Basketball - Gaelic Football (Hop)



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Balance

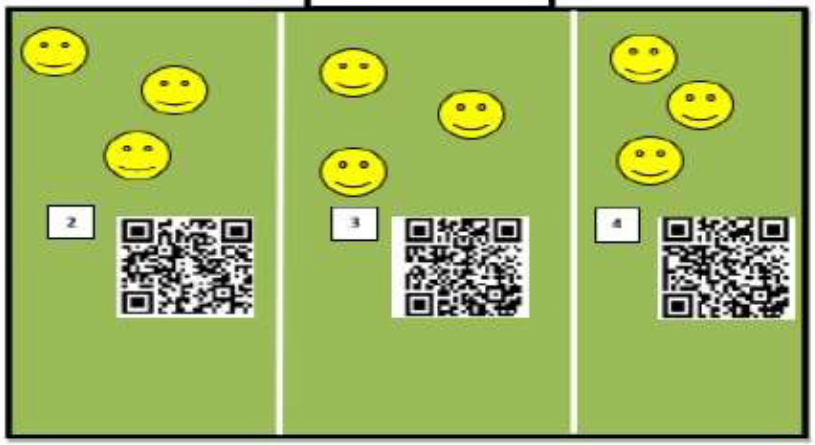
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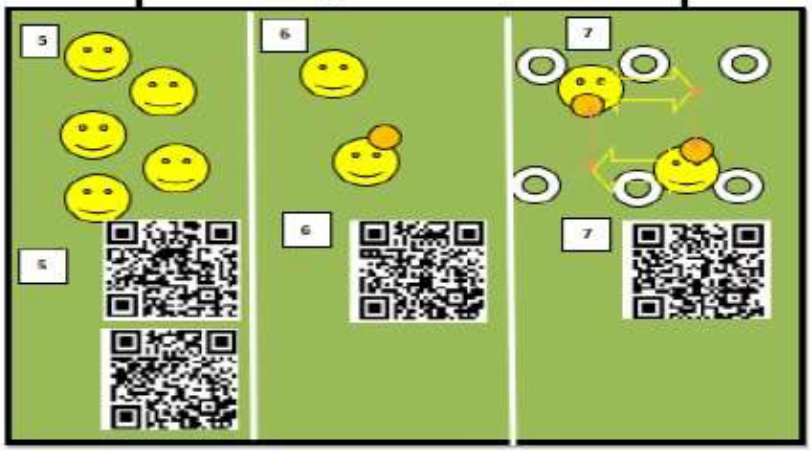
Basic



Challenge students to try the following activities with their eyes closed and/or on their non-preferred leg.

1) **Basic Balance. (Standing on one-foot alternating legs)**
2) **Balance and Arm Movements.**
3) **Balance and Object Control.**
4) **Balance and Twist.**

Various Dynamic Progressions



Challenge students to develop their ability to maintain or regain static balance from unstable positions including flight and while catching an object.

5) **Basic Lateral Bound with Balance.**
   Advanced Lateral Bound with Balance.
6) **Lateral Bound with Catch and Balance (Basic to Advanced).**
7) **Co-Operative Lateral Bound with Catch and Balance.**

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Balance

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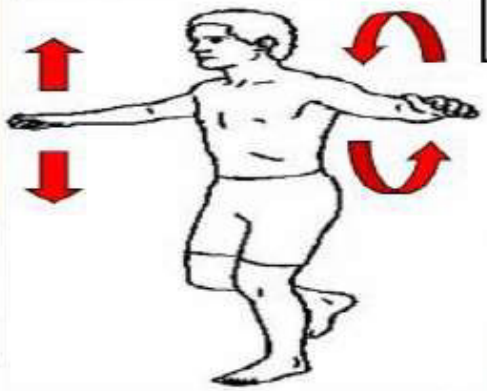
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Basic Balance

Maintain a stable and upright trunk by engaging the core while arms are working.



BALANCE [GET SKILLED: GET ACTIVE]
(1) Standing leg still, foot flat on the ground.
(2) Non-standing leg bent back behind at the knee, not touching the standing leg.
(3) Head stable, eyes focused forward.
(4) Body stable and upright.
(5) Arms stretched out wide at the sides with no excessive movements.

Activities & Sports for this skill:

Gymnastics & Dance, Team Games



Lateral Bound

Progress from a 'Basic' to an 'Advanced' Lateral Bound by increasing the height and/or distance while maintaining balance (single leg) on landing.



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Run

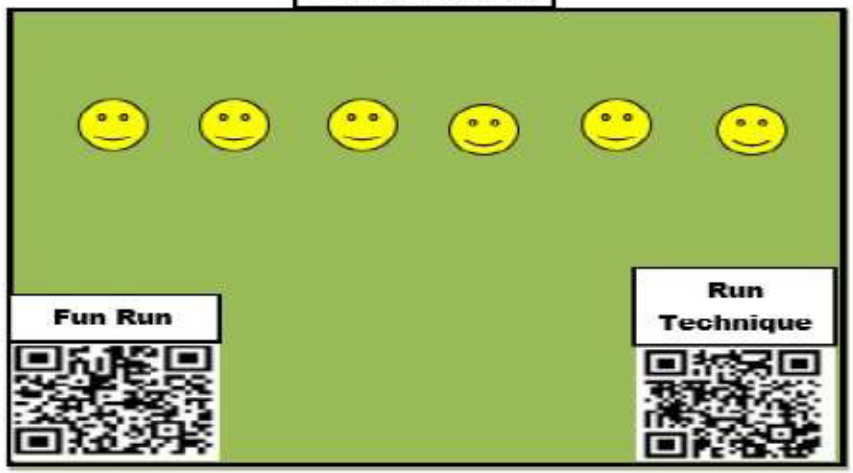
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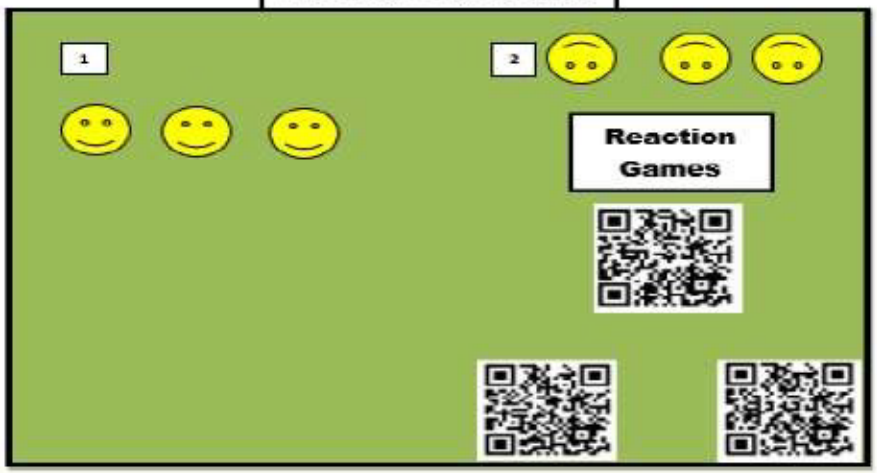
Project FLAME

Basic Stations



- Run as fast as possible (sprint) for a distance of 10m – 20m.
- Students should land on the ball of their foot when sprinting.
- Run while focussing on specific body parts (legs, hands and head) as cued.

Various Progressions



1) Marching for a distance of 10m – 20m exaggerating a sprinting technique as cued in card overleaf.
2) **Wall Exchanges:** Students place both hands on the wall in front of them and adopt an exaggerated sprinting position facing the wall (i.e. one knee lifted with toes pointing up, chin facing forward, and on the ball of the standing foot). On the leader's call of 'go', students react and switch and hold in position for the next 'go'

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Run

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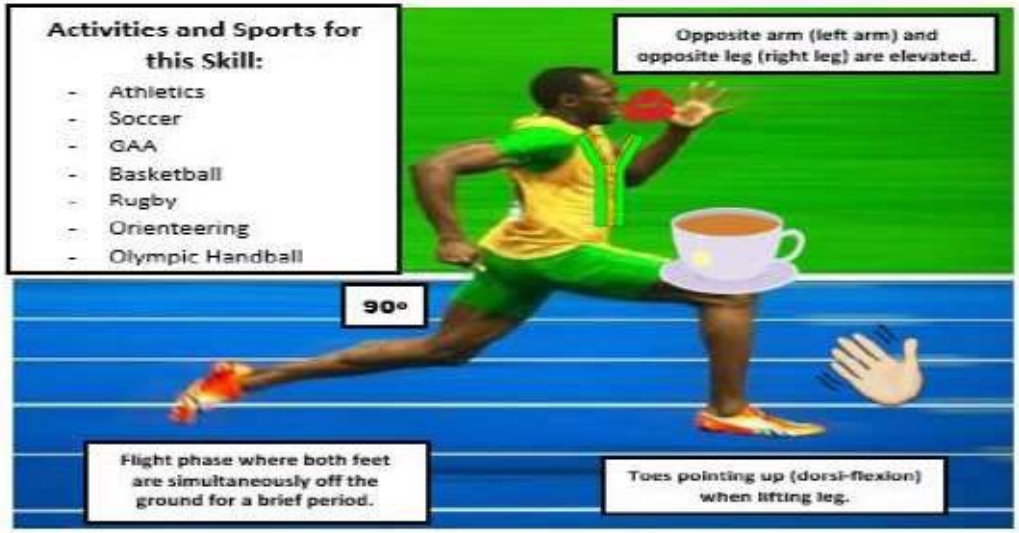
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Activities and Sports for this Skill:

- Athletics
- Soccer
- GAA
- Basketball
- Rugby
- Orienteering
- Olympic Handball





RUN [TGMD-2]
(1) Arms alternately moving in opposition to legs, elbows bent.
(2) Brief period where both feet are off the ground.
(3) Narrow foot placement landing on heel or toe.
(4) Non-standing leg bent approximately 90 degrees.



LEGS

'Cup of tea up on the knee'

'Hello toe'

HANDS

'Hip to lip don't cross the zip'

HEAD

'Sort the chin and you will win'

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Skip

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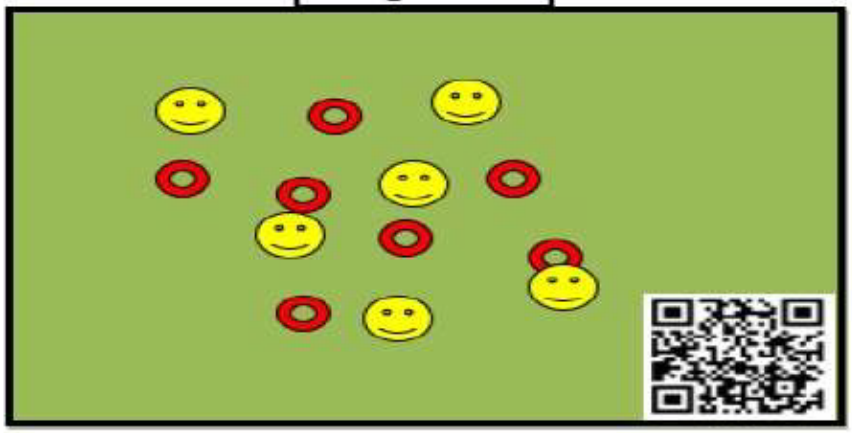
Basic Station



- Students skip for a distance of 10m – 20m.
- Focus on the step-hop rhythm, rather than performing the movement with speed.
- Ensure the arms are alternately moving in opposition to legs.

Students explore the skip using a range of the following:
- different distances between steps.
- keep feet low.
- spring to gain height.
- different arm positions.

Progression



- Students move around the area by skipping only. They must skip over a cone as they come to it and maintain the step-hop skipping technique while avoiding contact with other members of the group.
- Have students develop skipping patterns, changing direction, length of step and height of hop.

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Skip

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Arms alternately moving in opposition to legs.



Light springing steps

SKIP [TGMD]
(1) A rhythmical repetition of the step-hop on alternate feet.
(2) Foot of non-standing leg carried near surface during the hop phase.
(3) Arms alternately moving in opposition to legs at about waist level.

Activities and Sports for this Skill:

- GAA
- Athletics
- Basketball

Step-hop rhythm



Arms swinging

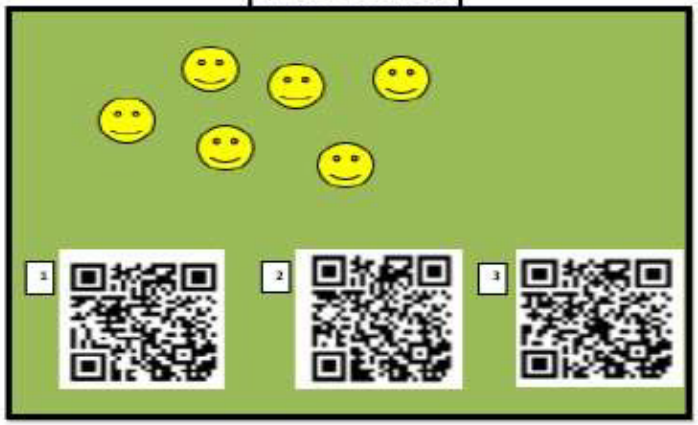


Take off and land on the front of your foot

26

Vertical Jump

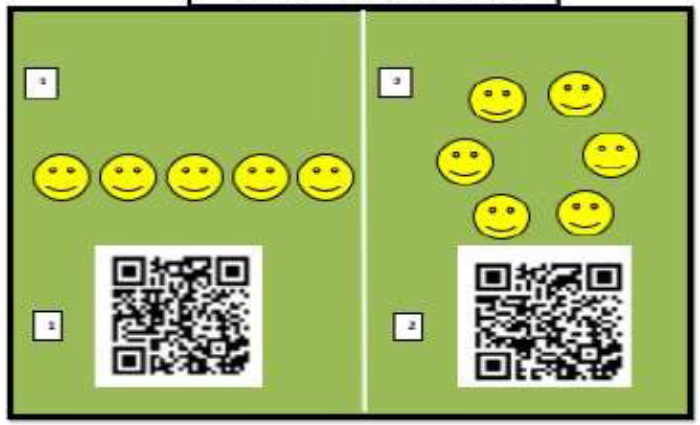
Basic Station



Encourage students to jump as high as possible.

1) **Basic Vertical Jump**.
2) **Clap High Five (Vertical Jump)** to develop use of arms.
3) **Landing Technique and Reaction** to develop control of landings.
4) **Vertical Jump 'Time'**: Students always begin the vertical jump by facing 12.00 o'clock. The aim is to jump, turn in the air and execute a controlled landing with feet both facing a set hour on the clock.

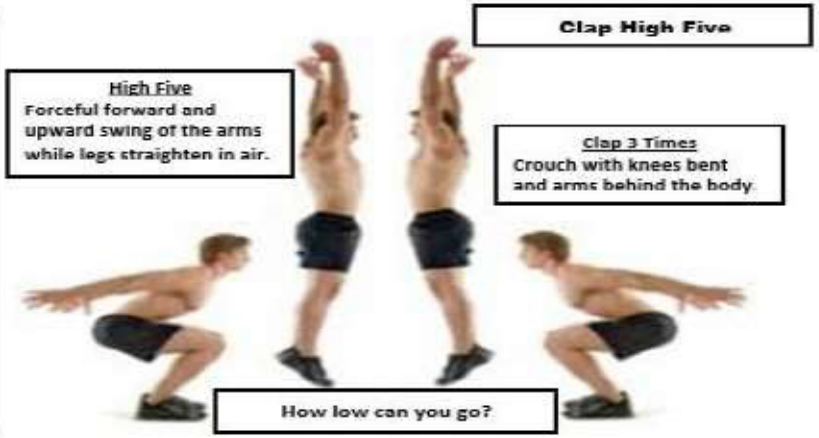
Various Progressions



1) **Mexican Wave Vertical Jump**: students line up in the aforementioned crouch position with knees bent and arms behind the body. A student at one end begins the 'Mexican Wave' by completing a vertical jump and the rest follow in suit like a domino effect.
2) **Mexican Wave Circle**: As above but this time students may change the direction of the 'Mexican Wave' by landing and facing in the opposite direction. The next student must try and react by using his/her peripheral vision while correctly executing the components of the vertical jump.

Vertical Jump





VERTICAL JUMP [GET SKILLED: GET ACTIVE]
(1) Eyes focused forward or upward throughout the jump.
(2) Crouch with knees bent and arms behind the body.
(3) Forceful forward and upward swing of the arms.
(4) Legs straighten in air.
(5) Land on balls of feet and bend knees to absorb landing.
(6) Controlled landing with ≤1 step any direction.



Vertical Jump 'Time'

Activities and Sports for this Skill:

- Basketball
- Volleyball
- Olympic Handball
- Circuits (HRF)
- Spikeball

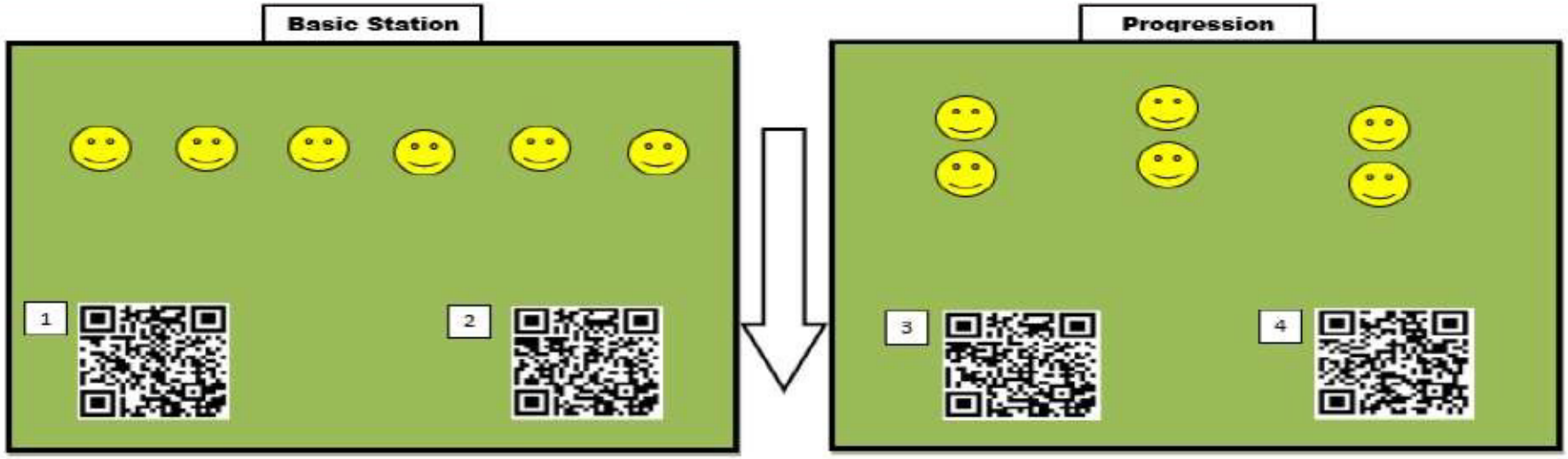
Horizontal Jump

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1) Basic Horizontal Jump.

2) Explore the horizontal jump:

- Experiment with different arm positions during the preparatory movement phase, flight phase and landing.

3) Students work with a partner [of similar ability]. The aim of this progression is for the partner behind (who starts approximately half a meter behind i.e. out of touching distance) to tag the partner in front. The partner in front does a horizontal jump as far as possible and holds in position. The partner behind then does a horizontal jump and aims to reduce the distance between the partners after each jump and tag the partner in front after a set number of jumps and/or within a set distance.

4) Horizontal Jump to Target

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Horizontal Jump



HORIZONTAL JUMP [TGMD-2]
(1) Preparatory movement includes bending of both knees with arms stretched out behind body.
(2) Arms reach forcefully forward and upward with full extension above the head.
(3) Take off and land on both feet together.
(4) Arms thrust downward during landing.

Activities and Sports for this Skill:

- Athletics (Long Jump) - Orienteering

Landing phase

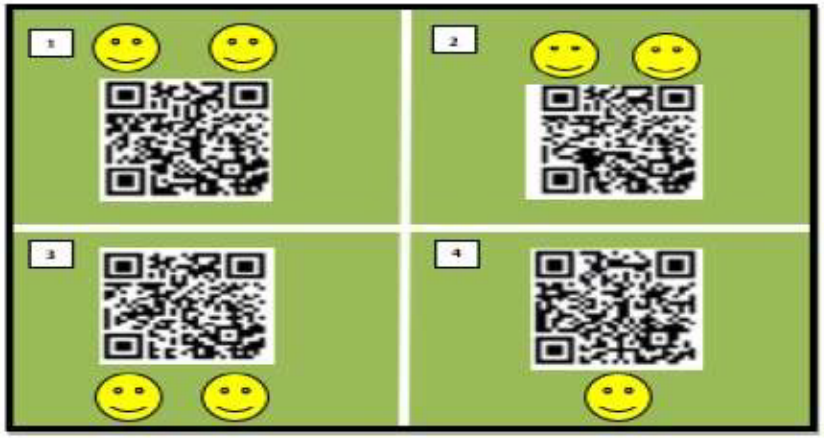




Flight phase

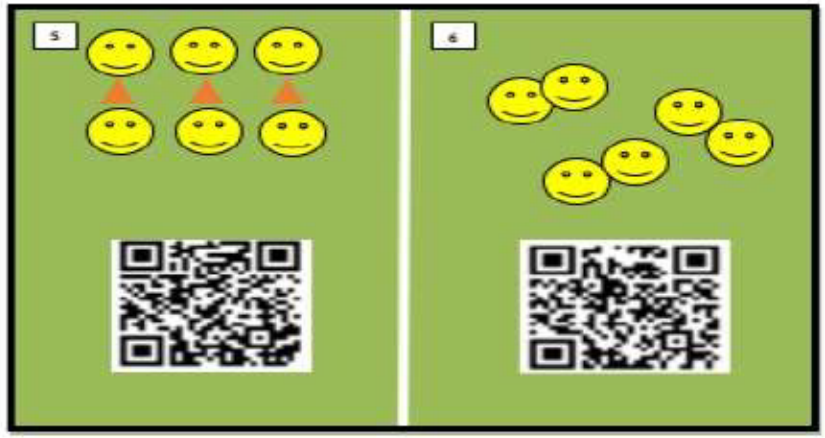
30

Deep Squat



Deep Squat preparatory movements and joint mobility:

1) Achilles Stretch (Ankle Mobility) for Deep Squat
2) Calf/Soleus Stretch for Deep Squat
3) Frog Squat
4) Bunny Hops



5) Deep Squat Cone Reaction Game. Students adopt a squat position facing a partner with a cone turned upside down between them. Maintaining the squat position, students are led by the 'caller' who shouts different parts of the body which students must touch (for example, head, hips, toes, nose etc.) until the caller shouts cone and the quickest person of each pair to grab it gets a point.

6) Deep Squat Thumb War Game. Students move around the area and adopt a squat position to play a game of 'Thumb War' before moving on and repeating the same again.

Deep Squat

Activities & Sports for this skill: Rugby, Athletics, Weight-Lifting



Deep Squat







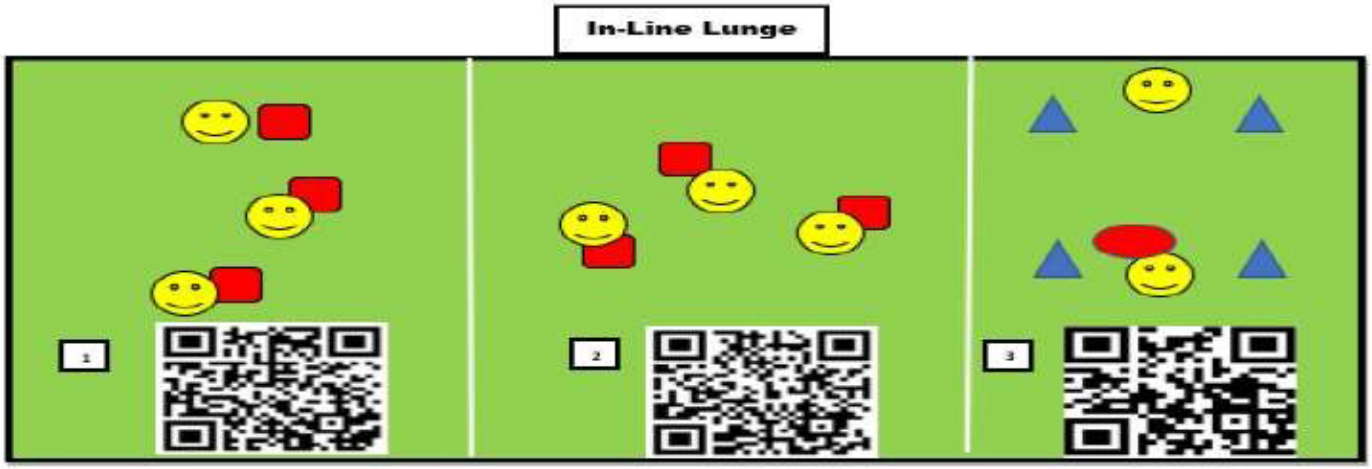
Toes pointing forward and shoulder width apart.





DEEP SQUAT
(1) Dowel maximally pressed overhead and aligned over feet. Note lumbar flexion.
(2) Toes point forward.
(3) Knees aligned over feet and knees do not go passed the toe line.
(4) Thighs break parallel with the floor on descent (i.e. femur below horizontal).

In-Line Lunge



1) **Beanbag Lunge 01**
2) **Beanbag Lunge 02**
   Explore different positions to place the beanbag during the lunge:
   below the knee that's lowering to the ground …
   on top of the head …
   on top of the brush handle or equivalent (as available) …
3) **In-Line Lunge Frisbee 03**-Explore passing a frisbee in a cooperative paired task, performing a lunge in the direction of the cone as they pass the frisbee

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In-Line Lunge



Keep body straight/upright



Keep both feet in-line
Eyes look straight ahead

Place foot outside the hand





Follow your fingers with your eyes



IN-LINE LUNGE
(1) Dowel remains in contact with head, [middle] back and backside.
(2) Dowel remains vertical.
(3) No body movement (i.e. balance is maintained).
(4) Knee touches board behind heel of front foot.
(5) The front heel remains in contact with the board and the back-heel touches board when returning to starting position.

Activities & Sport for this Skill:
Yoga, General Stretching for all sports

Active Straight Leg Raise

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Hamstring Assisted Partner Stretch (Doorframe).

- One student lies flat on the ground or mat as appropriate. The partner (standing) then holds one leg in place upright (note: This should not cause pain or discomfort to the student on the ground). The student on the ground then lifts the leg on the ground up next to the leg being held upright and lowers it down again in a slow but controlled fashion. Repeat. Focus on breathing into the stretch also. Swap legs then swap roles.

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Active Straight Leg Raise



Activities & Sport for this skill:
Dance, Gymnastics, All sport exercises in warm-up phase

ACTIVE STRAIGHT LEG RAISE
(1) Knee on floor remains touching the ground.
(2) Leg on floor does not turn outwards at the hip.

Shoulder Mobility

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1) Shoulder Mobility 01 (Front and Back)
2) Shoulder Mobility 02 (Rowing)
3) Shoulder Mobility 03 (Press Up and Pull Down)
4) Shoulder Mobility 04 (Wall Angel)
5) Shoulder Mobility 05 (Wall Slides)
6) Shoulder Mobility 06 (V Slides)
7) Shoulder Mobility 07 (Windmill)

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Shoulder Mobility

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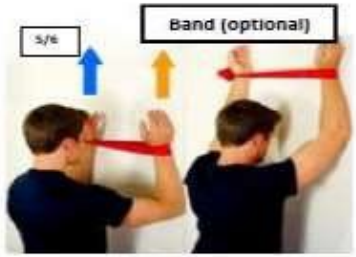




Activities & Sport for this skill: Weightlifting, General Stretching,







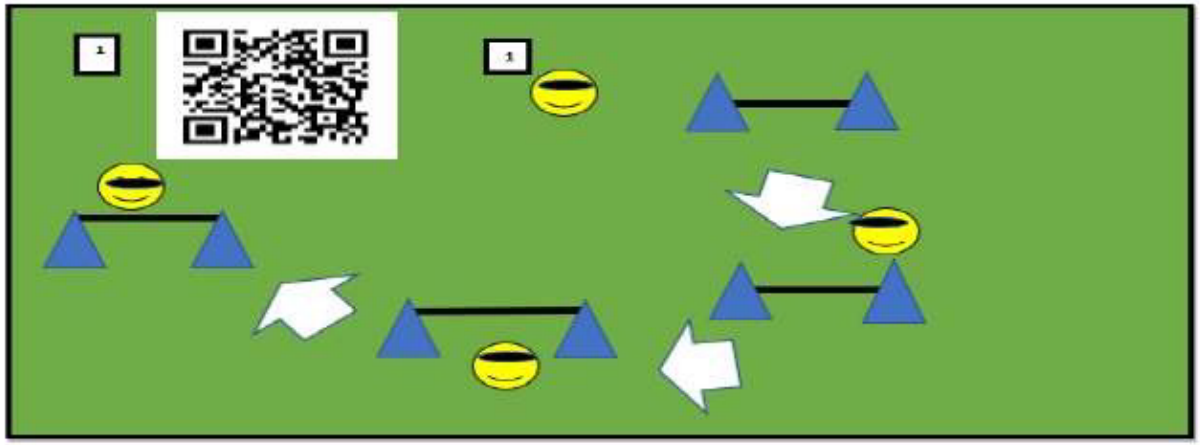
Brush Handle or equivalent





SHOULDER MOBILITY
(1) Does not walk hands towards each other (i.e. one single motion).
(2) Head remains in neutral position (i.e. looking straight ahead).

Hurdle Step



1) The Cube- Hurdle Step- An escalating challenge!

- Participants are blindfolded, (other students act as a guide)
- A series of cones and hurdles are laid out at varying heights. (No.1 is lowest, 4 is highest)
- Participants must hurdle step over these obstacles without knocking over the hurdles If they knock them over, they return to the start (Dowel is optional)
- As in the Cube TV show the game can be made easier as necessary

- **Progressions**

-Fastest time

-A point system (Deducted one point for knocking one, must try and complete a full round without knocking them)

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Hurdle Step

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Activities & Sports for this Skill: Athletics



Over the gate!

Look Straight ahead



Up and Over the Gate!



Minimal movement in back



Grasp the Bar tight across the shoulders



Dowel and Hurdle Parallel to ground





Hurdle Step
(1)Hips, knees and ankles remain in one straight line
(2) Minimal Movement in the lower back
(3) Dowel remains in contact with shoulders
(4) Dowel remains parallel with Hurdle



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Trunk Stability Push-Up

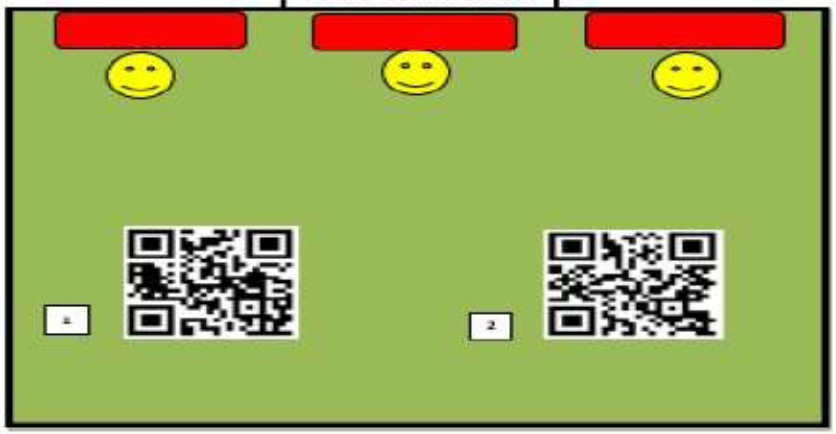
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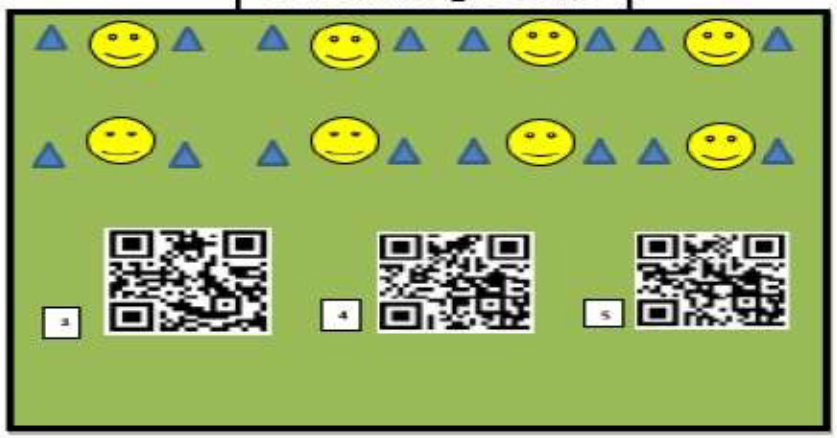
Basic Stations



1: Do a push up with knees in contact with ground (Incline Optional).

2: Step-Up boxes are used as an incline surface on which students do push ups. *Ensure students are not leaning on the edge of the Step-Up box as it may topple over.

Various Progressions



3: 1V1. Students do a push up before each attempt to roll ball into opponent's goal. Hold Position between shots.

4: Starting 1m apart, each student must do a push up before each forward movement. You must catch the other player before they reach the end line.

5: Students perform forward moving caterpillar push-ups and attempt to catch the person in front of them before they reach the finish line. Evader has a 1.5m head start.

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Trunk Stability Push-Up

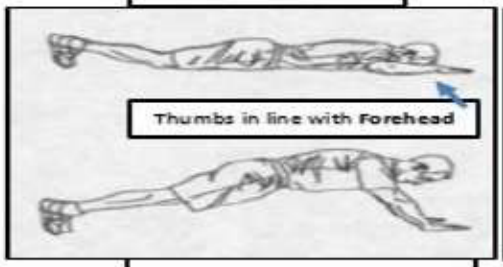
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Males



Females







TRUNK STABILITY PUSH-UP

(1) Body lifts as one unit.

Knee Push-Ups



Incline Push-Ups



Caterpillars

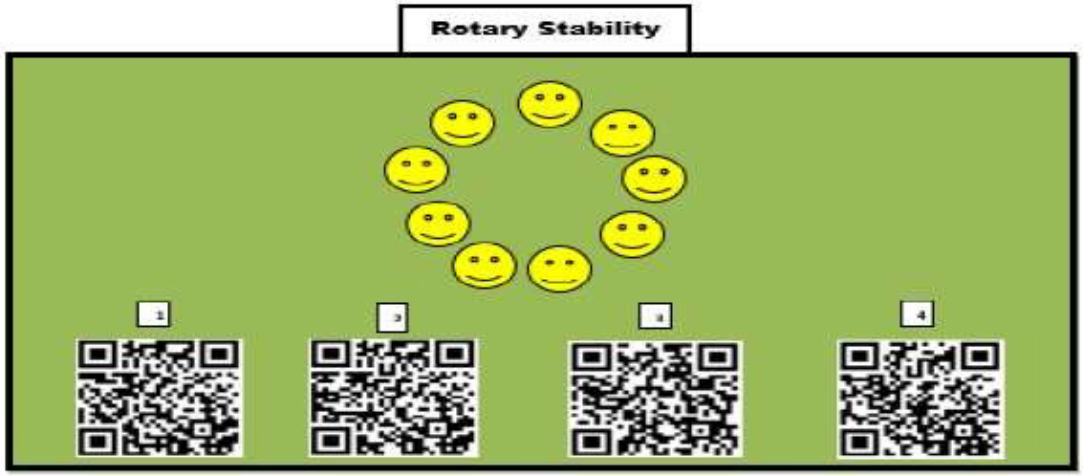


Activities and Sports for this Skill:

-Circuits (HRF)

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Rotary Stability



1) **Spiderman Rotation 01**

2) **Spiderman Rotation 02**

Complete 5-10 repetitions on both hands before switching leg positions.

3) **Superman Kneeling**

Complete 5-10 repetitions using opposite arm and leg (i.e. right arm stretched forward and left leg stretched back, then switch sides) before attempting same arm and leg.

4) **Superman Standing**

Rotary Stability

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Project FLAME

Place foot outside the hand



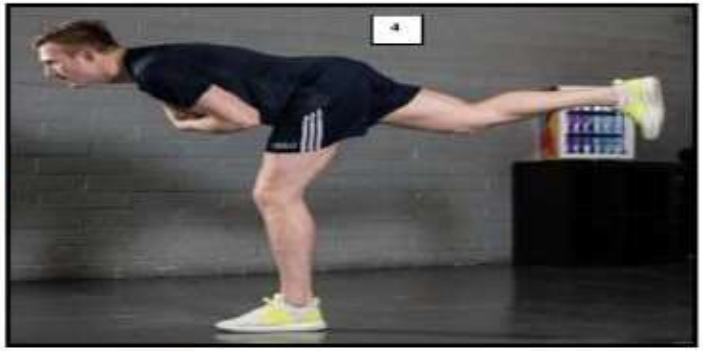
Follow your fingers with your eyes

2









ROTARY STABILITY
(1) Ankles with toes tucked under (i.e. dorsiflexion).
(2) Back remains flat/parallel to board).



same arm, same leg.





Activities and Sports for this Skill:

-Circuits (HRF)

-Yoga

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Multi-Movement Activities

These Activities develop Movement Capabilities across a number of Movement Patterns

Superman Standing	Reach, Roll & Lift	Downward Dog - Cobra (Yoga)
Spiderman Rotation	Trunk Twists	Prisoner Game

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Kinaesthetic Classroom Breaks

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Project FLAME – Kinaesthetic Classroom Breaks

With Physical Education time only timetabled for a double period a week during Junior Cycle, attempting to introduce physical activity in non-traditional classroom settings is becoming a popular alternative. Promoting the need to be active and cognisant of one's health, and health-related behaviour is extremely important as 'Student Wellbeing' becomes a priority within education. To supplement Physical Education lessons, we have devised 'Kinaesthetic Classroom' breaks which enable students to get active within most classroom settings. Our teacher Diarmuid provides simple audio cues and a visual demonstration for students to replicate. Teachers are encouraged to provide support and encouragement to students in an effort to get them to engage with the activity. Currently, seven videos have been developed as part of our resource pack. We are looking to expand on these videos over time, and welcome feedback on the current videos, as well as any ideas you may have for activities for use in the classroom .







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Kinaesthetic Classroom Breaks

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Project FLAME – Kinaesthetic Classroom Breaks

01- Hip Twists

02- Chair Squats

03- Vertical Jump

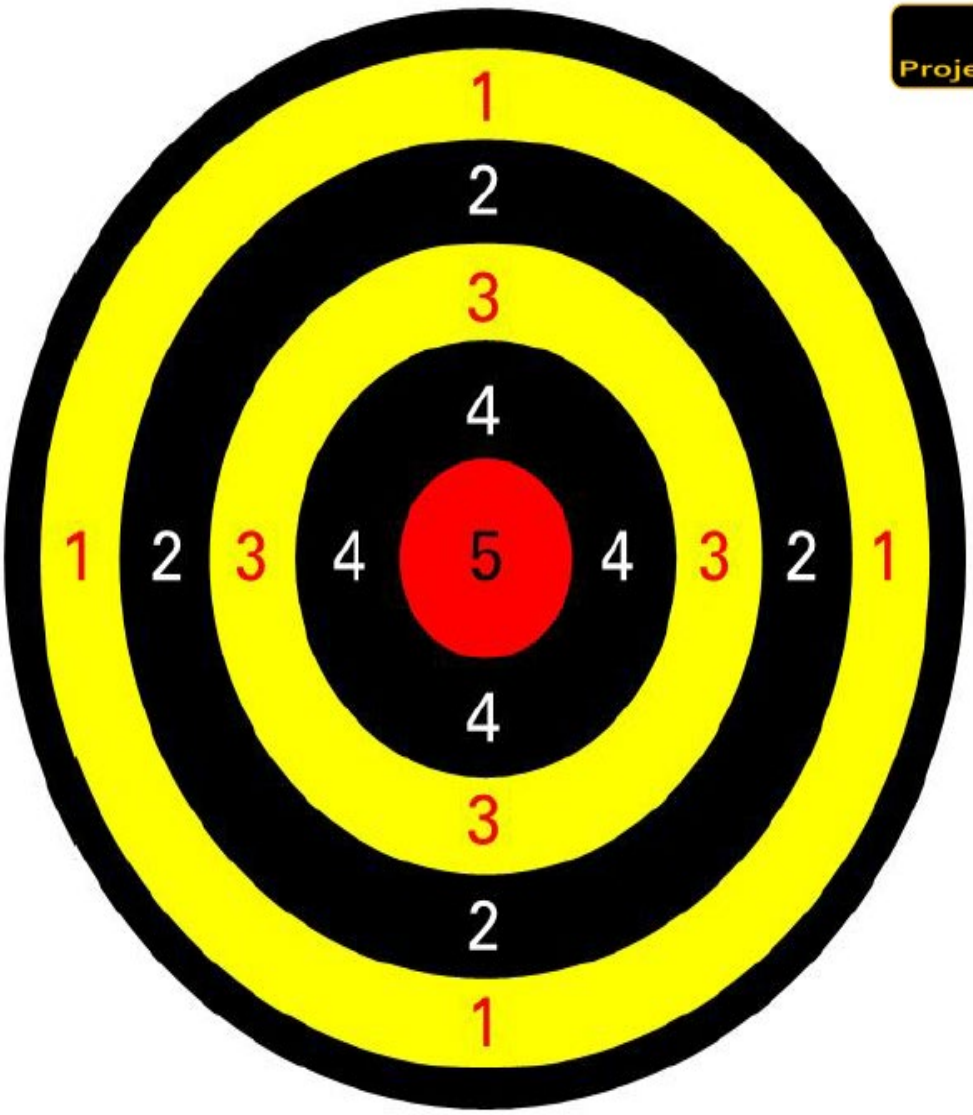
04- Balance

05- Running and Skipping

06- Lunge

07- Landing Technique

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Project FLAME
1
2
3
4
1 2 3 4 5 4 3 2 1
4
3
2
1

Project FLAME activities- YouTube Links

Active Straight-Leg Raise

Active Straight Leg Raise Hamstring Assisted Partner Stretch (Doorframe) –

https://www.youtube.com/watch?v=V3pB7WUSPoA

Core and hamstring strength- Superman Standing https://youtu.be/VnjqpcUrQE8

Balance

Balance Balance and Arm Movements – https://www.youtube.com/watch?v=2dbm32CHla0

Balance and Object Control – https://www.youtube.com/watch?v=4DVgUfpYYeQ

Balance and Twist – https://www.youtube.com/watch?v=4rKO1byt9RQ

Basic Lateral Bound with Balance – https://www.youtube.com/watch?v=VhJvcv2eO_U

Advanced Lateral Bound with Balance – https://www.youtube.com/watch?v=Bjr-NImdaB4

Lateral Bound with Catch and Balance (Basic to Advanced)-

https://www.youtube.com/watch?v=VtZVi8aYwkQ

Co-Operative Lateral Bound with Catch and Balance https://www.youtube.com/watch?v=BazXC_rKXMQ

Catch

Catch Basic Catch – https://www.youtube.com/watch?v=P5OtkrZ1EU8

Advanced Catch – https://www.youtube.com/watch?v=ElcFu9jns_g

Catch- High and Low- https://youtu.be/GPc-w56fz58

Catch- High https://youtu.be/09-4BrLAVvQ

Catching Game 1 – https://www.youtube.com/watch?v=HsORCbE7fYU

Catching Game 2 – https://www.youtube.com/watch?v=0XuG4AQAFP8

Deep Squat

Deep Squat Achilles Stretch (Ankle Mobility) for Deep Squat –

https://www.youtube.com/watch?v=Ux_l4YSf23g

Calf/Soleus Stretch for Deep Squat – https://www.youtube.com/watch?v=0mxxIb2DG7I

Frog Squat – https://www.youtube.com/watch?v=lBkGpaikTEA

Bunny Hops – https://www.youtube.com/watch?v=rn4-o1siTxc

Deep Squat Cone Reaction Game – https://www.youtube.com/watch?v=alY2vG6Ayjk2

Deep Squat Thumb War Game – https://www.youtube.com/watch?v=unuM822xZ3M

Dribble

Dribble Basic Dribble – https://www.youtube.com/watch?v=rVbXCfYQn-Q

Double Dribble – https://www.youtube.com/watch?v=0qmoCPUVAAs

Cone Dribble – https://www.youtube.com/watch?v=wniX6iqvfOg

Legs Dribble – https://www.youtube.com/watch?v=cWw5dwNwN2g

Basic Seated Dribble – https://www.youtube.com/watch?v=TR286oqTJKk

Advanced Seated Dribble – https://www.youtube.com/watch?v=AKaJewgPiAI

Horizontal Jump

Horizontal Jump Basic Horizontal Jump 01 – https://www.youtube.com/watch?v=ktrRYSDUJNc

Basic Horizontal Jump 02 – https://www.youtube.com/watch?v=GFtqwm3r4Tk

Horizontal Jump Tag (Pair) – https://www.youtube.com/watch?v=FQ6oa_DE4uQ

Horizontal Jump Tag (Group) – https://www.youtube.com/watch?v=wvkrIBeCvRg

Horizontal Jump- Controlled Jump and Land https://youtu.be/GIPZzUyNWjI

Hurdle Step

Hurdle Step- Blindfold- https://youtu.be/qRmK0H4SYgE

In-line Lunge

In-Line Lunge Beanbag Lunge 01 – https://www.youtube.com/watch?v=Nsr4sUuXL7s

Beanbag Lunge 02 – https://www.youtube.com/watch?v=j4kk0byydeI

In-Line Lunge Frisbee- https://youtu.be/AApxuOMXs5s

Kick

Kick Basic Kick 1 – https://www.youtube.com/watch?v=o5aE5DTfXrc

Basic Kick 2 – https://www.youtube.com/watch?v=cOpMBMQlbNs

Kick- Long Passing game https://youtu.be/c4fAEKP0ZXo

Kick- Co-operative Passing- https://youtu.be/lNeHh8iL9eo

Multi-Movement-

Multi-Movement Activity- Spiderman https://youtu.be/kC_SuUzsXyA

Multi-Movement Activity- Shoulder Mobility and core strength- roll reach and lift-

https://youtu.be/vRbyZsrDxBw

Yoga- Downward Dog Pose- https://youtu.be/fjDUxQ79Prk

Rotary Stability

Rotary Stability Twist - https://youtu.be/Zx9yYIF8keo

Run

Run Fun Runs – https://www.youtube.com/watch?v=4bcWgkbIj34

Running Technique – https://www.youtube.com/watch?v=gWA0w0sjFZQ3

Left-Foot Strike – https://www.youtube.com/watch?v=NUBaGEygB_w

Right-Foot Strike – https://www.youtube.com/watch?v=wCOvjfg8crU

Exchange - https://www.youtube.com/watch?v=4EVNmwXTDEY

Shoulder Mobility

Shoulder Mobility Shoulder Mobility 01 (Front and Back) –

https://www.youtube.com/watch?v=c5uDW-xWzZo

Shoulder Mobility 02 (Rowing) – https://www.youtube.com/watch?v=u2c3x-1o4Y0

Shoulder Mobility 03 (Press Up and Pull Down) – https://www.youtube.com/watch?v=t2P0NWPtuTw

Shoulder Mobility 04 (Wall Angel) – https://www.youtube.com/watch?v=sAIw7BDKRIY

Shoulder Mobility 05 (Wall Slides) – https://www.youtube.com/watch?v=MeLIzYmYsMM

Shoulder Mobility 06 (V Slides) – https://www.youtube.com/watch?v=RjKe-Giqjkg

Shoulder Mobility 07 (Windmill) – https://www.youtube.com/watch?v=CQhSvVmELnw

Skip

Skip Basic Marching Technique 01 – https://www.youtube.com/watch?v=yEf5LQ6CCT8

Basic Marching Technique 02 – https://www.youtube.com/watch?v=Mqb4DX5wE5I

March into Basic Skip – https://www.youtube.com/watch?v=jRR0svBmKzI

High Skip – https://www.youtube.com/watch?v=pWtROQ-mqI8

Cone Skip – https://www.youtube.com/watch?v=A-OD3Rnn8T0

Strike

Strike Basic Strike – https://www.youtube.com/watch?v=TjGaQKyOvYc

Twist and strike- https://youtu.be/Zx9yYIF8keo

Throw

Throw Basic Throw – https://www.youtube.com/watch?v=P7ZHLIhy3tc

Throwing Game – https://www.youtube.com/watch?v=TP-nR8WwOOQ4

Throw-Partner Game- Hoop Dreams- https://youtu.be/flXeEoK5A6c

Throw-Target Game “Clay pigeon shooting”- https://youtu.be/1pQBNTVAHVM

Throw- ‘Wall Ball- off left and right’ https://youtu.be/_Zkz-SdygGA

Trunk Stability Push-Up

Trunk Stability- Caterpillar Walks- https://youtu.be/h_sJqdEdSS8

Trunk Stability- Push-Up race- https://youtu.be/SzWT7llvWLM

Trunk Stability- Push-up Pass https://youtu.be/u-1_fGLbNqQ

Push-Up- Incline- https://youtu.be/2HiSgYorgtg

Kneeling- Incline Push-Up- https://youtu.be/y5QNbl6foS4

Push-Up- Decline https://www.youtube.com/watch?v=g1W8UUwujNg

Vertical Jump

Vertical Jump Basic Vertical Jump – https://www.youtube.com/watch?v=Z1fMk5vCsU0

Clap High Five (Vertical Jump) – https://www.youtube.com/watch?v=FpgDAWXJrNQ

Landing Technique and Reaction – https://www.youtube.com/watch?v=TkNwl6-wzMI

Mexican Wave Vertical Jump – https://www.youtube.com/watch?v=pIyZK-Bg7Fs

Mexican Wave Circle – https://www.youtube.com/watch?v=Mc_OGY-Us4