An Investigation into the Relationship between Fundamental Movement Skills, Physical Activity and Sedentary Behaviour in Irish Primary School Children

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Abstract

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Introduction: The ability to perform fundamental movement skills (FMS), has been positively associated with physical activity (PA) participation in childhood, and is considered an important prerequisite to lifelong participation in sport and PA. At present, there is a lack of evidence investigating the relationship between PA and FMS proficiency in an Irish context, with no research published examining the relationship between FMS proficiency and sedentary behaviour (SB). Thus, this study aimed to establish if a relationship exists between FMS proficiency, PA levels and SB levels in Irish primary school children.
Methods: One hundred and fifty participants (mean age = 7.7 ± 0.6 years) were conveniently recruited from four primary schools in the midlands region of Ireland. Proficiency in 13 FMS were assessed using the Test of Gross Motor Development (TGMD-3). PA and SB were assessed using the Children's Leisure Activities Study Survey (CLASS), self-report and proxy-report version. Following pre-testing the schools were assigned to a control group and an FMS intervention group. The FMS intervention group received two 45-minute sessions per week for 8 weeks in place of normal PE classes and the control group continued with usual PE class for 8 weeks. Following the 8-week intervention, a post-test was conducted.
Results: Parents reported that 25% of children were not meeting the recommended moderate-vigorous PA (MVPA) recommendations of at least 60 minutes of MVPA daily. During the week, parents also reported 24% of children exceeding the screen time (ST) recommendations of < 2 hours/day, with this increasing to 77% at the weekend. Light physical activity (LPA) as reported by the children showed a weak, negative association with the object control (OC) subtest and total TGMD-3 score. Vigorous physical activity (VPA) showed a weak, positive association with the OC subtest and the locomotor (LOC) subtest with a moderate, positive association reported between VPA and total TGMD-3 score. SB showed a weak, negative association with total TGMD-3 score and OC subtest. LPA, moderate physical activity (MPA) and SB as reported by the parent showed no association with any FMS variables. VPA showed a weak, positive association with total TGMD-3 score and a moderate positive association with the OC subtest. Following the intervention there was a significant difference between the intervention group and control group for 5 of the 13 FMS examined with the intervention group showing the greatest improvements. The only significant differences observed between the intervention and control group for PA was parent-reported MPA and MVPA. SB also decreased but this was not significant.
Conclusion: Higher PA levels were positively associated with better FMS, indicating there is a relationship between these two, but this relationship was weak. Following the intervention, 5 of the 13 FMS, MPA and MVPA significantly improved, demonstrating the effectiveness of the intervention. Therefore, targeted interventions which increase FMS and PA levels and reduce SB levels are required to sustain a child's development and involvement in PA in later life.

Declaration

I hereby declare that this research is entirely the result of my own investigation and that appropriate credit has been given where reference has been made to the work of others. This work has not been submitted for any academic award, or part thereof, at this or any other education establishment.

Signed   Date

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List of Abbreviations

BF	Body Fat
BMI	Body Mass Index
BOT	Bruininks-Oseretsky Test of Motor Proficiency
BP	Blood Pressure
C	Control
CATCH	Child and Adolescent Trial for Cardiovascular Health
CHAMP	Children’s Health Activity Motor Programme
CLASS	Children’s Leisure Activities Study Survey
CO_2	Carbon Dioxide
CSPAP	Comprehensive School Physical Activity Program
CSPPA	Children’s Sports Participation and Physical Activity Survey
EE	Energy Expenditure
FMS	Fundamental Movement Skills
GAQ	Girls Health Enrichment Multi-Site Study Activities Questionnaire
GLASS	Great Leaders Active StudentS
GMQ	Gross Motor Quotient
HBSC	Health Behaviour in School-Aged Children
HR	Heart Rate
INT	Intervention
KTK	Körperkoordinationtest für Kinder
LOC	Locomotor Skills

LPA	Light Physical Activity
M-ABC	Movement Assessment Battery for Children
METS	Metabolic Equivalents
MIGI	Move It Groove It
MOT 4-6	Motoriktest für vier-bis sechsjährige Kinder
MPA	Moderate Physical Activity
MVPA	Moderate Vigorous Physical Activity
NHANES	National Health and Nutrition Examination Survey
O_2	Oxygen
OC	Object Control Skills
PA	Physical Activity
PAQ-C	Physical Activity Questionnaire for Older Children
PASS	Physical Activity and Skills Study
PDMS	Peabody Developmental Motor Scales
PE	Physical Education
PGMQ	Pre-schooler Gross Motor Quotient
PLUNGE	Professional Learning for Understanding Games Education
SB	Sedentary Behaviour
SCORES	Supporting Children’s Outcomes using Rewards, Exercise and Skills
SPANS	Australian New South Wales School Nutrition and Physical Activity Study
ST	Screen Time

TGMD	Test of Gross Motor Development
TOMI	Test of Motor Impairment
TV	Television
VPA	Vigorous Physical Activity
WHO	World Health Organisation
Y-PATH	Youth Physical Activity Towards Health

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Chapter 1: Introduction

1.1. Background

Growing evidence suggests that the prevalence of overweight and obesity among school-age children and adolescents has increased in recent decades across all countries, including Ireland (Popkin et al., 2006; Wang and Lobstein, 2006). The prevalence of overweight and obesity is associated with a reduction in PA levels (Chan et al., 2010), as more people become physically inactive and this tracks from adolescence into adulthood (Chan et al., 2010), leading to a wide range of diseases such as coronary heart disease, type two diabetes, breast cancer, and colon cancer (Lee et al., 2012).

The current Irish physical activity (PA) guidelines recommend that all children and young people (2-18 years) should be active, at a moderate to vigorous level, for at least 60 minutes every day, incorporating muscle-strengthening, flexibility and bone-strengthening exercises up to three times a week (Department of Health and Children, 2009; WHO, 2010). For children of this age group PA includes play, games, sports, transportation, recreation, physical education or planned exercise, in the context of family, school, and community activities (WHO, 2015). However, while PA is central to reducing the levels of overweight and obesity in Ireland, Irish children are not meeting the recommended PA guidelines (Woods et al., 2010). The Children's Sport Participation and Physical Activity Study (CSPPA) found that only 19% of primary school children met the minimum PA recommendations of at least 60 minutes of moderate to vigorous physical activity (MVPA) daily (Woods et al., 2010). Therefore, there is an immediate need for effective strategies to increase PA in Irish primary school children, in order to reduce the myriad of health problems, which can track from adolescence into adulthood.

It has been proposed that motor competency is an underlying mechanism which can influence an individual's participation in PA (Stodden et al., 2008) and research suggests that fundamental movement skill (FMS) proficiency and PA participation in children and youth are linked (Barnett et al., 2008; Barnett et al., 2013; Laukkanen et al., 2014; Mazzardo et al., 2008; Robinson, 2010; Stodden et al., 2013). Since FMS are considered a prerequisite to the specific skills used in popular forms of PA, there may be a relationship between an individual's participation in PA and an individual's mastery in FMS (Okely et al., 2001). Further, understanding this relationship, may assist children in developing the skills and attitudes that improve perceived competence and confidence, which could contribute to an increase in FMS and potentially influence children to lead a physically active lifestyle in later life.

1.2. Relationship between FMS and Physical Activity

FMS are the building blocks for movement, which ultimately form the foundation for many of the specialised skills required in sport and leisure activities (Hardy et al., 2013). FMS can be categorised into three main categories including locomotor (LOC) (e.g. running and hopping), object-control (OC) (e.g. catching and throwing) and stability (e.g. balancing and twisting) skills (Gallahue and Ozmun, 2006). FMS among children have the potential to be mastered by the age of six; however, a growing body of evidence suggests that many children never achieve proficiency in FMS development (Goodway and Branta, 2003). There is a common misconception that FMS are acquired naturally (Hardy et al., 2010), when in fact, FMS must be taught and children must be provided with practice opportunities to achieve proficiency along with encouragement, instruction and feedback (Logan et al., 2011).

It is proposed that FMS proficiency provides physical, social and psychological benefits (Gallahue and Ozmun, 2006; Lubans et al., 2010; Tsangaridou, 2012). Failure to develop these skills between the ages of two to seven years can make it more difficult to achieve FMS, thus affecting the ability to partake in activities for daily living, recreation and/or competition (O'Keefe et al., 2007). In particular, there is an increasing body of evidence from Australia and the UK supporting the positive correlation between FMS proficiency and levels of PA (Barnett et al., 2008; Fisher et al., 2005; Holfelder and Schott, 2014; Hume et al., 2008; Laukkanen et al., 2014; Mazzardo et al., 2008), with competency in a range of FMS in childhood been found to be a predictor of PA in adolescence (Barnett et al., 2009). It is plausible that children with poorer motor skills may become less active adolescents with associated poorer fitness levels (Barnett et al., 2008). Therefore, by assisting children to become competent and confident performers of FMS, it may lead to a greater willingness to participate in competitive and non-competitive sporting activities that provide opportunities to increase lifelong involvement in PA (Barnett et al., 2008). However, at present, the majority of research investigating the relationship between FMS and PA has been conducted in Australia (Barnett et al., 2008; Barnett et al., 2009), which makes it difficult to generalise the results to an Irish context due to the environmental, cultural and curriculum differences which exist between the two countries. In addition, although a number of studies have investigated the relationship between FMS and PA, none have investigated the relationship between FMS and SB.

1.3. Sedentary Behaviour

Sedentary behaviour (SB) (which may include TV viewing, computer and game-console use, workplace sitting, and time spent in automobiles) has emerged as a new focus for research on PA and health (Owen et al., 2010). Examining time spent in SB is worthwhile, as it displaces the amount of time spent in light PA, contributing to a reduction in overall PA energy expenditure (Owen et al., 2010). SB is associated with increased risk of cardio-metabolic disease, all-cause mortality and a variety of physiological and psychological problems, independent of PA levels (Owen et al., 2010; Saunders et al., 2014). Physiologically, it has been suggested that the loss of local contractile simulation induced through excessive sitting leads to both the suppression of skeletal muscle lipoprotein lipase activity and reduced glucose uptake (Hamilton et al., 2008; Owen et al., 2010). According to the CSPPA primary school children spend 2.6 hours daily in sedentary activities (Woods et al., 2010). Similar findings were reported in the 'Growing Up in Ireland Study', with 45% and 35% of nine-year olds reported to have a TV and a video/DVD player in their bedroom, respectively (Layte and M^{c}Crory, 2011). Boys were also reported to be spending more time playing video games, such as the PlayStation and Xbox (30%), compared to girls (12%) (Layte and M^{c}Crory, 2011). Currently, no research has examined the relationship between FMS proficiency and SB. Thus, if a relationship exists between FMS proficiency and SB, targeted interventions to improve FMS proficiency could potentially reduce SB and increase PA levels.

1.4. Aims and Objectives of the Research Study

Aim:

The aim of this study is to determine whether relationships exist between PA, SB and FMS proficiency in Irish primary school children.

Objectives:

- To investigate if a relationship exists between PA levels and FMS proficiency in Irish primary school children.
- To investigate if a relationship exists between SB and FMS proficiency in Irish primary school children.
- To assess the effectiveness of an FMS intervention at improving FMS, PA levels and SB in Irish primary school children.

Chapter 2: Literature Review

2.1. Introduction

The purpose of this chapter is to provide a critical overview of the literature surrounding this field. A brief introduction to PA, PA recommendations, measurements of PA amongst children and the current PA levels is provided. An overview of the FMS assessment tools, FMS proficiency levels, the benefits associated with FMS in particular PA and the relationship between these two variables will be provided. In addition, SB is examined addressing the guidelines, prevalence and health consequences associated with SB. Finally, both short and long-term FMS intervention programmes are examined to conclude the review.

2.2. Physical Activity

2.2.1. Introduction to Physical Activity

2.2.1.1. What is PA?

PA is defined as 'any bodily movement produced by skeletal muscle which results in an overall increase in energy expenditure (EE) above normal resting levels' (Caspersen et al., 1985, p.126). PA consists of several dimensions including: duration (units of time); frequency (number of sessions, bouts or days); intensity (commonly expressed as metabolic equivalent multiples of resting metabolic rate or METS [light = 1.8-2.9, moderate = 3.0-5.9, vigorous = $\geq$ 6.0]); mode (the type of physical activity behaviour e.g. bicycling, walking, football); and domain (the context or reason for the physical activity e.g. household chores, transport, leisure, physical education, occupation) (Dollman et al., 2009; Warren et al., 2010). PA can also be subdivided into different intensities, predominantly used are; moderate vigorous physical activity (MVPA) and VPA. MVPA is defined as any PA categorised by an energy expenditure > 3 METS (WHO, 2010), while VPA is defined as any PA categorised by an energy expenditure > 6 METS (WHO, 2010). MVPA includes sport, physical education (PE) and formal exercise to active play and other physically demanding activities such as dancing, swimming, skateboarding, walking and cycling (Department of Health, 2016). It is suggested by the WHO (2010) that while the main focus for PA for children should be primarily aerobic they should also partake in muscle-strengthening, flexibility and bone-strengthening exercises three times a week and PA should be enjoyable (Department of Health, 2016; WHO, 2010).

2.2.1.2. Physical Activity Recommendations

PA guidelines have been developed to educate the general population on the optimal amount of PA that is required to maintain a healthy lifestyle (Davies et al., 2011; Department of Health, 2016; Physical Activity Guidelines Advisory Committee, 2008). PA guidelines for children have been established across different countries, and encourage children and adolescents to partake in at least 60 minutes of MVPA every day, that incorporates muscle strengthening, flexibility and bone-strengthening exercises up to three times a week (Davies et al., 2011; Department of Health, 2016; US Department of Health and Human Services, 2012). PA includes play, games, sports, transportation, recreation, PE or planned exercise, in the context of family, school, and community activities (WHO, 2010).

2.2.1.3. Benefits of Physical Activity

Several benefits are associated with regular participation in PA including: lower blood pressure (BP), lower serum lipid and lipoprotein levels and a reduction in adiposity, particularly amongst youth (Van Der Horst et al., 2007). In addition, PA has also been associated with an improvement in psychological health, such as higher levels of self-esteem and lower levels of anxiety and stress (Van Der Horst et al., 2007). PA is also important during childhood to attain and maintain appropriate bone strength, and to contribute to normal skeletal development (Dietz, 1998). Whilst PA is essential to health, physical inactivity has been well established as one of the leading risk factors for non-communicable disease (Lee et al., 2012). Physical inactivity is defined as 'performing insufficient amounts of PA, that is, not meeting specified PA guidelines' (Tremblay et al., 2017, p.9). The benefits of physical activity which will be discussed in further detail below are body composition and cardiometabolic health.

2.2.1.3.1. Body Composition

The relationship between body composition and PA has been extensively studied with studies showing a positive association (Baranowski et al., 1992; Janssen and

LeBlanc, 2010). Abbott and Davies (2004) examined the relationship between PA and body composition among children aged 5-10 years (8.4 ± 0.9 years). Body fat and BMI were significantly negatively associated with PA ($r = -0.43$; $p = 0.002$ and $r = -0.45$; $p = 0.001$, respectively). Time spent in VPA was also significantly negatively associated with percentage body fat ($r = -0.44$; $p = 0.004$) but not BMI. MPA was not shown to be correlated with body fat or BMI. Similarly, Dencker et al. (2006) reported that time spent in VPA was significantly negatively associated with total body fat ($r = -0.38$; $p < 0.05$). MPA may not have been correlated with BMI as this intensity is not high enough to elicit a decrease in BMI. Therefore, it is important that the intensity of PA is important for reducing body composition in children.

2.2.1.3.2. Cardiometabolic Health

PA has shown mixed results towards cardiometabolic health such as blood lipids (Bell et al., 2007; Carnethon et al., 2005) and blood pressure (Carnethon et al., 2005; Dasgupta et al., 2006; Nielsen et al., 2003), with limited results published linking the increases in PA to improvements in children. Significant improvements in blood lipids are normally observed with an improvement in PA, with aerobic based interventions reporting the greatest improvements in blood lipids (Janssen and LeBlanc, 2010). However, large scale intervention studies have not reported large improvements (Janssen and LeBlanc, 2010). Studies which have reported significant improvements in blood lipids have had the greatest effect sizes, whereas studies which have reported limited or no associations have had lower effect sizes and possibly underpowered (Janssen and LeBlanc, 2010). Therefore, the design of interventions towards decreasing blood lipid profiles amongst children remains unclear.

A review by Janssen and LeBlanc (2010), reported that intervention studies which have aimed to reduce systolic blood pressure in hypertensive children in response to aerobic exercise training have reported significant reductions in systolic blood pressure (Danforth et al., 1990; Ewart et al., 1998; Jago et al., 2006). Danforth et al. (1990) examined the effects of 12-week aerobic exercise programme on blood pressure in hypertensive children (n = 11; 8-12 years), with results showing a significant reduction in diastolic blood pressure ($p < 0.001$) and systolic blood pressure ($p < 0.005$) following the intervention. Similarly, Ewart et al. (1998) reported that an aerobic exercise class in place of regular PE class showed a significant reduction in systolic blood pressure ($p < 0.03$). These studies show that if a child has developed hypertension from an early age then an aerobic exercise intervention can help lower blood pressure. However, in children without hypertension no significant relationship between PA and blood pressure have been reported (Janssen and LeBlanc, 2010). These findings may be insignificant due to the inadequate intensity and duration amongst youth (Janssen and LeBlanc, 2010). Therefore, it is important that the intensity and duration of intervention programmes are tailored to reduce blood pressure and blood lipid profiles.

Therefore, increased participation in PA may result in the reduced risk of the onset of a range of chronic diseases (WHO, 2010). The prevalence of youth physical inactivity (Woods et al., 2010) and the rise of obesity in the last decade amongst youth (Centers for Disease Control and Prevention, 2011) is a growing cause for concern. In particular, children and adolescents have become the focal point for the promotion of PA to enhance health and reduce levels of obesity and SB worldwide. If this is targeted from an early age, it will ultimately prevent health complications in later life. The CSPPA found that one in four children (n = 1215; mean age of 13.4 $\pm$ 2.1 years) were unfit, overweight or obese (Woods et al., 2010). Therefore, in order to reduce this obesity epidemic, it is crucial that PA is introduced in order to maintain a healthy body weight (Woods et al., 2010).

2.2.2. Measurement of Physical Activity in Children

It is crucial that the method used to assess PA and EE is valid, reliable and practical (Sirard and Pate, 2001). Sirard and Pate (2001) proposed three different groups for assessing PA and EE including criterion methods, objective techniques and subjective techniques (Table 2.1). This section will provide an overview of the methods used to assess PA and EE in youth.

Table 2.1: Methods of Assessing Physical Activity and Energy Expenditure in Children and Adolescents (Sirard and Pate, 2001)

Criterion Methods	Objective Techniques	Subjective Techniques
Direct Observation	Heart Rate Monitors	Self-Report Questionnaires
Doubly Labelled Water	Pedometers	Interviews
Indirect Calorimetry	Accelerometers	Proxy-Reports
Direct Calorimetry		Diaries

2.2.2.1. Criterion Methods

The criterion methods are the ‘gold standard’ methods used to assess PA and EE and are the ideal methods to be used to validate both subjective and objective methods (Vanhees et al., 2005). However, these ‘gold standard’ methods tend to be less practical, more time consuming, very expensive and their use is generally not feasible in large-scale research studies (Vanhees et al., 2005). Commonly used criterion methods include direct observation, doubly labelled water and direct or indirect calorimetry.

2.2.2.1.1. Direct Observation

Direct observation is the most practical tool for the measurement of PA and patterns of PA, and typically involves the observation of a child at home or in school for extended periods and instantaneous recording of the child’s PA (Sirard and Pate, 2001). The categories of activities are usually recorded on a momentary time-sampling basis at specific time intervals that range from five seconds to one minute (Gibney et al., 2017). Direct observation provides information on PA behaviour and has a number of advantages including; the period for observation is flexible and it allows for the quantification of PA and the recording of factors related to PA behaviour such as the environment in which the child is present, the presence of significant others (e.g. parent), and the availability of toys and equipment (Gibney et al., 2017). Direct observation systems vary in length of the observation period, with some prescribing observation for an entire day and others requiring 30-120 minute sessions (Pate et al., 2010). However, it is time consuming to train observers, time intensive testing, expensive and inconvenient for large-scale studies (Puhl et al., 1990; Trost, 2007; Vanhees et al., 2005). Participants may also react to being observed, with Puhl et al. (1990) reporting that 16.6% of children aged 5-6 years reacted to the observers and changed their behaviour.

2.2.2.1.2. Doubly Labelled Water

Doubly labelled water is recognised as the reference method or ‘gold standard’ for the assessment of EE in free-living subjects (Armstrong and Welsman, 2006). It is an unobtrusive and non-invasive means to measure EE whereby a dose of a radio-labelled isotope ($^2H_2{}^{18}O$) is ingested to provide a direct measure of carbon dioxide (CO_2) production and an accurate estimate of EE (Sirard and Pate, 2001; Trost, 2007). Over the next 5-14 days the hydrogen atoms (^2H) are eliminated as water (H_2O), while the oxygen atoms (O_2) are eliminated as water (H_2O) and carbon dioxide (CO_2) (Sirard and Pate, 2001). Recordings (i.e. urine samples) need to be obtained over a period of 3 days and dietary records need to be kept throughout the recording period (Sirard and Pate, 2001; Trost, 2007). Advantages of this method are that the measurements can be performed over extensive time periods (1-2 weeks), it does not cause any change in PA behaviour in the subjects, accurate to within 3-4 % of calorimeter values, and by combining this method with conventional indirect calorimetry it is possible to measure the individual components of daily EE (Goran, 1994; Sirard and Pate, 2001). It is, however, excessively costly (Trost, 2007), does not provide information on the frequency, intensity or duration of PA (Armstrong and Welsman, 2006; Sirard and Pate, 2001; Trost, 2007) and it is a complicated analysis (Goran, 1994).

2.2.2.1.3. Calorimetry

There are two types of calorimetry, indirect and direct. Indirect calorimetry measures heat production indirectly through the examination of oxygen consumption. This measurement requires the participant to wear a face mask or a mouthpiece with a nose clip along with a container for the collection of expired air (Laporte et al., 1985). EE is measured from O_2 consumed and CO_2 produced (Sirard and Pate, 2001). The O_2 consumed is dependent on the composition of the food being metabolised (i.e. carbohydrates versus fat) (Vanhees et al., 2005). Therefore, by measuring the O_2 consumption, indirect estimation of EE can be made (Vanhees et al., 2005).

Direct calorimetry involves the measurement of the total heat dissipated by the body by enclosing the subject in a sealed chamber that is insulated from the surrounding environment (Levine, 2005; Schutz, 1995). By measuring the participant's total heat loss, the rate of EE can be estimated (Levine, 2005). Direct calorimetry is well known as the 'gold-standard' measurement of human EE and is the most accurate method for quantifying the metabolic rate; however, it is an expensive, complex and time-consuming method that is restricted to use under laboratory conditions (Hills et al., 2014; Ndahimana & Kim, 2017).

2.2.3. Objective Techniques

The most commonly used methods for the objective assessment of PA include heart rate (HR) monitoring, pedometers and accelerometers. The use of objective methods may be limited with regard to sample size, although some methods are suited for large-scale epidemiological studies.

2.2.3.1. Heart Rate Monitoring

The recording of HR is typically minute-by-minute and can be stored for several hours and days, thus providing information about duration, frequency and the intensity of the activity in addition to total EE (Vanhees et al., 2005). To interpret the intensity of PA for HR, the FLEX HR method is generally used (Livingstone et al., 1990). This method requires an individual threshold calibration to determine the intensity of the activity for each individual, which is normally done via lab-based indirect calorimetry measurement whilst working at a range of different intensities (Livingstone et al., 1990). The main advantages of the HR monitor are that the results are directly related to the physiological response to PA, it is easy to measure a specific activity, detailed data is received, can be worn for an unlimited period of time, it is transportable and lightweight and demonstrates good reliability (Eston et al., 1998, Vanhees et al., 2005; Welk et al., 1998). However, it is widely recognised that factors such as age, body size, proportion of muscle mass used, emotional stress, and cardiorespiratory fitness influence the HR-VO_2 relationship. In addition, HR response tends to lag momentarily behind changes in movement and remains elevated after the cessation of movement; therefore, HR monitoring may mask the sporadic activity patterns of children (Dollman et al., 2009). Finally, participant discomfort can occur over a given period of time (Sirard and Pate, 2001; Trost, 2007).

2.2.3.2. Pedometers

Pedometers are simple electronic devices used to measure the number of steps taken over a period of time (Sirard and Pate, 2001). These steps can be converted to distance (km) when an average stride length is entered (Vanhees et al., 2005). Pedometers utilise a spring motion that records vertical plane motion only and are typically worn on a belt over the right hip or along the midline of the thigh (Sirard and Pate, 2001; Vanhees et al., 2005). Advantages of pedometers are that they are relatively inexpensive compared to accelerometry and HR monitoring, are unobtrusive, can be re-used, are portable and demonstrate good reliability and validity (Duncan et al., 2006; Eston et al., 1998; Oliver et al., 2006; Tudor-Locke et al., 2004). They have also been shown to be positively correlated with other methods to assess PA such as accelerometers ($r = 0.86$), doubly labelled water ($r = 0.60$) and self-report questionnaires ($r = 0.94$) (Tudor-Locke et al., 2002). However, pedometers assess ambulatory activity and may not be as sensitive to changes in speed of movement (Duncan et al., 2006; Trost, 2007). Pedometers cannot provide qualitative information on exercise and other types of activities such as cycling and horse riding for example (Duncan et al., 2006; Trost, 2007). Therefore, pedometer data cannot provide accurate estimates of the intensity of an activity, record counts during cycling or increases in EE due to carrying objects or walking/running uphill (Duncan et al., 2006; Hands et al., 2006; Rowlands et al., 1997).

2.2.3.3. Accelerometers

Accelerometers provide objective information relating to accelerations of the trunk or other body parts at user-specified time intervals (Trost, 2007) using a piezo-electric transducer and microprocessor, which quantify recorded signals to ‘counts’ (Esliger et al., 2005; Sirard and Pate, 2001). Proprietary algorithms sum these results over specific time intervals known as epochs. The length of the epoch is commonly set at 1 minute intervals, however this varies depending on the accelerometer being used (Atkin et al., 2012). Count thresholds are then applied at certain points to determine the intensity level of the activity being performed (Warren et al., 2010). Thus, accelerometers can be used to classify the frequency, intensity and duration of PA over a given time period such as days or weeks (Trost, 2007).

Due to the accelerometer's small size, robust design features, relatively modest cost, capacity to record data continuously for an extensive period of time (days or weeks) and their lack of visual feedback to the individual wearing the device makes them particularly attractive to researchers quantifying behaviour amongst youth (De Vries et al., 2006; Freedson et al., 2005; Hills et al., 2014; Trost, 2007). However, they are not able to measure some activities such as cycling and climbing and give no information on the type of PA completed (Dollman et al., 2009; Sirard and Pate, 2001; Vanhees et al., 2005). This can result in an underestimation of PA; hence, the data recorded may not be a true reflection of total EE. Certain factors need to be taken into consideration when selecting the most appropriate accelerometer such as the length of time the accelerometer should be worn for, classification of wear time, non-wear time (including sleeping, showering and aquatic activities) and the average number of days valid for research (Choi et al., 2011). Also, the placement of the accelerometer is important as it can affect the output (Welk, 2005). Typically, the accelerometer is placed as close as possible to the body's centre of mass (e.g. waist, wrist and thigh) (Plasqui et al., 2013). The minimum number of days that youth wear the accelerometer differs (Plasqui et al., 2013), but the length of the monitoring period should reflect the PA levels of the population of interest (Metzger et al., 2008). According to Trost (2007), in order to achieve a reliability of 0.80, 4-9 days of monitoring amongst youth is required, however the 7 day monitoring protocol now appears to be the standard protocol used for youth as it includes both weekdays and weekends (Rowlands et al., 2008). Inclusion of both week and weekend days are recommended as studies have shown differences in patterns of activity between these two types of days (Metzger et al., 2008).

2.2.4. Subjective Techniques

Subjective techniques rely on information obtained from individuals using some form of self-report (Gibney et al., 2017). Self-report methods are the most commonly used tools for the assessment of PA, and include diaries, logs and self- or interviewer-administered questionnaires (Warren et al., 2010). The self-report measures reported below are the most common questionnaires used for research in children aged 7-16 years. These self-report measures were examined to determine the most suitable questionnaire applicable to an Irish primary school setting.

2.2.4.1. Self-Report Physical Activity Measurement

Several self-report methods have been used to assess PA in children including self-administered recalls, interviewer administered recalls, diaries and proxy reports compiled by parents and teachers (Trost, 2007). Depending on the purpose of the study, self-report measures vary considerably in the specificity with which type, duration, frequency, and intensity of PA are evaluated (Trost, 2007). Advantages of self-report methods include the ease of administration, ability to characterise activity historically, ability to record activity type, and low cost (Hands et al., 2006; Trost, 2007). As a result, self-reports methods are commonly used in epidemiological research due to the overall impracticality of objective measurement techniques (Trost, 2007).

Despite the convenience of self-report PA measurement, limitations include participant's inability to accurately recall activities and difficulties associated with quantifying the time of activity (Hands et al., 2006; Sirard and Pate, 2001; Trost, 2007). Also, the lower cognitive functioning of children compared to adults can make it more difficult to accurately recall intensity, frequency and especially duration of activities (Sirard and Pate, 2001). In addition, children have an activity pattern that is much more variable and intermittent than that of adults (Baquet et al., 2007). Baranowski et al. (1984) reported that children younger than 10 years of age cannot recall activities accurately and are unable to quantify the time frame of activity. In addition, young children may not fully understand the concept of PA (Trost, 2007). Trost et al. (2000) investigated children's understanding of the concept of PA in fourth-grade students (mean age 9.8 ± 0.3 years) and identified that approximately 60% of fourth-grade students had difficulty differentiating sedentary activities (e.g. playing computer games) and active pursuits (e.g. outdoor games) suggesting that caution should be taken when using self-report measurements in children aged 10 years and younger. Thus, proxy-reported methods are more appropriate for young children (Corder et al., 2008). However, they are susceptible to additional problems because recall of children's PA can be difficult for adults (Corder et al., 2008).

Over the past decade, numerous questionnaires have been developed for different populations, including children and adolescents, with major differences in length, type of activities and recall period used (Chinapaw et al., 2010). Recalling PA is a highly complex cognitive task in which information is requested about PA performed at some point in the past, with recall periods varying from one day (Ridley et al., 2006) to one week (Jurisson and Jurimae, 1996) or a typical week (Telford et al., 2004). Selection of an appropriate PA questionnaire depends not only on the specific purpose of the study, but also the characteristics of the population, the outcome of interest, reliability, validity and responsiveness (Chinapaw et al., 2010). Several PA questionnaires have been developed for use among children (Chinapaw et al., 2010). Such questionnaires include the Multimedia Activity Recall for Children and Adolescents (MARCA) (Ridley et al., 2006), Synchronised Nutrition and Activity Program (SNAP) (Moore et al., 2008), Girls Health Enrichment Multi-Site Study Activities Questionnaire (GAQ) (Baranowski et al., 1989), Physical Activity Questionnaire for Older Children (PAQ-C) (Kowalski et al., 1997) and the Children's Activities Study Survey (CLASS) (Telford et al., 2004).

2.2.4.1.1. Multimedia Activity Recall for Children and Adolescents (MARCA)

The MARCA is a questionnaire which asks children (10-12 years) to recall their previous day's activities in time slots of five minutes or more and is conducted on a computer (Ridley et al., 2006). Children can choose from over 200 activities grouped into 7 categories (Ridley et al., 2006). The child is asked to drag an icon along a timeline to indicate the start and end time of the activity (Ridley et al., 2006). The MARCA calculates a child's PA level, time spent above a given MET level, and time spent lying, sitting, standing or walking (Ridley et al., 2006).

Ridley et al. (2006) examined the test-retest reliability (n = 32; 11.8 ± 0.7 years) and construct validity (n = 66; 11.6 ± 0.8 years) of the MARCA on children in Australia. Test-retest reliability was reported as high (ICC = 0.88-0.94) where children undertook the MACRA twice within a 24 hour period, while construct validity was shown to be acceptable (rho = 0.36-0.45) against the ActiGraph accelerometer. Advantages of MARCA include its collection of data on multiple modalities of PA and SB, it integrates a compendium of energy costs that contains child-specific data and it reduces the burden on the researcher related to data entry and analysis. However, it requires access to a computer which schools may be limited to, a licence to download and only one day of PA and SB is monitored. Monitoring a child's PA and SB levels over one day would not give a true representation of a child's overall PA and SB levels (Chinapaw et al., 2010).

2.2.4.1.2. Synchronised Nutrition and Activity Program (SNAP)

SNAP is a researcher–led assessment tool which examines commonly consumed foods, (n = 40), drinks (n = 9) and PA (n = 29) in children aged 7-16 years (Moore et al., 2013). The list of commonly consumed foods and drinks was developed using a combination of findings from the National Diet and Nutrition Survey with PA developed from the Compendium of Physical Activities (Moore et al., 2013). The duration of each activity is estimated in minutes by dragging a slider along a timeline with a timescale ranging from 0-3 hours, which is segmented into 10 minute intervals for the first hour and 30 minute intervals thereafter (Moore et al., 2013). Each PA is also assigned a MET value with 3 given for MPA and 6 given for VPA (Moore et al., 2013).

Moore et al. (2008) compared the ActiGraph accelerometer against the SNAP. The total MVPA was 112 minutes according to the ActiGraph accelerometer and 103 minutes according to the SNAP. In addition, the percentage of children meeting the MVPA recommendations was 70% according to SNAP and 68% according to the

ActiGraph accelerometer. These results show that whilst the SNAP underestimated MVPA, the two methods were comparable. However, reliability of the SNAP has not been examined, it requires a licence to access, requires the reading ability of an 8 year old child, it cannot provide instantaneous feedback and it is time consuming (15-40 minutes to complete).

2.2.4.1.3. Girls Health Enrichment Multi-Site Study Activities Questionnaire (GAQ)

The GAQ (Baranowski et al., 1989) is a questionnaire designed for 8-10 year old girls which is divided into two sections. The first section consists of a checklist with 28 different activities. For each activity the child is asked to check off whether they performed the activity the previous day and if they usually partake in the activity with the duration and frequency defined by three categories. The second section has 7 questions which relate to SB performed the previous day and usually, both having five categories of duration. A total PA score is estimated for the 28 activities performed the previous day, applying the code 0 for no activity to 2.5 for activities > 3 hours. Scoring is determined by the intensity level of the activity using appropriate MET values for children for each of the 28 physical activities (Treuth et al., 2003; Treuth et al., 2004). Studies conducted by Treuth et al. (2003) and Treuth et al. (2004) have examined the reliability of the GAQ on school children in America.

Treuth et al. (2003) compared the ActiGraph accelerometer, against a pedometer, Digiwalker, SW200, and two self-report methods the Activitygram and the GAQ (n = 68 girls; 9.0 ± 0.8 years) over a period of 6 days and reported excellent reliability for 18 physical activities assessed by the GAQ ($r = 0.80$; $p < 0.0001$). Reliability was lower for the Activitygram (ICC = 0.23) and was not statistically significant for the pedometer (ICC = 0.08). In a similar study Treuth et al. (2004) examined the reliability and validity of the GAQ on 172 girls aged 8-10 years (8.8 ± 0.8 years) using the ActiGraph accelerometer worn for a period of 3 days. Results at baseline showed that poor correlations were observed between the GAQ usual activity score and average Actigraph minutes of MVPA between 12 noon and 6 pm for the total sample ($r = 0.11$; $p = 0.14$) and the comparison group ($r = 0.15$; $p = 0.17$).

From the studies conducted on the GAQ the validity may be questionable as it has only be shown to be valid when more than one day was assessed (Treuth et al., 2003; Treuth et al., 2004), it is based on African American PA and may not be applicable to an Irish population and the target age group is girls aged 8-10 years. In addition, validity of the GAQ has only been shown in females and not males.

2.2.4.1.4. Physical Activity Questionnaire for Older Children (PAQ-C)

The PAQ-C is a self-administered, 7-day recall instrument that has been extensively used in the assessment of PA levels in children (8-14 years) (Kowalski et al., 1997). It was designed to be relatively quick to complete (< 20 minutes), to be inexpensive, to have low staff burden (self-administered), and to be easy to understand. The PAQ-C has nine items each scored on a 5-point scale, used to derive a total activity score (Kowalski et al., 1997).

The PAQ-C has been reported to be both reliable and valid for the assessment of PA levels in children during the school year (Crocker et al., 1997). In a study conducted by Crocker et al. (1997), the authors examined the test-retest reliability of the PAQ-C over a 1-week period using intra-class correlation methods. Participants were assessed twice, exactly one week apart during regular school hours. The internal consistency of the PAQ-C scores using coefficient alpha were shown to be fair ($\alpha = 0.79$) and good ($\alpha = 0.89$) for assessments one and two, respectively. Test-retest reliability of the PAQ-C found estimated reliability for a single score was acceptable for both males ($r = 0.75$) and females ($r = 0.82$) (Crocker et al., 1997).

In a more recent study, Benitez-Porres et al. (2016) examined the reliability and validity of the PAQ-C in 10-12 year old (10.98 $\pm$ 1.17 years) Spanish school children using an accelerometer and showed that the correlation between the accelerometer and the PAQ-C for total PA to be significant, although weak ($r = 0.23 – 0.28$; $p < 0.05$). The highest correlation was observed for item 9 on the PAQ-

C (Week Summary) ($r = 0.95$; $p < 0.01$). However, in relation to the studies conducted by Crocker et al. (1997) and Benitez-Porres et al. (2016) there is a lack of agreement on the validity of the PAQ-C for the assessment of PA in children. In addition, there is no SB aspect included, the questions may be too difficult for primary school children between the ages of 6-8 years as the PAQ-C is designed for children aged 8-14 years and there is no discrimination between specific activity intensities e.g. LPA, MPA and MVPA.

2.2.4.1.5. Children's Leisure Activities Study Survey (CLASS)

The CLASS is a questionnaire designed for 5-6 and 10-12 year old children (Telford et al., 2004). The CLASS was developed to investigate PA and SB habits of children at primary school entry age (5-6 years) and primary school exit age (10-12 years) in Australia. PA is examined under four dimensions including type (structured/unstructured; PE/school sport; play; games/sports), intensity (sedentary; light; moderate; vigorous), frequency (times per week) and duration (hours/minutes per week). Activities are classified as moderate or vigorous by assigning the metabolic equivalent units (METS) at rest. A MET is a measurement to classify the intensity of PA. The questionnaire consists of 30 activities; with 18 classified as moderate intensity (3-5.9 METS) and 12 classified as vigorous (< 6 METS). There are two identical questionnaires, one for parents (proxy-report) and one for children (self-report). For both the parent and child, the questionnaire details information on the frequency of activities during a typical week (Monday-Friday) and weekend (Saturday and Sunday), with the duration of each activity (hours/minutes per week/weekend) present in the parent questionnaire only. For children only, a question in relation to the enjoyment of the activities was required where the child coloured in an appropriate face corresponding to their enjoyment level. SB levels are also assessed by both the parent and child during the week (Monday-Friday) and weekend (Saturday and Sunday) and consists of a list of 12 sedentary activities. An open-ended question also allowed both the parent and child to record any other sedentary activity that was not listed. The total amount of time spent in each sedentary activity during a typical weekday and weekend is summed to give a total weekday and weekend SB value. Studies conducted by Telford et al. (2004) and Huang et al. (2009) have examined the reliability and validity of the questionnaire.

Telford et al. (2004) examined the reliability, convergent validity and criterion validity of the CLASS questionnaire on a sample of 5-6 (n = 58; 5.3 $\pm$ 0.5 years) and 10-12 (n = 111; 10.6 $\pm$ 0.8 years) year old children in Australia. To assess reliability, the 10-12 year old children completed the self-report questionnaire in class 7 days after the baseline administration whilst parents completed a second, identical questionnaire at least 14 days after baseline administration. Validity was assessed by requiring each child to wear an accelerometer (MT1) for 8 consecutive days. For test-retest reliability, individual PA items for MPA and VPA in both the proxy-report and self-report questionnaire ranged from 62-94% agreement. Self-reported PA frequency and duration had acceptable reliability for 11 of the 29 items (r = 0.31-0.79) and 8 out of the 29 items (r = 0.34-0.92) reported among 10-12 year old children. For convergent validity 24 out of the 29 items assessed on the questionnaire had 70% or more agreement between the proxy-report and self-report questionnaire for 10-12 year old children. Finally, a significant correlation existed between the MTI accelerometer and proxy-reported VPA for 10-12 year olds (r = 0.24; $p < 0.01$). However, the relationship between the duration of PA reported by the proxy-report and the MTI accelerometer for 5-6 and 10-12 year old children was low (r = -0.04-0.05 and r = 0.07-0.24, respectively). According to Treuth et al. (2004), this may have been due to parents not being able to quantify their children's PA as the activities they partake in tend to be less structured and consists of free-play activities that are intermittent in nature.

The reliability and validity of the CLASS questionnaire was also examined by Huang et al. (2009) in Hong Kong. The questionnaire was modified to suit the Chinese population and was renamed the CLASS-C questionnaire. Children (n = 214; 9-12 years) completed the questionnaire at the start and the end of the study to assess test-retest reliability and the GT1M ActiGraph accelerometer was used as the criterion measure. Test-retest reliability of the CLASS questionnaire showed weekly MVPA and VPA to have excellent reliability (ICC = 0.71 and ICC = 0.73, respectively) than that for MPA (ICC = 0.61) which reported a moderate reliability. A moderate and significant correlation was observed between the questionnaire and the accelerometer in estimating total time spent in MVPA for girls ($r = 0.48$; $p < 0.05$) but not for boys ($r = 0.21$; $p > 0.05$). Similarly, the correlation between the questionnaire and the GT1M in assessing SB was significant for girls ($r = 0.25$; $p < 0.05$) but not for boys ($r = 0.06$; $p > 0.05$).

Thus, the CLASS questionnaire has been found to be reliable, but its validity may be questionable (Telford et al., 2004; Huang et al., 2009). However, the CLASS questionnaire has several advantages such as: 1) it gives information on both PA and SB with a list of activities, 2) the physical activities are applicable to most Irish activities children would partake in 3) information is based over a typical week 4) the feasibility (easy to implement in a school-based setting) and the low cost 5) there is both a proxy-report and self-report form which facilitates comparison between the child and parent and 6) it does not require a licence to download making it easier to access.

2.2.5. Physical Activity Levels in Ireland

PA levels in Ireland are reportedly low among children, with PA recommendations not being met (Currie et al., 2012) and children spending more time in sedentary activities, contributing to health complications. The Health Behaviour in School-Aged Children (HBSC) report found that in Ireland, 31% and 43% of females and males aged 11 years old self-reported accumulating at least 60 minutes of MVPA daily (Currie et al., 2012). By the age of 13, a substantially lower 20% of females and 36% of males reported to be meeting the PA guideline (Currie et al., 2012). These low levels of PA, the overall decline in PA with age and the gender differences in PA levels between males and females reported in the HBSC study was consistent with the findings of the Growing Up in Ireland Study (Layte and McCrory, 2011).

Irish data from the CSPPA ($n = 5,397$; mean age = 13.8 ± 2 years) found that 19% of primary school children met the minimum PA recommendations of at least 60 minutes of MVPA daily (Woods et al., 2010). Girls were less likely than boys to meet PA recommendations (10% vs 18%; $p < 0.0001$) with the likelihood of meeting PA recommendations decreasing with increasing age in both girls and boys ($p < 0.001$) (Woods et al., 2010). Among primary school children no gender difference existed up to three days of the week; however from four days onwards a higher proportion of boys, than girls, met the PA recommendations (Woods et al., 2010). However, the current PA recommendations of $\geq$ 60 minutes of MVPA daily is not beyond the reach of primary school children in Ireland, with 98% achieving this amount of PA once a week, 80% achieving it three days per week, and 39% engaging in MVPA for 60 minutes on five days of the week (Woods et al., 2010). The CSPPA data shows that children who are active every day for at least 60 minutes have higher levels of aerobic fitness, are less likely to be overweight or obese and have a healthier blood pressure profile than those who are less active (Woods et al., 2010). Establishing active lifestyles from a young age is an important goal in order to reduce complications in relation to health in later life. Therefore, ensuring that children develop PA habits, learn basic motor skills, and enjoy positive early experiences of PA is essential. This can be achieved through PE, extra-curricular sport, extra-school clubs and general PA.

2.2.6. Correlates of Physical Activity

Despite the health benefits associated with PA, a rapid decline in PA during adolescence has been reported (Davison & Lawson, 2006; Van Der Horst et al., 2007). Better understanding of the correlates of PA in children will support the development of effective interventions that promote an active lifestyle and ultimately prevent a sedentary lifestyle (Davison & Lawson, 2006; Heitzler et al., 2006; Van Der Horst et al., 2007). The literature identifies biological, demographic, social, environmental and psychological factors that may influence youth to participate in PA (Heitzler et al., 2006).

2.2.6.1. Biological and Demographic

Biological and demographic factors such as age, gender, socio-economic status and BMI have been examined as correlates of PA amongst children (Biddle et al., 2011). Pfeiffer et al. (2009) examined the correlates of objectively measured PA among preschool children (n = 22; 3-5 years) and reported that MVPA was small but positively associated with children's age ($r = 0.12$; $p < 0.05$) and BMI ($r = 0.18$; $p < 0.001$). Similarly, King et al. (2010) reported that overweight and obese children had a lower MVPA level ($p < 0.001$). Thus highlighting that children with a higher BMI have lower PA levels. As a result children may choose sedentary activities over engaging in PA for a variety of reasons, including potential embarrassment when engaging in PA, stigma associated with being overweight, and the potential pain associated with engaging in PA (Zhu and Owen, 2017).

2.2.6.2. Environmental and Social

Environmental influences can have a huge influence on children as they have no control over the choices they make (Ferreira et al., 2006). In a review conducted by Sallis et al. (2000), six environmental variables were reported to influence a child's participation in PA including access to programmes, time spent outdoors, parental transport to PA, season, urban/rural environment and neighbourhood safety. Nilsson et al. (2009) examined the correlates of objectively measured PA in 9 (9.6 ± 0.4 years) and 15 (15.5 ± 0.5 years) year old children and found that time spent outdoors after school was significantly related to a higher mean percent time spent in MVPA ($p < 0.01$). Similarly, King et al. (2010) examined the environmental correlates of 7-year-old children in England. The season was positively associated with total volume of PA ($p < 0.001$) and the percentage of time spent in PA ($p < 0.001$). These results highlight that if children are given the opportunity to play outdoors after school it can facilitate an increase in their MVPA. However, the season may have an impact as children; in particular, girls have a lower MVPA level in spring, autumn and winter compared to the summer ($p < 0.001$). Therefore, parents should encourage their children to partake in sport during all seasons, and if this is not possible outdoors, to incorporate indoor activities to maintain MVPA levels.

Research regarding the relationship between a child and parent's PA level have reported mixed findings (Gustafson and Rhodes, 2006; Ferreira et al., 2006). Some studies have reported that parental PA is a moderate predictor of children's PA

(Moore et al., 1991; Welk et al., 2003) whereas other studies have reported a weak correlation (Dempsey et al., 1993; Sallis et al., 1992). In particular, father's PA level has been shown to have an influence on a child's PA level, with children 3.5 times more likely to participate in PA if their father was active (Ferreira et al., 2006; Gustafson and Rhodes, 2006; Moore et al., 1991). Similarly, Yang et al. (1996) found that children with active fathers were more likely to partake in sport and less likely to drop out of sport. This may have been due to the support offered by the father. Therefore, if a child receives encouragement and a parent is involved in PA it will influence the child to partake in PA.

2.2.6.3. Psychological

Psychological factors such as perceived competence, self-efficacy, attitudes, perceived benefits and general barriers have been examined as correlates of PA amongst youth (Sallis et al., 2000; Heitzler et al., 2006). The psychological correlates of PA which will be discussed in more detail are self-efficacy and perceived competence. Self-efficacy is one of the most important psychological correlates of PA and is defined as 'one's confidence in their ability to be physically active' (Strauss et al., 2001, p. 898). Strauss et al. (2001) examined the correlates of objectively measured PA in 10-16 (13.2 ± 0.2 years) year old children and found a moderate correlation between high levels of PA and self-efficacy ($r = 0.34$; $p < 0.001$). Children with increased levels of self-efficacy were significantly more likely to have increased high levels of PA compared to children with low levels of self-efficacy ($OR = 4.07$; $p < 0.001$). Similarly, Anderson et al. (2007) examined the psychological correlates of 11-13 year old girls in America. High levels of PA were associated with self-efficacy ($r = 0.71$; $p = 0.008$) and enjoyment of PA ($r = 0.87$; $p = 0.008$). In addition, self-efficacy was 3.44 times greater ($p < 0.001$) in girls who participated in structured PA compared to girls who participated in no structured PA. These findings suggest that interventions to increase PA may enhance a child's belief in their ability to exercise, therefore, increasing their motivation to become physically active (Anderson et al., 2007; Strauss et al., 2001).

Perceived competence has been positively associated with participation in PA (Sallis et al., 2000; Heitzler et al., 2006). Perceived competence is defined as 'a person's own beliefs in their abilities' (Fairclough, 2003, p.1). How children perceive their competence has important implications for participation in PA (Shen et al., 2018). Shen et al. (2018) examined the perceived competence of children (n = 320; 9-11 years) during an eight month PA intervention. Following the intervention it was reported that children with low competence were less likely to enjoy PA compared to children with high perceived competence. Parental support, especially amongst girls had an effect on their perceived competence, as girls perceiving themselves as having low competence more likely to participate in PA if they received support from their parents. Therefore, it is important that parents have a role to play with regards their child's PA level. If parents can stay involved and encourage children to partake in PA this can have a positive impact on their health throughout the lifespan.

Positive associations between parental support, parental involvement in PA, PA equipment at home, child's enjoyment of PA and a child's belief in their own ability to be physically active are found to be the most commonly reported correlates prevalent among young children (King et al., 2010; Nilsson et al., 2009). Another correlate that requires further examination is FMS amongst children, and its association with PA particularly amongst the Irish primary school population (Barnett et al., 2016).

2.3. Fundamental Movement Skills

2.3.1. Phases of Motor Development

The process of motor development is brought about by changes in motor behaviour which bridges the entire life span (Adolph and Franchak, 2016). Infants, children, adolescents and adults are involved in the lifelong process of learning how to move with control and competence in response to everyday challenges brought about by factors within the individual, the environment, and the task itself (Adolph and Franchak, 2016; Gallahue and Ozmun, 2006). Gallahue and Ozmun (2006), created the hourglass model (Figure 2.1), to illustrate lifelong motor development which depicts that motor development follows a set sequence of development but the rate of development is variable. The model is categorised into four distinct phases; the reflexive movement phase, the rudimentary movement phase, the fundamental movement phase and the specialised movement phase. Each of these phases is further subdivided into a number of stages, which an individual progresses through at different rates depending on physical, social, psychological and environmental factors (Gallahue and Ozmun, 2006).

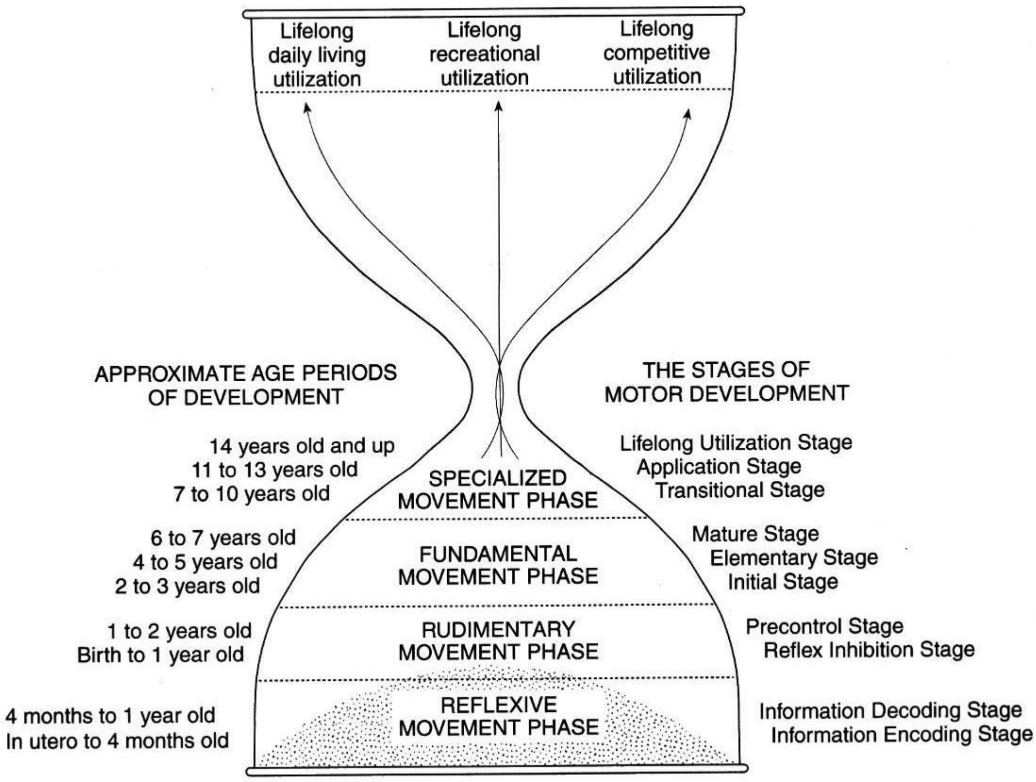

Figure 2.1: The Phases and Stages of Motor Development (Gallahue and Ozmun, 2006)

The reflexive movement phase begins when the infant is in the womb to approximately one-year-old. During this phase, the infant gains information about the immediate environment, for example, touch, light, sounds and changes in pressure. These movements are classed as involuntary movements with two different types of reflexes developed known as primitive reflexes (e.g. sucking reflex) and postural reflexes (e.g. crawling reflex). The rudimentary movement phase includes the control of voluntary movements which are vital for survival such as postural stability (control of the head, neck and trunk muscles), manipulation (reaching, grasping and releasing) and locomotion (crawling, creeping and walking). Once the skills of balance and locomotion are mastered during the rudimentary phase, children begin to explore their surrounding environment and experiment with their body's movement capabilities. The fundamental movement phase begins between the ages of two and seven years and is broken down into three stages; the initial stage (2-3 years), elementary stage (3-4 years) and mature stage (5-6 years). During each of these stages, the child begins with movement that is characterised by improperly sequenced parts, eventually developing towards movements which involve greater control and rhythmical co-ordination. Although some children might meet the fundamental movement phase primarily through maturation, the vast majority of children require opportunities for practice, encouragement, and instruction in an environment that facilitates the learning required to develop these skills (Clark, 2007; Gallahue and Ozmun, 2006). If children are not given the opportunity to practice these skills then it can have detrimental consequences in later life for participation in PA (Bardid et al., 2016; Robinson et al., 2015). The final phase is the specialised movement phase (7-14 + years) where movement becomes a tool that is applied to a variety of complex movement activities for daily living, recreation, and sporting pursuits. The skills the child has learnt in the fundamental movement phase become the foundation for the participation in specialised sports and allows the child to branch into a sport they can excel in. However, before a child can reach this level of maturation the overall contribution FMS plays with regards the development of the child needs to be understood.

2.3.2. What Are Fundamental Movement Skills?

FMS are the building blocks for movement, which ultimately form the foundation for many of the specialised skills required in sport and leisure activities (Hardy et al., 2013). FMS can be categorised into three main categories including LOC (e.g. running and hopping), OC (e.g. catching and throwing) and stability (e.g. balancing and twisting) skills (Gallahue and Ozmun, 2006). LOC skills involve movement from one point to another in a vertical or horizontal dimension such as running, jumping, hopping and skipping (Gallahue & Cleland-Donnelly, 2007). OC skills require the use of a body part or implement to send or receive objects such as catching, throwing, striking and dribbling (Gallahue & Cleland-Donnelly, 2007). Stability skills include bending, twisting and single leg stance and require postural control for the maintenance of both static and dynamic balance (Gallahue & Cleland-Donnelly, 2007). FMS among children have the potential to be mastered by the age of six, but children must be taught these skills and provided with practice opportunities to achieve proficiency (O'Keefe et al., 2007). However, globally children are demonstrating very poor levels of FMS mastery (Bolger et al., 2017; Bryant et al., 2014; Okely and Booth, 1999; Valentini et al., 2007). A number of assessment tools have been established to assess FMS proficiency among children and adolescence.

2.3.3. FMS Assessment Tools

FMS assessment tools assess either quantitative (product-oriented) or qualitative aspects (process-oriented) of movement. Product-oriented assessment tools involve measuring the product or outcome of the performance with the result normally compared to a set of normative data (Hands, 2002; Logan et al., 2016) and include Körperkoordinationtest für Kinder (KTK) (Kiphard and Schilling, 1974; Kiphard and Schilling, 2007), the Motorikest für vier-bis sechsjährige Kinder (MOT 4-6) (Zimmer and Volkamer, 1987) the Movement Assessment Battery for Children (M-ABC, M-ABC-2) (Henderson and Sugden, 1992; Henderson et al., 2007) and the Peabody Developmental Motor Scales (PDMS, PDMS-2) (Folio and Fewell, 1983; Folio and Fewell, 2000). Process-oriented assessment tools evaluate how a movement is performed and describe qualitative movement patterns (Hands, 2002; Logan et al., 2016) and include the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-BOT-2) (Bruininks, 1978; Bruininks and Bruininks, 2005), Get Skilled; Get Active (New South Wales Department of Education and Training, 2000) and the Test of Gross Motor Development (TGMD, TGMD-2, TGMD-3) (Ulrich 1985;

Ulrich, 2000; Ulrich and Webster, 2015) (Logan et al., 2016). The different FMS assessment tools will be discussed below.

2.3.3.1. Körperkoordinationtest für Kinder (KTK) (Kiphard and Schilling, 1974; Kiphard and Schilling, 2007)

The KTK (Kiphard and Schilling, 1974; Kiphard and Schilling, 2007), a shortened version of the Hamm-Manburger Körperkoordination Test für Kinder (Kiphard and Schilling, 1974) examines gross body control and coordination through dynamic balance skills (Cools et al., 2009). The KTK consists of four items (walking backwards along balance beams of different widths, hopping for height, jumping sideways over a slat and moving sideways on boards), is suitable for children aged 5-14 years and takes approximately 20 minutes to complete per child (Cools et al., 2009). Acceptable inter-rater (r = 085) (Kiphard and Schilling, 2007), intra-rater (ICC = 0.77-0.89) (Olesen et al., 2014) and test-retest (r = 0.80-0.97) (Kiphard and Schilling, 2007) reliability and validity (Bardid et al., 2016; Fransen et al., 2014) have been reported for the KTK.

Convergent and divergent validity between the KTK Motor Quotient (MQ) and the Motoriktest für vier-bis sechsjährige Kinder Motor Quotient (MOT 4-6 MQ) was assessed among 5-6 year old children (Bardid et al., 2016). Results showed a strong correlation (r = 0.63) between the total scores of the KTK MQ and MOT 4-6. Moreover, the KTK total score was strongly correlated with the MOT 4-6 gross motor score (r = 0.62). Similarly, Fransen et al. (2014) found a strong correlation (r = 0.62) between the KTK and the Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition (BOT-2), with both studies showing some evidence of convergent validity. Therefore, the KTK is a useful tool for examining gross body control and coordination through dynamic balance skills. Despite these advantages, the KTK is limited to one aspect of gross movement skill assessment and does not examine OC or LOC functioning (Cools et al., 2009).

2.3.3.2. Movement Assessment Battery for Children (M-ABC) (Henderson and Sugden, 1992)

The M-ABC, a revision of the Test of Motor Impairment (TOMI), was developed to identify a delay or deficiency in a child's movement skill development (Cools et al., 2009). The test features eight individual assessment protocol items that assess children's FMS over three movement skill categories: balance skills (static and dynamic; 3 items); ball skills (2 items); and manual dexterity skills (3 items) (Cools et al., 2010). Each item is rated on a 6-point rating scale, where 5 equates to the weakest performance and 0 equates to the best performance (Cools et al., 2009). The assessment protocol has four age bands (4-6 years; 7-8 years; 9-10 years and 11-12 years) (Cools et al., 2010). Advantages of the M-ABC include its cross-cultural validity, which is based on comparison with local sample data, and its simple test administration, which facilitates large sample screening over a short period (Cools et al., 2009).

Studies on the M-ABC have reported acceptable reliability (Chow and Henderson, 2003; Croce et al., 2001; Smits-Englesman et al., 2008) (Table 2.2) and validity (Croce et al., 2001; Van Waelvelde et al., 2004; Yeger et al., 2010). Croce et al. (2001) estimated the concurrent validity of the M-ABC, and demonstrated a strong correlation for both the long ($r = 0.70$-0.90) and short form ($r = 0.60$-0.90). Yeger et al. (2010) examined the construct validity of the M-ABC on Israeli children ($n = 249$; 8.27 ± 2.34 years) and showed that variables such as age, gender and socioeconomic status had an impact on children's motor performance. When comparing genders, a difference was found between the age bands in relation to the total M-ABC scores ($p < 0.0001$); with the boys scoring significantly better than the girls in the ball skills subscale ($p \leq 0.001$) and girls scored significantly better in the balance subscale ($p \leq 0.05$). A lower socioeconomic status was also significantly correlated with a higher manual dexterity subscale score ($r = 0.39$; $p \leq 0.0001$). These studies show the suitability of the M-ABC at identifying a delay or deficiency in a child's movement skill development (Cools et al., 2009). However, limitations of the test include the large age range and the time required for test administration (8 items/20-30 minutes) (Cools et al., 2009).

Table 2.2: Reliability of the Movement Assessment Battery for Children (M-ABC)

FMS Assessment Tool	Author	Participants N; Age	Country	Reliability		
				Inter-Rater	Intra-Rater	Test-Retest
Movement Assessment Battery for Children (M-ABC)	Chow & Henderson (2003)	n = 75 4-6 yrs	Hong Kong	ICC = 0.96	NT	ICC = 0.77
	Croce et al. (2001)	n = 106 5-12 yrs	USA	NT	NT	ICC = 0.92-0.98
	Smits-Englesman et al. (2008)	n = 154 Boys (3 yrs) Girls (3 yrs)	Netherlands	ICC = 0.58-0.81	ICC = 0.58-0.81	ICC = 0.67-0.85

NT: Not Tested. ICC: Intra-Class Correlation Coefficient. ICC's of > 0.75 is excellent, 0.40-0.75 is fair to good and 0-0.40 is poor (Cohen, 1988).
Correlation values (r) of > 0.60 is large, 0.30-0.60 is moderate and 0-0.30 is small (Waltz, 2010).

2.3.3.3. Bruininks-Oseretsky Test of Motor Proficiency (BOT) (Bruininks and Bruininks, 2005)

The BOT-2 is an individually administered assessment designed to measure fine and gross motor skills of children and youth aged 4-21 years old (Dietz et al., 2007). The test has 53 items and takes approximately 40-60 minutes to administer per individual, with the condensed version of 14 items taking 15-20 minutes to complete (Bruininks and Bruininks, 2005). The BOT-2 is made up of four motor area composites which comprises of: 1) fine manual control (control and co-ordination of the distal musculature of the hands and fingers); 2) manual co-ordination (control and co-ordination of the arms and hands i.e. object manipulation); 3) body co-ordination (control and co-ordination of the large musculature used in maintaining posture and balance) and 4) strength and agility (aspects of fitness and co-ordination involved in casual play, competitive sports, and other PA) (Bruininks and Bruininks, 2005). The condensed BOT-2 is also available and it can be used as a screening tool to achieve rapid and easy scoring reflecting overall motor proficiency (Cools et al., 2009). There are many advantages of the BOT-2 which include the ease of administration, demonstrated construct validity and the strong inter-rater (ICC > 0.90) and moderate test-retest reliability (ICC $\geq$ 0.80) (Dietz et al., 2007). However, caution must be taken when using the BOT-2 as an assessment tool as the weak test-retest reliabilities for some subtests and motor area composites for some age groups have limited the confidence of practitioners using this test (Dietz et al., 2007).

2.3.3.4. Test of Gross Motor Development (Ulrich, 1985; Ulrich, 2000; Ulrich and Webster, 2015)

The Test of Gross Motor Development (TGMD) measures gross movement performance based on qualitative aspects of movement skills (Ulrich, 2000). The TGMD was originally developed and validated in the United States (Ulrich, 1985), since then it has been re-evaluated and updated to form the TGMD-2 (Ulrich, 2000) and the most recent version the TGMD-3 (Ulrich and Webster, 2015). The age range (3-10 years) covers the period in which the most dramatic changes in a child's gross movement skill development can occur (Ulrich, 2000). Scoring of each version of the TGMD is based on the presence (1) or absence (0) for each performance criteria (Ulrich, 1985). The TGMD has three to four performance criteria whereas the TGMD-2 and TGMD-3 have three to five performance criteria (Ulrich, 1985; Ulrich, 2000; Ulrich and Webster, 2015). Skill scores for the TGMD, TGMD-2 and TGMD-3 may be summed to provide a total raw score for either the LOC or OC subtests subscale, with both of these combined to provide a total raw score (Table 2.3) (Ulrich, 1985) which is known as the Gross Motor Quotient (GMQ) (Ulrich, 2000). These raw scores are the maximum scoring attainable for the TGMD (Table 2.3). Normative data has been published for the TGMD (n = 909) and TGMD-2 (n = 1,208) for American children aged 3-10 years from 10 states (Ulrich, 2000), with data collection currently underway for the TGMD-3 (Ulrich, 2017).

Table 2.3: Raw Scores for the TGMD, TGMD-2 and TGMD-3

Variable	TGMD	TGMD-2	TGMD-3
Run	8	8	8
Gallop	8	8	8
Hop	8	10	8
Skip	6		6
Horizontal Jump	8	8	8
Slide	8	8	8
Leap	6	6	
Locomotor Subtest Total	52	48	46
T-Hand Strike	8	10	10
One-Hand Forehand Strike			8
Stationary Dribble	6	8	6
Two-Hand Catch	8	6	6
Kick	8	8	8
Overhand-Throw	8	8	8
Underhand Throw		8	8
Object-Control Subtest Total	38	48	54
Total TGMD-3 Score	90	96	100

Table Adapted from: Ulrich (1985), Ulrich (2000) and Ulrich & Webster (2015).

The TGMD assesses 12 FMS, subdivided into seven LOC (run, gallop, hop, leap, horizontal jump, skip, slide) and five OC (two-hand strike, stationary ball bounce, catch, kick, overhand throw) skills (Ulrich, 1985). In the TGMD-2, the skip was removed from the LOC subtest and the underhand roll was added to the OC subtest (Ulrich, 2000). Recently, a third version of the TGMD (TGMD-3) was developed with the OC subtest being renamed the ball skills subtest (Ulrich, 2017). In addition, the skip was reinstated as a LOC skill and the leap was removed while, the underhand roll was removed as a ball skill and the underhand throw and one-hand forehand strike of a self-bounced ball were introduced bringing the total skill count to 13 (Ulrich, 2017).

Several studies have been conducted on the TGMD, TGMD-2 and TGMD-3 and have reported both the reliability (Barnett et al., 2014; Estevan et al., 2016; Farrokhi et al., 2014; Houwen et al., 2010; Rintala et al., 2017; Simons and Eyitayo, 2016; Simons et al., 2007; Sun et al., 2011; Ulrich, 1985; Ulrich, 2000; Valentini et al., 2012; Wagner et al., 2015; Webster and Ulrich, 2017) (Table 2.4) and validity (Estevan et al., 2016; Simons et al., 2007; Simons and Eyitayo, 2016; Sun et al., 2011; Ulrich, 1985) of the tool. The reliability of the TGMD was first reported by Ulrich (1985) based on a norm-referenced perspective and included stability, inter-tester, internal consistency and the standard error of measurement. Similarly, Ulrich (2000) reported the reliability of the TGMD-2 based on three forms of error variance; content sampling (the homogeneity of the test items), time sampling (the extent to which a child's performance is constant over time) and inter-rater difference. Reliability for the TGMD, TGMD-2 and TGMD-3 has been shown to be good to excellent (Table 2.4) highlighting its ability to reliably assess FMS in children.

Table 2.4: Reliability of the Test of Gross Motor Development (TGMD, TGMD-2, TGMD-3)

FMS Assessment Tool	Author	Participants N; Age	Country	Reliability		
				Inter-Rater	Intra-Rater	Test-Retest
TGMD	Ulrich (1985)	n = 909 3-10 yrs	USA	Run (ICC = 0.80) Gallop (ICC = 0.93) Hop (ICC = 0.97) Leap (ICC = 0.93) HJ (ICC = 0.92) Skip (ICC = 0.94) Slide (ICC = 0.97) THS (ICC = 0.93) Dribble (ICC = 0.97) Catch (ICC = 0.92) Kick (ICC = 0.91) OT (ICC = 0.86)	NT	Run (ICC = 0.84) Gallop (ICC = 0.97) Hop (ICC = 0.98) Leap (ICC = 0.97) HJ (ICC = 0.97) Skip (ICC = 0.97) Slide (ICC = 0.99) THS (ICC = 0.97) Dribble (ICC = 0.99) Catch (ICC = 0.95) Kick (ICC = 0.97) OT (ICC = 0.98)
TGMD-2	Barnett et al. (2014)	n = 37 4-8 (6.2 ± 0.8 yrs)	Australia	Dribble (ICC = 0.94) Strike (ICC = 0.85) OT (ICC = 0.84) Roll (ICC = 0.82) Kick (ICC = 0.80) Catch (ICC = 0.71)	NT	NT
	Farrokhi et al. (2014)	n = 1,438 3-11 yrs	Iran	NT	ICC = 0.95-0.99	ICC = 0.65-0.81
	Houwen et al. (2010)	n = 75 8.5 ± 1.8 yrs	Netherlands	LOC (ICC = 0.82) OC (ICC = 0.93) Total Score (ICC = 0.89)	LOC (ICC = 0.85) OC (ICC = 0.93) Total Score (ICC = 0.95)	LOC (ICC = 0.86) OC (ICC = 0.87) Total Score (ICC = 0.92)

	Simons et al. (2007)	n = 99 8 yrs	Belgium	LOC (r = 1.00; p < 0.05) OC (r = 1.00; p < 0.05) Total Score (r = 1.00; p < 0.05)	NT	LOC (ICC = 0.90) OC (ICC = 0.92) Total Score (ICC = 0.98)
	Sun et al. (2011)	n = 135 5 yrs	Taiwan	ICC = 0.52-1.00	NT	NT
	Valentini et al. (2012)	n = 2,764 3-10 yrs	Brazil	LOC (α = 0.86-0.94) OC (α = 0.87-0.92)	α = 0.92-0.99	LOC (r = 0.83; p < 0.001) OC (r = 0.91; p < 0.001) Total Score (r = 0.90; p < 0.001)
	Ulrich (2000)	n = 1,208 3-10 yrs	USA	r = 0.98	NT	Content Sampling (r = 0.91) Time Sampling (r = 0.96)
TGMD-3	Estevan et al. (2016)	n = 178 3-11 (6.94 ± 1.89 yrs)	Spain	ICC = 0.90	ICC = 0.98	NT
	Simons & Eyitayo (2016)	n = 19 8.73 ± 0.23 yrs	Belgium	LOC (r = 0.91) OC (r = 0.83) Total Score (r = 0.93)	LOC (r = 0.99) OC (r = 0.85) Total Score (r = 0.88)	NT
	Wagner et al. (2015)	n = 189 7.15 ± 2.02 yrs	Germany	LOC (ICC = 0.88; p < 0.001) OC (ICC = 0.99; p < 0.001)	LOC (ICC = 0.97; p < 0.001) OC (ICC = 0.99; p < 0.001)	LOC (ICC = 0.94; p < 0.001) OC (ICC = 0.98; p < 0.001)
	Webster & Ulrich (2017)	n = 30 6.33 ± 2.09 yrs	USA	NT	NT	LOC (ICC = 0.97) OC (ICC = 0.95) Total Score (ICC = 0.97)

NT: Not Tested. ICC: Intra-Class Correlation Coefficient. ICC's of > 0.75 is excellent, 0.40-0.75 is fair to good and 0-0.40 is poor (Cohen, 1988).
Correlation values (r) of > 0.60 is large, 0.30-0.60 is moderate and 0-0.30 is small (Waltz, 2010).

Cronbach's Alpha (α) of ≥ 0.90 is excellent, ≥ 0.80-0.90 is good, ≥ 0.70-0.80 is acceptable, ≥ 0.60-0.70 is questionable, ≥ 0.50-0.60 is poor and 0-0.50 is unacceptable (George and Mallery, 2003).

HJ: Horizontal Jump. LOC: Locomotor. OC: Object-Control. OT: Overhand Throw. TGMD: Test of Gross Motor Development. THS: Two-Hand Strike.

Ulrich (1985) also examined the construct validity of the TGMD by testing three hypotheses: 1) the TGMD would reflect gross motor development; 2) gross motor development would improve significantly across age and 3) intellectually disabled children would score significantly lower than non-intellectually disabled children of similar age. To test the first hypothesis a factor analysis was conducted on the 12 FMS using the standardisation sample ($n = 909$). The factor analysis accounted for 62% of the total common variance with 9 of the 12 skills having a loading of this factor at or above 0.50 suggesting the skills are highly related. Secondly, gross motor development was positively correlated across age levels ($r = 0.81$-0.87). The results showed that the LOC subtest ($r = 0.81$), OC subtest ($r = 0.84$) and GMQ ($r = 0.86$) were highly related to chronological age. Thirdly, non-intellectually disabled children scored significantly higher ($p < 0.01$) on the TGMD than intellectually disabled children. The three hypotheses tested showed excellent construct validity of the TGMD.

Simons et al. (2007) examined the content validity of the TGMD-2 and reported all items of the LOC subtests to be moderate to strongly correlated with the LOC subtest score ($r = 0.48$-0.67; $p < 0.05$). In addition, all six items included in OC subtests were moderate to strongly correlated with the OC subtest score ($r = 0.36$-0.76; $p < 0.05$). A significant but moderate correlation between OC and LOC subtest scores was also found ($r = 0.54$; $p < 0.05$). The GMQ was also highly correlated with both the OC subtest standard score ($r = 0.89$; $p < 0.05$) and the LOC standard score ($r = 0.86$; $p < 0.05$).

Validity of the TGMD-3 has also recently been established (Estevan et al., 2016; Simons and Eyitayo, 2016). Simons and Eyitayo (2016) examined the content validity of the TGMD-3 ($n = 19$; 8 years, 7 ± 9 months) and reported a strong correlation between chronological age and the LOC subtest ($r = 0.69$; $p = 0.01$) and total raw scale scores ($r = 0.61$; $p = 0.05$) but not for the ball skill subtest ($r = 0.20$; $p = 0.43$). Similarly, Estevan et al. (2016) examined the construct validity of the TGMD-3 on Spanish children ($n = 178$; 6.94 ± 1.89 years) with the results showing a positive relationship between children's age and their motor competence in LOC skills ($r = 0.72$; $p < 0.001$), ball skills ($r = 0.80$; $p < 0.001$) and total FMS score ($r = 0.83$; $p < 0.001$), highlighting a strong level of construct validity.

The reliability and validity of the three versions of the TGMD have been well established in several countries to assess FMS among children aged 3-10 years. The TGMD is an attractive tool for assessing FMS due to the ease of administration, basic equipment and the time required for implementation. The tool can also be used for the identification of FMS proficiency levels (Ulrich, 2000) and so is a suitable tool to measure FMS proficiency of Irish primary school children.

2.3.4. FMS Proficiency Levels

When given the necessary opportunities and appropriate encouragement, children have the developmental capability to achieve mature performance of FMS by six years of age (Gallahue and Donnelly, 2003). However, national (Bolger et al., 2017; O'Connor et al., 2018) and international (Bryant et al., 2014; Okely and Booth, 1999; Okely and Booth, 2004; Valentini et al., 2007) research has reported low levels of FMS competence in primary school children. From the limited research available FMS proficiency levels of Irish primary school children are presented in Table 2.5.

Table 2.5: FMS Proficiency Levels in Irish Primary School Children

Author	Participants	FMS Assessment Tool	FMS Proficiency Levels					
			Mastery		Near Mastery		Poor	
			Boys	Girls	Boys	Girls	Boys	Girls
Bolger et al. (2017)	n = 203 **Senior Infants:** 6.0 ± 0.4 yrs **First Class:** 9.9 ± 0.4 yrs	TGMD-2	**Run:**71.8% **Gallop:**48.2% **Hop:**24.5% **Slide:**40% **Leap:**51.8% **Jump:**11.8% **Kick:**77.3% **Dribble:**22.7% **Catch:**25.5% **Strike:**18.2% **Throw:**41.8% **Roll:**12.7%	**Run:**87.1% **Gallop:**58.1% **Hop:**32.3% **Slide:**48.4% **Leap:**65.6% **Jump:**12.9% **Kick:**40.9% **Dribble:**28% **Catch:**18.3% **Strike:**21.5% **Throw:**18.3% **Roll:**1.1%	NR	NR	NR	NR
O'Connor et al. (2018)	n = 63 9.9 ± 1.3 yrs Ireland	TGMD-3	**Run:**100% **Gallop:**44.1% **Hop:**58.8% **Skip:**82.4% **HJ:**61.8% **Slide:**97.1% **THS:**29.4% **FHS:**85.3% **Dribble:**85.3% **Catch:**97.1% **Kick:**88.2% **OT:**97.1% **UT:**100%	**Run:**100% **Gallop:**48.3% **Hop:**58.6% **Skip:**69% **HJ:**48.3% **Slide:**96.6% **THS:**17.2% **FHS:**82.8% **Dribble** 65.5% **Catch:**89.7% **Kick:**20.7% **OT:**89.7% **UT:**89.7%	**Gallop:**44.1% **Hop:**35.3% **Skip:**14.7% **HJ:**29.4% **Slide:**2.9% **THS:**67.7% **FHS:**14.7% **Dribble:**14.7% **Catch:**2.9% **Kick:**11.8% **OT:**2.9%	**Gallop:**48.3% **Hop:**41.4% **Skip:**31% **HJ:**41.4% **Slide:**3.4% **THS:**55.2% **FHS:**17.2% **Dribble:**34.5% **Catch:**10.3% **Kick:**72.4% **OT:**10.3% **UT:**10.3%	**Gallop:**11.8% **Hop:**5.9% **Skip:**2.9% **HJ:**8.8% **THS:**2.9%	**Gallop:**3.4% **HJ:**10.3% **THS:**27.6% **Kick:**6.9%

FHS: One-Hand Forehand Strike. HJ: Horizontal Jump. NR: Not Reported. OT: Overhand Throw. THS: Two-Hand Strike. UT: Underhand Throw. Mastery: All components of the skill present. Near Mastery: All but one of the components of the skill missing. Non-Mastery: More than one component missing.

In Ireland, two studies (Bolger et al., 2017; O'Connor et al., 2018) (Table 2.5) have examined FMS proficiency levels among children, however, caution must be taken when interpreting these results as both of these studies used different cohorts. Bolger et al. (2017) examined primary school children whereas O'Connor et al. (2018) examined juvenile Gaelic games players. Bolger et al. (2017) reported low levels of FMS mastery among senior infant (n = 102; 6.0 ± 0.4 years) and 4th class (n = 101; 9.9 ± 0.4 years) children with mastery levels ranging from 12.4% for the horizontal jump to 78.8% for the run. In direct comparison, O'Connor et al. (2018) reported higher levels of mastery in eight FMS namely the run (100% vs 77.2%), hop (58.7% vs 36.6%), slide (96.8% vs 49.5%), horizontal jump (55.6% vs 13.9%), two-hand stationary strike (23.8% vs 20.8%), dribble (76.2% vs 50.5%), catch (93.7% vs 38.6%) and overhand throw (93.7% vs 45.5%). Surprisingly, a lower mastery level was reported by O'Connor et al. (2018) for the kick (57.1% vs 82.2%) considering the population examined were juvenile Gaelic games players. According to O'Connor et al. (2018), this may have been due to the requirements of the TGMD-3 as this assessment tool requires kicking a stationary ball off the ground, whereas in Gaelic football in most scenarios the ball is kicked from the hand. While FMS proficiency levels in Ireland are low similar trends are evident from an international perspective.

From an Australian perspective, Okely and Booth (1999) assessed six FMS on primary and high school children (n = 5,518, school years 4, 6, 8 and 10, mean ages 9.3, 11.3, 13.3 and 15.3 years, respectively). Results revealed that for boys and girls in all year groups, five of the six skills did not exceed a mastery level of 40%. The only skill to exceed a mastery level above 40% was the overhand throw. Similarly, Okely and Booth (2004) assessed FMS proficiency among Australian primary school children (n = 1,288, school years 1-3, aged 6-9 years) and found that for boys and girls in all year groups, no skill exceeded 35% mastery level. Furthermore, in only one skill, static balance, did the proportion of children who displayed advanced skill proficiency (i.e. mastery or near mastery) exceed 50%.

In England, similar trends are evident (Bryant et al., 2014). Bryant et al. (2014) assessed FMS proficiency among English primary school children (n = 281; 8.4 ± 1.6 years) using the 'Process Orient Checklist' taken from the New South Wales 'Move it Groove it' Physical Activity in Primary Schools: Summary Report with eight FMS being assessed (run, side gallop, hop, kick, catch, overarm throw, vertical jump and static balance). Results of the study showed that for six out of the eight FMS assessed the majority of children were classed as having 'non-mastery' (more than one component missing). Only the catch (40.3%) and balance (34.2%) were reported to having 'near mastery' (all but one of the components of the skill missing). The highest 'mastered' skill was the catch with 37.8% of children demonstrating mastery. The skills with the lowest percentages of 'mastery' (all components of the skill present) were the sprint (3.3%), gallop (12.8%) and hop (3.9%). These results reported by Bryant et al. (2014) particularly for the run are much lower than the results reported in Irish primary school children (Bolger et al., 2017) (71.8% v 3.3%). In addition, higher levels of mastery in four other skills was noted in Irish primary school children (Bolger et al., 2017) compared to English primary school children (Bryant et al., 2014). These skills were the gallop (53.2% vs 12.8%), hop (28.4% vs 3.9%), kick (59.1% vs 19.2%) and throw (30.1% vs 17.9%). Three of the four locomotor skills reported by Bolger et al. (2017) had a higher mastery which may have been due to the high number of overweight participants in the study conducted by Bryant et al. (2014) and the different assessment tools used (TGMD-2 v Process Orient Checklist). Weight status has been shown to be significantly inversely associated with FMS proficiency as studies speculate that overweight and obese participants execute significantly lower locomotor skill performance potentially due to the discomfort of engaging in these types of activities (Cliff et al., 2011; Southall et al., 2004).

Evidence shows that FMS proficiency levels among children are low (Bolger et al., 2017; Bryant et al., 2014; Hardy et al., 2015; Okely and Booth, 1999; Valentini et al., 2007); with a need for interventions aimed at FMS development. Furthermore, research has also shown that gender differences exist between males and females in relation to FMS proficiency (Bolger et al., 2017; Cliff et al., 2009; Foulkes et al., 2015; Goodway et al., 2003; Hardy et al., 2010; Hardy et al., 2015; O'Connor et al., 2018; Spessato et al., 2013; Van Beurden et al., 2003).

2.3.5. Gender Differences

Notable differences in FMS proficiency are evident between males and females with findings reporting males to be more proficient in OC related skills (Hardy et al., 2010; Hardy et al., 2015; O'Connor et al., 2018; Van Beurden et al., 2003). Some studies have reported no gender differences within LOC skills (Goodway et al., 2003; Hume et al., 2008; O'Brien et al., 2015; O'Connor et al., 2018; Van Beurden et al., 2003), while others have reported boys (Hardy et al., 2015; Spessato et al., 2013) or girls (Bolger et al., 2017; Hardy et al., 2010; Van Beurden et al., 2002) as more proficient.

In relation to Irish primary school children, Bolger et al. (2017) examined gender differences among senior infant infants (6.0 ± 0.4 years) and 4th class (9.9 ± 0.4 years) children with 12 FMS being assessed. With regard the LOC skills, females were shown to have significantly higher LOC skill proficiency than males ($p = 0.005$; $n^2 = 0.063$) whereas males showed a significantly higher OC skill proficiency compared to females ($p < 0.001$; $n^2 = 0.241$). The greater LOC skill level reported by females may be due to the type of activities that girls are more likely to participate in such as dance and gymnastics (Booth et al., 1999; Woods et al., 2010). In relation to the OC skills similar findings have been reported by O'Connor et al. (2018). These findings are likely attributable to and explained by biological, environmental and/or sociocultural factors (Garcia, 1994; Thomas and French, 1985). Males are influenced by competitiveness and they also partake in more sport/activities that involve object manipulation such as soccer, Gaelic football, hurling and rugby which allows for a greater exposure to, and practice of, these skills (Booth et al., 2006). Females are however less likely to avail of these practice opportunities.

Similar findings are also noted in international primary school children (Bryant et al., 2014; Hardy et al., 2015; Van Beurden et al., 2003). Van Beurden et al. (2003) conducted a quasi-experimental study on Australian primary school children (n =

1,045; 7-10 years) with eight FMS being assessed and found males to be significantly better at the kick ($p < 0.001$) and overhand throw ($p < 0.001$) while females performed significantly better in the hop ($p = 0.037$) and the side gallop ($p = 0.049$). Similarly, Hardy et al. (2015) compared the findings from the School Physical Activity and Nutrition Survey (SPANS) (2010) to the SPANS survey (2015) and found that among Australian primary school children males performed significantly better than females in the catch (67% v 53%), kick (54% v 16%) and overhand throw (52% v 18%). Additionally, Bryant et al. (2014) investigated FMS proficiency among English primary school children ($n = 281$; 8.4 ± 1.6 years) and reported males to be significantly better than females in kicking ($p = 0.0001$) and throwing ($p = 0.0001$) with females performing significantly better at static balance ($p = 0.0001$). Thus most research identified gender differences at the primary school level with females outperforming males in the LOC skills and males outperforming females in the OC skills.

2.3.5.1. Factors that Affect Gender Differences

As outlined previously FMS proficiency tends to differ between genders, and this can be attributable to and explained by biological, environmental and/or sociological factors (Thomas and French, 1985). Males are biologically bigger and stronger than females following puberty, therefore they possess a greater advantage in FMS which require strength (e.g. throwing a ball) (Thomas and French, 1985). Gender differences are therefore more likely to be associated with children's socialisation which is influenced by family, peers and teachers (Garcia, 1994; Thomas and French, 1985).

Parent's play a significant role with regards a child's participation in FMS. In particular, a parent's interaction with their child, their attitude towards participation in PA, PA behaviours and equipment in the family home play a significant role of a child's performance of FMS (Barnett et al., 2011; Barnett et al., 2013; Cools et al., 2011; Thomas and French, 1985). For example, Cools et al. (2011) reported that while boy's FMS performance was positively associated with father's PA ($r = 0.13$; $p \leq 0.01$), girl's FMS performance was positively associated with frequency of providing equipment ($r = 0.17$; $p \leq 0.01$). However, recent evidence suggests that interactions during PA among females tend to be conducted in a co-operative and caring manner while interactions amongst boys are influenced by competitiveness and a sense of individualism (Hardy et al., 2010). These interactions during PA may reflect the gender differences evident, while the limited skill practice available, particularly for females, could contribute to the development of specific FMS in females (e.g. skipping) (Hardy et al., 2010). This may also explain the high female drop out from sport at a young age.

2.3.6. Benefits of FMS

A positive association between FMS and PA (Hume et al., 2008; Raudsepp and Päll, 2006), fitness (Barnett et al., 2008) and academic achievement (Ericsson, 2008; Haapala et al., 2014; Jaakkola et al., 2015; Pienaar et al., 2013), and an inverse association with body weight status (Cliff et al., 2009; D'Hondt et al., 2009; Graf et al., 2004; Hume et al., 2008) has been reported.

2.3.6.1. FMS and PA

FMS competency has been identified as a potential underlying mechanism towards regular participation in PA (Lubans et al., 2010). This relationship between FMS and PA is reciprocal in nature as children must be physically active in order to develop FMS, with the relationship anticipated to strengthen with age, and is likely mediated by changes in cognitive awareness (Stodden et al., 2008). As children get older, the relationship between their actual and perceived competence in performing motor skills strengthens (Stodden et al., 2008). However, there is very little evidence of this relationship in early childhood. Similarly, Seefeldt (1980) stated that there is a 'critical threshold' of motor skill competence whereby some children will be competent in FMS and successful at maintaining a physically active lifestyle throughout life whereas other children will fall below this threshold, be less successful and drop out of PA. Therefore, it is essential that children are given the opportunity to practice FMS early in life particularly before leaving primary school. If these skills are not taught at a young age it can have a negative effect later in life.

Holfelder and Schott (2014) indicated that 20 out of 23 studies found a positive association between FMS and PA. Similarly, Lubans et al. (2010) reported that of 13 studies that specifically examined FMS, 12 found a positive association between FMS and PA. This association has been found within pre-school aged children (Fisher et al., 2005), primary school aged children (Raudsepp and Päll, 2006) and adolescents (Barnett et al., 2008; McKenzie et al., 2002; Okely et al., 2001) with research now highlighting that FMS is positively associated with different types of PA including; MVPA (Fisher et al., 2005; Hume et al., 2008; Wrotniak et al., 2006), total PA (Fisher et al., 2005) and organised PA (Barnett et al., 2009; Okely et al., 2001).

Barnett et al. (2016) and Holfelder and Schott (2014) have also examined the relationship between PA and the subtests of FMS. The relationship between OC skill competence and PA levels was supported in only 45% (Barnett et al., 2016) and 26% (Holfelder and Schott, 2014) of the studies. Similarly, the relationship between PA levels and LOC skill competence is uncertain and supported in only 45% of studies (Barnett et al., 2016). Logan et al. (2015) examined the strength of the relationship between FMS and PA across different age groups (3-5 years, 6-12 years and 13-18 years). For children aged 3-5 years, the relationship between FMS competence and PA was low to moderate ($r = 0.16\text{-}0.48$; 4 studies) whereas low to high correlations ($r = 0.24\text{-}0.55$; 7 studies) were reported for children aged 6-12 years. Similar to 3-5 year old children, for adolescents aged 13-18 years the relationship between FMS competence and PA was low to moderate ($r = 0.14\text{-}0.35$; 2 studies). Contrary to the model proposed by Stodden et al. (2008), the findings reported by Logan et al. (2015) show that the relationship between FMS competence and PA has not been shown to increase with age, however caution must be taken into consideration as only two studies were examined.

In a longitudinal study, Barnett et al. (2009) investigated the relationship between childhood FMS proficiency and adolescent PA and reported that OC proficiency in childhood was associated with time in both organised PA and MVPA accounting for 18.2% and 12.7% of the variation, respectively. Based on these findings, it can be speculated that OC skills in both childhood and adolescence are a significant predictor of adolescent participation in PA. This may be because OC skills are often associated with PA of a moderate and/or vigorous intensity as these skills are fundamental for the involvement in various games and sports that involve OC skill related performance (Barnett et al., 2009; Raudsepp and Päll, 2006). Therefore, adolescents who are proficient at performing OC skills are more likely to participate in activities that allow for an increase in PA levels (Barnett et al., 2009). In contrast, McKenzie et al. (2002) found no significant association between FMS competence and PA levels as measured using the 7-day PA Recall questionnaire six years later. However, only three skills were assessed during the study and if more skills had been assessed the findings may have been different. A major limitation of the longitudinal studies is the use of subjective measures to assess PA levels which can lead to bias and recall error. Objective measures such as the use of an accelerometer may be a more accurate method to assess PA levels.

Only one Irish study has examined the relationship between FMS and PA levels (O'Brien et al., 2015). However, this study examined Irish adolescents and no significant associations were reported between FMS proficiency and PA levels for males, however, for females the LOC subtest ($r = 0.37$; $p < 0.05$) and total FMS score ($r = 0.36$; $p < 0.05$) were significantly related to VPA only. These findings were similar to those reported by Laukkanen et al. (2014), who reported that FMS among females showed a positive association with VPA ($r = 0.56$; $p < 0.05$), whereas contradictory findings were observed for males with FMS being positively associated with time spent in LPA ($r = 0.51$; $p < 0.05$) and MPA ($r = 0.55$; $p < 0.05$). In contrast, Cliff et al. (2009) reported that OC subtest among males was positively associated with MPA ($r = 0.52$; $p = 0.008$) and MVPA ($r = 0.48$; $p = 0.015$), with no association reported for females. Although each of these studies has examined the relationship between FMS and different levels of PA (MPA, MVPA and VPA) none of the studies have examined the relationship between FMS and LPA.

Inconsistencies in the findings reporting the relationship between FMS competence and PA may be due to the different activities males and females participate in.

According to Logan et al. (2015) OC skills are more highly correlated with male PA levels, whereas LOC skills are more highly correlated with female PA levels. These findings are reported by Hume et al. (2008) who found that MPA and MVPA showed weak but significant correlations with the OC proficiency score ($r = 0.24$; $p \leq 0.01$) among boys. VPA was weakly but significantly correlated with both total FMS score ($r = 0.21$) and the LOC proficiency score ($r = 0.29$; $p \leq 0.01$) in girls. The majority of studies examining the relationship between FMS and PA have focused on MVPA and VPA, with no studies examining the relationship between FMS and LPA. Measuring each level of PA is important as it provides an overall picture of a child's PA level rather than focussing solely on different levels of PA. Further longitudinal research studies which include a baseline, FMS skill intervention, and retention period measuring PA at each time point are needed to demonstrate if FMS competence directly influences future participation in PA.

2.3.6.2. FMS and Cardiorespiratory Fitness

Independent of PA, FMS proficiency has also been positively associated with cardio-respiratory fitness and cardio-respiratory endurance (Barnett et al., 2008; Okely et al., 2001). Barnett et al. (2008) examined the relationship between childhood FMS proficiency and adolescent cardio-respiratory fitness and found that OC proficiency in childhood was associated with cardio-respiratory fitness ($p = 0.012$) and accounted for a variation of 25.9% in fitness. Children with good OC skills achieved on average, more than six additional laps than children with poor OC skills (Barnett et al., 2008). Similarly, Okely et al. (2001) examined the relationship between cardio-respiratory endurance and FMS proficiency among adolescents ($n = 2{,}026$, grades 8 and 10; 13-16 years). FMS proficiency accounted for 21% and 28% of the variance in cardio-respiratory endurance for females, respectively; and 13% and 18% for males, respectively.

2.3.6.3. FMS and Weight Status

According to the conceptual model outlined by Stodden et al. (2008), motor competence can act as a contributor to the maintenance of a healthy weight status. However, if a child is overweight this can have a negative effect on FMS as children may drop out of PA and self-confidence levels could drop. Current research suggests that weight status is inversely associated with FMS proficiency (Cliff et al., 2009; D'Hondt et al., 2009; Graf et al., 2004; Hume et al., 2008; McKenzie et al., 2002; Morano et al., 2011; Siahkouhian et al., 2011; Southall et al., 2004; Williams et al., 2008). Siahkouhian et al. (2011) investigated the relationship between FMS and BMI in overweight and obese Iranian children (n = 200; 7-8 years) compared to a normal weight sample and reported significant negative correlations between the LOC skills subtest and BMI for the run ($r = -0.46$; $p < 0.01$), gallop ($r = -0.14$; $p < 0.05$), hop ($r = -0.38$; $p < 0.01$) and horizontal jump ($r = -0.28$; $p < 0.01$), with no significant correlations found for the OC skills: strike ($r = 0.05$) catch ($r = -0.13$) and kick ($r = -0.02$) and BMI. Similarly, Hume et al. (2008) found that a significantly higher percentage of non-overweight 9-12 year old Australian children achieved mastery/near-mastery in the run compared to their overweight peers (23.9% vs 8.9%, $p < 0.05$). Both studies suggest that poor FMS proficiency in relation to weight status may reflect the lack of opportunity available to participate in PA to support motor development (Morano et al., 2011). Furthermore, moving a heavier body mass against gravity can lead to discomfort, ultimately hindering overweight and obese participants to execute proficient skill execution during complex body movements (Graf et al., 2004; D'Hondt et al., 2010; Morano et al., 2011). Therefore, interventions should focus specifically on the prevention of overweight and obesity to ensure the development of FMS and increase participation in PA (Han et al., 2018).

2.3.6.4. FMS and Academic Achievement

Research has shown that children with high FMS proficiency will achieve a better academic performance (Ericsson, 2008; Haapala et al., 2014; Jaakkola et al., 2015; Pienaar et al., 2013; Son and Meisels, 2006; Westendorp et al., 2011). Pienaar et al. (2013) examined the relationship between FMS and academic performance among children ($n = 812$; 6.78 ± 0.49) in the North West Province of South Africa. A strong relationship between visual motor skills and visual perception was reported for mastery of maths, reading and writing ($p < 0.001$). The motor co-ordination standard score was not significantly related to the maths score, but was related to reading, writing and the overall score for academic performance ($p < 0.001$). Overall, children with a good motor co-ordination score have an 8.59% higher chance of achieving a good academic performance compared the children with poor motor co-ordination (Pienaar et al., 2013). Similarly, findings by Pienaar et al. (2013), Haapala et al. (2014) reported that children ($n = 174$; 7.7 ± 0.4 years), especially boys, with poorer motor performance showed worse academic skills. Poorer balance was related to poorer reading comprehension ($p = 0.04$) and fine motor skills were associated with poorer reading fluency in grades 1-2 ($r = 0.28$; $p < 0.01$ and $r = 0.23$; $p < 0.05$), reading comprehension in grade 3 ($r = 0.23$; $p < 0.05$) and arithmetic skills in grades 1-2 ($r = 0.23$; $p < 0.05$ and $r = 0.21$; $p < 0.05$) in boys. Among girls, motor performance had much weaker and generally statistically non-significant correlations with academic skills in girls, potentially due to girls reaching a level of maturation before boys (Haapala et al., 2014). Therefore, a higher level of academic performance is associated with a higher FMS proficiency in boys but not in girls (Jaakkola et al., 2015).

By promoting the development of FMS from an early age it is clear to see the benefits that are associated with FMS proficiency such as an increase in PA levels (Fisher et al., 2005), an increase in cardio-respiratory fitness (Barnett et al., 2008) and an improvement in academic performance (Jaakkola et al., 2015). However, children need to be given the opportunity to practice FMS for these benefits to occur and one factor which may reduce the likelihood of this is sedentary activities.

2.4. Sedentary Behaviour

SB (which includes TV viewing, computer and game-console use, workplace sitting, and time spent in automobiles) has emerged as a new focus for research in the area of PA and health (Owen et al., 2010). Examining time spent in SB is worthwhile, as it displaces the amount of time spent in light PA, contributing to a reduction in overall PA EE (Owen et al., 2010). SB is associated with increased risk of cardio-metabolic disease, all-cause mortality and a variety of physiological and psychological problems, independent of PA levels in adults (Owen et al., 2010; Saunders et al., 2014).

2.4.1. Definition of SB

SB definitions are inconsistent in current literature, with some studies classifying participants as sedentary when they are engaging in activities characterised by low EE (e.g. sitting) whereas other studies have referred to SB as not being physically active (Owen et al., 2000; Tremblay et al., 2010). However, it is important to understand that both SB and physical inactivity are two different constructs (Van Der Ploeg and Hillsdon, 2017). In order to provide clarity to researchers in the area of SB and physical inactivity, a conceptual model and consensus were finalised on the key terms associated with SB (Tremblay et al., 2017). Based on this model SB was defined as 'any waking behaviour characterised by an EE ≤ 1.5 METS, while in a sitting, reclining or lying posture' whereas physical inactivity was defined as 'an insufficient PA level to meet present PA recommendations' (Tremblay et al., 2017, p.9).

2.4.2. Sedentary Behaviours of Interest

Over the last decade, a sedentary lifestyle is becoming much more evident in society, primarily due to advances in technology, which causes an overall decline in PA and an increase in the volume of leisure time resulting in children partaking in sedentary activities (Pate et al., 2011). In addition, the mode of transport has also changed from primarily walking to driving (Speakman, 2004). The most prevalent modes of SB for children include TV, computer/video games, motorised transport, homework, listening to music, sitting and reading.

Children spend more time engaging with electronic devices such as TV, videogames and internet than any other activity (Cummings et al., 2007). TV viewing dominates media consumption, taking up about 4.5 hours a day followed by listening to music (2 hours and 31 minutes), computer use (1.29 hours), playing video games (1.13 hours), reading (38 minutes) and watching movies (25 minutes) (Rideout et al., 2010). TV viewing is higher among boys than girls. Biddle et al. (2009) reported that 25.9% of Hungarian boys spent > 4 hours watching TV at the weekend which exceeds the SB guidelines. Similarly, Fairclough et al. (2009) reported 54.4% of boys watched TV for ≥ 1 hour/day at the weekend compared to 41.8% of girls. Computers, in particular, are more likely to be used by boys for playing games, whereas girls are more likely to use computers for homework, communicating with friends and the internet (Hardy et al., 2007; Roberts, 2000). The use of motorised transport has increased for both boys and girls; however, caution must be taken when interpreting these results as it is unclear if children who are using motorised transport are being driven to active pursuits (Hinckson et al., 2014).

According to the ‘Growing Up in Ireland Study’ (GUI) 45% of nine-year olds reported to have a TV and 35% a video/DVD player in their bedroom (Layte and McCrory, 2011). Two-thirds of nine-year olds were reported to watch TV for 1-3 hours per day, with 10% reported to be viewing TV for 3 or more hours (Layte and McCrory, 2011). Boys also reported spending significantly more time playing video games, such as the PlayStation and Xbox, compared to girls (30% vs 12%, respectively) (Layte and McCrory, 2011). Eight-six percent of children were also reported to have a computer in the family home (Layte and McCrory, 2011). According to the CSPPA study, primary school children spent 2.6 hours per day engaging in sedentary activities (Woods et al., 2010). Similarly, in the Health Behaviour in School-Aged Children (HBSC) report, 48% of 11-year-old girls and 55% of 11-year-old boys reported watching TV for 2 or more hours per day (Currie et al., 2012). TV viewing increased among 13-year-old children (52% of girls and 56% of boys) and 15-year-old children (56% of girls and 60% of boys) with boys spending more time watching TV (Currie et al., 2012). The evidence suggests that SB is consistently high among children, particularly amongst boys and these sedentary activities can contribute to significant health effects if they are not reduced.

2.4.3. SB Guidelines for Children

SB guidelines for children have been established across four countries (Australia, Canada, UK and the USA). These guidelines advise to minimise the amount of time spent sitting and to break up prolonged periods of sitting (Australian Government Department of Health, 2014; Canadian Society for Exercise Physiology, 2011; Davies et al., 2011; US Department of Health and Human Services, 2012). It is recommended that the use of electronic media (e.g. TV, electronic games and computer use) is limited to < 2 hours/day (Australian Government Department of Health, 2014; Canadian Society for Exercise Physiology, 2011; Davies et al., 2011; US Department of Health and Human Services, 2011). Parents are also encouraged to give their children the best opportunity to participate in PA to reduce SB levels (Davies et al., 2011). No guidelines have been developed for Irish children, however in the 2016 Report Card on Physical Activity for Children and Youth it was highlighted that the development of SB guidelines for Ireland as a key action point going forward (Harrington et al., 2016).

2.4.4. Health Consequences of SB

Research has shown that SB is a distinct risk factor for an array of negative health outcomes in children (Zhu and Owen, 2017). Children are the most active segment of society, but there are growing concerns that elements of society are causing youth to become less active, more sedentary, more overweight, and less healthy (Zhu and Owen, 2017). Accumulating evidence shows that, independent of PA levels, SB is associated with increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems (Katzmarzyk et al., 2009; Owen et al., 2009; Treuth et al., 2007). Research has documented significant health consequences associated with SB in adults (Dunstan et al., 2011; Owen et al., 2010) but the effects are less clear amongst youth. This may be due to the longer time course of chronic diseases as children may be at an increased risk for future health problems, but the effects may not manifest until later in life (Zhu and Owen, 2017). The health consequences which will be discussed in further detail below are body composition, cardiometabolic diseases and fitness.

2.4.4.1. Body Composition

Research has focused primarily on the relationship between TV viewing and body composition. Although SB and BMI have been associated in several studies (r = 0.17-0.75) (Chen et al., 2007; Davison et al., 2006; Epstein et al., 2008; Hancox et al., 2004; Hancox and Poulton, 2006; Heelan and Eisenmann, 2006; Jago et al., 2005; Landhuis et al., 2008; Pardee et al., 2007), some have reported weak correlations (r = 0.17) (Marshall et al., 2004) and some have reported contradictory findings (Burke et al., 2006).

Early research on SB indicated that excess TV viewing was a likely contributor to overweight and obesity in youth (Andersen et al., 1998; Dietz and Gortmaker, 1985; Ekelund et al., 2006; Gortmaker et al., 1996) and a dose-response effect of time spent watching TV and the prevalence of obesity among children has been observed (Dietz and Gortmaker, 1985). Dietz and Gortmaker (1985) reported that each hourly increment of TV viewing was associated with a 1.2-2.9% increase in prevalence of obesity. In addition, Andersen et al. (1998) examined the relationship between BMI, body fat, and TV viewing among children and adolescents (n = 4,056; 8-16 years) and showed that boys and girls who watched ≥4 hours of TV/day had the highest skinfold thicknesses ($p < 0.001$) and highest BMI's ($p < 0.001$) while children who watched < 1 hour of TV/day had the lowest BMI's. In a more recent study, Ekelund et al. (2006) reported that TV viewing was significantly and positively associated with adiposity ($p = 0.021$) and that eating meals whilst watching TV was also significantly and positively associated with adiposity ($p = 0.029$). These findings suggest that TV viewing is associated with increased energy intake, which may affect energy balance and subsequent weight gain amongst youth. However, it is also plausible that TV viewing is increased as a result of children being overweight (Zhu and Owen, 2017). While these studies have shown an increase in body composition as a result of excessive TV viewing, Burke et al. (2006) reported that video game usage was not significantly related to the risk of overweight/obesity and TV viewing was not shown to predict an increase of overweight/obesity compared to boys (OR = 0.99 and OR = 1.04, respectively).

Long-term cohort studies have also demonstrated that increased TV viewing during childhood is a significant predictor of overweight and obesity in adulthood (Hancox et al., 2004; Landhuis et al., 2008). Viner and Cole (2005) reported that the greater total hours per day of weekend TV viewing at 5 years of age predicted a higher BMI at 30 years of age ($p < 0.0001$). Similar results were found in a longitudinal birth cohort study of New Zealand children (n = 991; 5-21 years), with average TV viewing between 5-15 years being associated with a higher BMI at 26 years ($p = 0.01$) (Hancox et al., 2004). Therefore, by reducing TV viewing, future BMI may be reduced.

2.4.4.2. Cardiometabolic Diseases

An association between TV viewing and cardiometabolic diseases has also been identified (Hancox et al., 2004; Lazarou et al., 2009; Martinez-Gomez et al., 2009; Pardee et al., 2007; Sardinha et al., 2008; Wells et al., 2008). Carson and Janssen (2011) examined the independent associations between volume, patterns and types of SB with cardio-metabolic risk factors among children and adolescents (n = 2,527; 6-19 years) and reported that the prevalence of a high cardiometabolic risk score (calculated from waist circumference, resting systolic BP, non-high-density lipoprotein cholesterol and C-reactive protein) increased significantly with the increasing hours of TV use ($p < 0.01$). In addition, children who watched TV ≥ 4 hours/day were 2.53 times more likely to have a high cardiometabolic risk score than those who watched TV for < 1 hour/day (Carson and Janssen, 2011). Similarly, Stamatakis et al. (2013) observed that > 2 hours/day of TV viewing was significantly associated with a higher cardiometabolic risk score ($p < 0.001$) in Portuguese children. Both of these studies have included PA, however, when PA is controlled studies have reported no association between TV viewing and cardiometabolic risk score (Ekelund et al., 2006; Martinez-Gomez et al., 2012).

Four research studies have examined the relationship between SB and BP and found a positive association (Lazarou et al., 2009; Martinez-Gomez et al., 2009; Pardee et al., 2007; Wells et al., 2008). In particular, Lazarou et al. (2009) reported that children who watched TV whilst eating were two times more likely to have elevated systolic BP and diastolic BP. Similarly, Pardee et al. (2007) reported that children who watched ≥ 4 hours of TV/day were 3.3 times more likely to have hypertension and for each additional hour of TV watched per day there was a 26% increased risk of having hypertension ($p < 0.001$). Studies have also reported significant positive associations between SB and high cholesterol levels and insulin resistance ($r = 0.21$-0.65) (Hancox et al., 2004; Lazarou et al., 2009; Martinez-Gomez et al., 2009; Martinez-Gomez et al., 2012; Pardee et al., 2007; Sardinha et al., 2008; Stamatakis et al., 2013). Therefore, it is important to reduce these sedentary behaviours which will allow for a healthier lifestyle.

2.4.4.3. Fitness

Three studies reported a negative association between TV viewing and cardiorespiratory fitness independent of PA levels (Armstrong et al., 1998; Katzmarzyk et al., 1998; Lobelo et al., 2009). A two-year longitudinal study conducted by Aggio et al. (2012) examined the relationship between ST and cardiorespiratory fitness and reported that the odds of becoming physically unfit were significantly higher for children who watched 2 or more hours of ST/day (OR = 2.55; 95% CI = 1.4-4.0). Similarly, Sandercock and Ogunleye (2013) found that the odds of being physically fit were significantly lower for boys reporting high (> 2 hours/day) (OR = 0.70; 95% CI = 0.58-0.85) and very high (> 4 hours/day) (OR = 0.45; 95% CI = 0.35-0.57) ST, and for girls reporting > 4 hours/day of ST (OR = 0.58; CI = 0.43-0.78). Further, a cross-sectional representative population survey was taken of the New South Wales (Australia) school students in Grades 6 ($n = 979$; 11.4 ± 0.01 years), 8 ($n = 801$; 13.5 ± 0.02 years) and 10 ($n = 970$; 15.4 ± 0.02 years) to examine the associations between sedentary activities, small-screen recreation (watching TV/DVDs/videos and recreational computer use) and cardiorespiratory endurance. Time spent in sedentary activities was associated with cardiorespiratory endurance among Grade 8 students ($p = 0.01$) and Grade 10 girls ($p = 0.03$). Cardiorespiratory endurance was also lower among Grade 8 students ($p < 0.001$) and Grade 10 girls ($p < 0.001$) who spent ≥ 2 hours/day on small-screen recreation compared with students who spent < 2 hours/day.

Sedentary activities have significant effects on a child's health which can track from adolescence into adulthood. It is important to understand the underlying mechanisms which cause children to partake in these sedentary activities to ultimately reduce the health consequences associated with these sedentary activities. However, if children are given the opportunity to reduce these sedentary behaviours this can have a positive effect towards reducing these comorbidities and allow children to lead a more physically active lifestyle.

2.4.5. Correlates of SB

Several reviews have been conducted to investigate the correlates of SB (Byun et al., 2011; Dolinsky et al., 2011; LeBlanc et al., 2015a; LeBlanc et al., 2015b). Correlates of sedentary behaviours are the factors which influence children to partake in sedentary pursuits (Byun et al., 2011). These reviews focus predominantly on total sedentary time and self-reported ST and identify biological, behavioural and environmental factors that may influence a child's level of SB (Hinkley et al., 2010). A better understanding of the correlates of SB in children allows for the support and development of effective interventions that promote an active lifestyle and ultimately prevent a sedentary lifestyle (Davison and Lawson, 2006; Van Der Horst et al., 2007).

2.4.5.1. Biological

Biological correlates such as BMI, waist circumference, percentage BF and gender have been shown to be positively correlated with a child's engagement in SB (Adegoke and Oyeyemi, 2011; Byun et al., 2011; Dolinsky et al., 2011; LeBlanc et al., 2015a; LeBlanc et al., 2015b). LeBlanc et al. (2015a) conducted a study on children from 12 different countries (Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, UK and USA) with 21 potential correlates of total sedentary time and ST examined. Across the total sample, total sedentary time was positively associated with percentage BF ($p < 0.0001$) and ST was positively associated with waist circumference ($p < 0.0001$). These results highlight that children with a higher BMI, waist circumference and percentage BF may choose sedentary activities over engaging in PA for a variety of reasons, including lack of experience of PA, potential embarrassment when engaging in PA, stigma associated with being overweight, and the potential pain associated with engaging in PA (Zhu and Owen, 2017).

2.4.5.2. Behavioural and Environmental

Parent's ST, not meeting PA guidelines, TV in the bedroom and computer in the bedroom and eating whilst watching TV are the behavioural and environmental correlates shown to be positively associated with SB (Byun et al., 2011; Dolinsky et al., 2011; LeBlanc et al., 2015a; LeBlanc et al., 2015b). Four studies (Cillero and Jago, 2010; Kourlaba et al., 2009; McGuire et al., 2002; Songül et al., 2002) found that a child's ST was higher if their parents also had a higher ST. Research suggests that a parents' lifestyle may have a strong influence on their children's lifestyle from an early age. These influences may become more noticeable as a child ages and parental rules within the household become more relaxed as children are given opportunities to make their own choices. It has been reported that parents tend to increase co-viewing as children move into early adolescence, therefore reducing time spent together in other social contexts (e.g. eating together). This would suggest that interventions that target both child and parent TV viewing together may be beneficial (Cillero and Jago, 2010).

Eating while watching TV is also a significant contributor towards SB in children (Gebremariam et al., 2013; Sisson et al., 2012; Sonneville and Gortmaker, 2008). Sonneville and Gortmaker (2008) estimated total energy intake associated with SB among children (n = 538; 11.71 ± 0.75 years) and reported that each 1 hour increase in TV viewing was associated with an additional energy intake of 106 kcal/day^{-1}. In addition, each 1 hour increase in computer and video game playing was associated with an additional energy intake of 92 kcal/day^{-1}. Excessive eating during TV viewing may be due to the large amount of time spent in screen media viewing and the types of food and beverages that are convenient to consume while viewing (Zhu and Owen, 2017). Food advertising may also contribute to the increase in energy consumption and poor dietary practices (Zhu and Owen, 2017). Therefore, by understanding the factors which contribute to a sedentary lifestyle for children it allows for the design of targeted interventions to reduce these activities and the health consequences associated with it.

2.5. Interventions

Intervention programmes have been shown to be successful at improving both FMS and PA levels and reducing SB levels among children and adolescents. Most interventions take place in preschools, primary schools and secondary schools, as they are easily accessible. Interventions which adopt a multi-component approach have been reported to be the most effective as they involve a vast network of co-operation and planning from school principals, school teachers, parents, students, FMS professionals and the community (Barnett et al., 2009; Van Capelle et al., 2017; Van Beurden et al., 2003). Several reviews investigating the effectiveness of FMS intervention programmes have reported programmes spanning a duration of between 4 weeks and 6 years (Lubans et al., 2010; Morgan et al., 2013, Riethmuller et al., 2009) with the average duration being reported between 11-12 weeks (Riethmuller et al., 2009). While, the optimal duration for intervention programmes has not been established, several studies have reported both short (Bardid et al., 2017; Brian et al., 2017; Bryant et al., 2016; Burns et al., 2017; Foulkes et al., 2017; Foweather et al., 2008; Goodway and Branta, 2003; Johnson et al., 2016; Lander et al., 2017; Miller et al., 2015; Mitchell et al., 2013; Nathan et al., 2017; Veldman et al., 2017) and long-term effects (Barnett et al., 2009; Chen et al., 2017; Cliff et al., 2011; Cohen et al., 2015; Johnstone et al., 2017; Jones et al., 2011; Kalaja et al., 2012; McGrane et al., 2017; Morano et al., 2014; Van Beurden et al., 2003) following the intervention.

Following the findings of the CSPPA study which reported that only 19% of Irish primary and 12% of post-primary pupils were meeting the recommended daily PA guidelines, Woods et al. (2010), proposed that a robust surveillance system to monitor PA and health behaviours should be implemented and recommended an increase in PA participation for children and youth in Ireland. This system would require multi-level partnership, collaboration and a common vision (Woods et al., 2010). However, the CSPPA study was only conducted over one academic year and a more long-term study would need to be implemented to track PA and health behaviours over time. However, the success of intervention programmes will depend on several factors such as the; duration of the intervention, duration and frequency of the sessions, implementation of the intervention, specific skills or components that will be targeted for the intervention, training involved in the implementation of the intervention and whom will deliver the intervention. Therefore, it is important to analyse previous intervention programmes that have been adopted to determine their overall effectiveness. For the purpose of this literature review, intervention programmes of 12 weeks duration or less were classified as short-duration and intervention programmes greater than 12 weeks were classified as long-duration.

2.5.1. Short-Duration Intervention Programmes (≤ 12 weeks)

Several studies have reported significant improvements for short-duration programmes (Bryant et al., 2016; Burns et al., 2017; Foweather et al., 2008; Johnson et al., 2016; Miller et al., 2015; Mitchell et al., 2013; Nathan et al., 2017) (Table 2.6). Intervention programmes as short as six weeks have led to significant improvements in FMS (Bryant et al., 2016; Johnson et al., 2016; Mitchell et al., 2013) with each session ranging from 60-120 minutes per week (Bryant et al., 2016; Burns et al., 2017; Foweather et al., 2008; Johnson et al., 2016; Miller et al., 2015; Mitchell et al., 2013; Nathan et al., 2017). In addition, teachers who are trained prior to the implementation of these interventions have been shown to be more effective (Miller et al., 2015; Nathan et al., 2017), with significantly greater FMS scores ($p < 0.001$) reported in comparison to teachers who had no prior knowledge of FMS.

In a study conducted on English primary school-children ($n = 165$; 8.3 ± 0.4 years) Bryant et al. (2016) reported significant improvements in FMS following a six-week school-based FMS programme where participants took part in one session per week for a duration of 60 minutes. Following the intervention there was a significant improvement for the intervention group for 7 out of the 8 FMS assessed (Table 2.6). Surprisingly, the control group also showed a significant improvement in 5 out of the 8 FMS assessed (Table 2.6). As the intervention group and control group were from the same school this may have led to students teaching each other the skills which may have been a reason for the improvement in the control group. Similarly, Mitchell et al. (2013) implemented a six-week intervention programme (Project Energise) where teachers received extra support and mentoring for implementing the intervention. As a result, post-intervention results showed a significant improvement in the 12 FMS assessed (kick [$p < 0.0001$], throw [$p < 0.0001$], strike [$p < 0.0001$], skip [$p < 0.0001$], leap [$p < 0.0001$], jump [$p < 0.0001$], gallop [$p < 0.0001$], bounce [$p < 0.0001$], catch [$p < 0.0001$] and hop [$p < 0.0001$]; slide [$p < 0.001$] and run [$p = 0.003$]). Furthermore, while studies of six-week duration (Bryant et al., 2016; Mitchell et al., 2013) have reported significant findings two studies (Foulkes et al., 2017; Johnson et al., 2016) have reported no significant improvement in FMS competence following a six-week intervention. The exact reasons for this are unknown as the intervention adopted the same duration as Bryant et al. (2016) and Mitchell et al. (2013), however, teachers who had no prior experience in FMS implemented the sessions. Therefore, programmes where teachers are given guidance, support and training prior to the implementation of the intervention may be more effective for short-duration interventions.

While short-duration intervention programmes have been shown to be effective at improving PA levels and FMS competence, it is essential that teachers are encouraged to implement these programmes. With the appropriate training teachers can provide an environment for children to upskill their FMS in a safe and friendly environment. While two studies (Robinson et al., 2017; Veldman et al., 2017) have examined a follow-up analysis, with both studies reporting that FMS was maintained over time more research is needed to see if these improvements can be maintained.

Table 2.6: Short-Duration Intervention Programmes Conducted on Primary School Children

Short-Duration Intervention Programmes (≤ 12 weeks)				
Author	**Study Population/Country**	**Intervention Details**	**Assessment Tools**	**Results**
Bryant et al. (2016) (School-based FMS program)	n = 165 (8.3 ± 0.4 yrs) **INT:** n = 82 **C:** n = 83 England	6 week program (1 x 60 min./week) (pre & post-test) consisting of circuits and dancing to music	**Subjective Assessment:** FMS (Process Orient Checklist) 8 skills were assessed (sprint run, side gallop, hop, kick, catch, overarm throw, vertical jump and static balance) **Objective Assessment:** 10m sprint run PA measured using pedometer (4 days)	**INT > C** **FMS:** **Boys:** 8 FMS ↑ compared to C ($p < 0.05$) **Girls:** 8 FMS ↑ compared to C ($p < 0.05$) **PA:** There was an ↑ in INT average daily step-count post-INT (girls; $p < 0.001$ and boys; $p < 0.05$)
Burns et al. (2017) **CSPAP (Comprehensive School Physical Activity Program)**	n = 1,460 (8.4 ± 1.8 yrs) United States	12 week program (pre & post-test)	FMS (TGMD-2)	**FMS:** Total FMS scores ↑ 72.6%- 82.4% ($p < 0.001$; $d = 0.67$) Younger children (7-9 yrs) improved more than older children (10-12 yrs) ($p < 0.01$; $d = 0.30$-0.55)

Foweather et al. (2008) **After-School Multi-Skills Club**	**INT:** n = 15 (9.1 ± 0.3 yrs) **C:** n = 19 (9.2 ± 0.3 yrs) England	9 week program (2 x 60 min./week) (pre & post-test)	7 FMS (Department of Education and Training) (vertical jump, leap, sprint run, kick, catch, throw and static balance)	Static balance (β = 2.56; SE = 0.92; $p = 0.005$) > for INT compared to C
Miller et al. (2015) **PLUNGE (Professional Learning for Understanding Games Education)**	**INT:** n = 97 (11.12 ± 1.28 yrs) **C:** n = 71 (11.2 ± 0.61 yrs) Australia	7 week program (pre & post-test)	3 FMS (TGMD-2) (throw, catch and kick) PA (Yamax Digi-walker CW700) Athletic Competence (Harter's Self-Perception Profile for Children)	**INT > C** **FMS:** OC competence ↑ at post-test in INT compared to C ($p < 0.001$; $d = 0.96$) **PA:** In-class step count ↑ at post-test in INT compared to C ($p < .001$; $d = 1.02$; 47%)
Mitchell et al. (2013) **Project Energise (Funded by the Waikato District Health Board and contracted to Sport Waikato)** Multi-component school-based intervention	**INT:** 11 schools n = 701 tested for LOC n = 598 tested for OC (5-12 yrs) **C:** No C group New Zealand	6 week program (pre & post-test)	12 FMS (TGMD) (kick, throw, strike, skip, leap, jump, gallop, bounce, catch, hop, slide and run)	**FMS:** 12 FMS ↑
Nathan et al. (2017)	**INT:** n = 83 (6.1 ± 0.9 yrs)	10 week program (2 x 30 min./week)	6 FMS (TGMD-3) (OC: stationary dribble, kick, catch, overhand throw,	**INT > C** **FMS:**

GLASS (Great Leaders Active StudentS)	**C:** n = 91 (6.1 ± 0.9 yrs) Australia		underhand throw and two handed strike) PA measured using pedometer (5 days during school)	OC competence ↑ for the INT compared to the C ($p < 0.001$; d = 0.95) 5 of the 6 OC assessed showed significant INT effects: Strike ($p < 0.001$; d = 0.70) Dribble ($p = 0.04$; d = 0.64) Catch ($p = 0.014$; d = 0.63) Overhand Throw ($p = 0.031$; d = 0.33) Underhand Throw ($p < 0.001$; d = 0.67) **PA:** No significant difference was reported

Correlation values (r) of > 0.60 is large, 0.30-0.60 is moderate and 0-0.30 is small (Waltz, 2010).
BMI: Body Mass Index. C: Control Group. CLASS: Children's Leisure Activities Study Survey. CRF: Cardio-Respiratory Fitness. FMS: Fundamental Movement Skills. GMQ: Gross-Motor Quotient. INT: Intervention Group. LOC: Locomotor Skills. OC: Object Control Skills. MVPA: Moderate-Vigorous Physical Activity. PA: Physical Activity. PAQ-C: Physical Activity Questionnaire for Older Children. TGMD: Test of Gross Motor Development. ↑: Increase.

2.5.2. Long-Duration Intervention Programmes (≥ 12 weeks)

Longer-duration studies have also been investigated and these intervention programmes are often implemented in place of usual PE lessons over a period of one (Barnett et al., 2009; Cohen et al., 2015; Kalaja et al., 2012; McGrane et al., 2017; Van Beurden et al., 2003) or two (Chen et al., 2017) academic years. Multi-component, after-school community-based and non-school based intervention programmes have shown positive improvements in FMS competence (Bardid et al., 2017; Barnett et al., 2009), PA (Cohen et al., 2015; Van Beurden et al., 2003), CRF (Cohen et al., 2015), weight status (Cliff et al., 2011; Morano et al., 2014) and reductions in SB activities (Cliff et al., 2011). For these programmes, emphasis is placed upon the overall delivery of the programme with particular attention focused towards the encouragement of school principals, teachers, parents and students to maximise adherence. Specific workshops and training days are also often implemented with constant feedback from the teachers allowing for the successful implementation and re-evaluation of these interventions.

To date in Ireland no studies have been conducted to examine the effectiveness of an FMS intervention programme on primary school children. The Youth Physical Activity Towards Health (Y-PATH) (O'Brien et al., 2013) intervention is the only Irish based programme that has assessed FMS and PA levels among Irish adolescents (n = 482; 12-13 years) using a multi-component approach. This intervention targeted four key components; student (specific focus on health related activity and FMS in PE), parent/guardian (parents/guardians are educated about the health benefits of PA), teacher (all staff participated in two workshops with the main objective being to improve PA participation among staff and students during school time) and online resources (resources made available on a website) (O'Brien et al., 2013). Both the intervention group and the control group improved significantly in LOC skills, OC skills and total FMS at post-test. However, only the intervention group maintained their LOC skill, OC skill and total FMS competence at the 3-month follow-up whereas the control group only maintained competence in LOC skills (O'Brien et al., 2013).

From an Australian perspective, schools which have adopted a multi-component school-based intervention have shown improvements in FMS and PA. The "Move it Groove it" (MIGI) program, a collaborative health promotion intervention targeting FMS and PA among primary school children (n = 1,045; school years 3 and 4; 10.1 years) reported an overall improvement of 16.8% for FMS competence after a one year intervention. The intervention group improved significantly in 7 out of the 8 FMS assessed (sprint run, side gallop, kick, vertical jump, overhand throw, catch and hop) with the largest difference in performance for boys being the sprint run (26%; $p < 0.001$) and for girls the side gallop (22%; $p < 0.001$). The only skill which did not show an improvement following the intervention was static balance. VPA levels increased by 3.3% following the intervention, however this only translated to an extra 58 seconds of PA per 21 minute class (Van Beurden et al., 2003). Using the same sample as Van Beurden et al. (2003), Barnett et al. (2009) conducted a six-year follow-up study of the MIGI intervention involving 276 participants (16.4 years) from the original sample. Results revealed that the intervention group improved their catch ability relative to the control group and were five times more likely to be able to catch ($p = 0.001$). However, there was no significant difference reported for PA between the two groups. These results would suggest that the six-year follow-up study had very little long-term improvements on FMS competence and PA levels. However, it is unknown if the schools who participated in the original study by Van Beurden et al. (2003) continued with the implementation of the program. In addition, PA was assessed by self-report (Adolescent Physical Activity Recall Questionnaire) which may allow for a risk of bias as participants may have difficulty in accurately recalling activities and quantifying the specific time of the activity. Finally, the intervention had five key strategies which may have been too complex for schools to fully implement over one academic year. If the schools had a longer duration program perhaps the improvements would have been more significant.

Cohen et al. (2015) addressed the issues encountered during the MIGI intervention in the Supporting Children's Outcomes Using Rewards, Exercise and Skills (SCORES) intervention. The SCORES intervention took place over one academic year and it introduced multiple components in three phases (Table 2.7) and used an accelerometer (ActiGraph GT3X+) to assess PA levels over seven consecutive days. Following the intervention, the intervention group engaged in 13 minutes more daily MVPA ($p < 0.008$) and sustained an improvement in CRF with the ability to perform five extra laps on the 20m multi-stage fitness test ($p = 0.003$) compared to the control group. While the study showed improvements in PA levels and CRF, the intervention had little or no effects on FMS competence which was similar to the study conducted by Barnett et al. (2009). However, Cohen et al. (2015) adopted principles which allowed for the successful implementation of the SCORES intervention. Teachers received specific training on the principles of the self-determination and competence motivation theories and were encouraged to use the SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) principles to deliver PE lessons. A multi-component approach from school principals, school teachers, parents, students, FMS professionals and the community allowed for continuous encouragement for the participants during the intervention.

A two-year follow-up study conducted by Chen et al. (2017) on American children (n = 1,227-1,588; 5.6 years) examined the effects of the CATCH PE programme on four subjective FMS (run, underhand catch, weight transfer and hand-dribble) and reported that over a two-year period competency levels of each of the four subjective FMS were greater in year two compared to year one (run; 77.5% vs 83.1%; underhand catch; 72.7% vs 81.9%; weight transfer (69% vs 87.6%; and hand-dribble; 65.5% vs 72.1%). However, this study did not have a control group and therefore it is difficult to determine if the improvements had an intervention effect.

Research has demonstrated clear benefits following implementation of an intervention, particularly from a school-based multi-component perspective. As research has shown that more frequent short-duration programmes were more effective than less frequent long-duration programmes, examining whether FMS proficiency levels can be maintained over time is crucial information for research practitioners for the design of appropriate interventions in a school-based setting.

In addition, participants and academic school staff may show greater adherence to a short-duration programme than a long-duration programme.

Table 2.7: Long-Duration Intervention Programmes Conducted on Primary School Children

Long-Duration Intervention Programmes (≥ 12 weeks)				
Author	**Study Population/Country**	**Intervention Details**	**Assessment Tools**	**Results**
Bardid et al. (2017) **Multimove for Kids Project** (Government Funded/Community-Based FMS programme)	**INT:** n = 523 (5.6 ± 1.4 yrs) **C:** n = 469 (5.9 ± 1.6 yrs) Belgium	30 week program (1 hr/week) (pre & post-test)	FMS (TGMD-2) 12 skills were assessed	**INT > C** **INT:** ↑ in both LOC ($\beta = 3.78$; SE = 1.08; $p < 0.001$) and OC ($\beta = 4.46$; SE = 1.06; $p < 0.001$) skills compared to C **Girls:** Lower gain in OC ($\beta = -3.50$; SE = 0.49; $p < 0.001$) but higher gain in LOC ($\beta = 1.01$; SE = 0.44; $p = 0.022$) compared to boys
Barnett et al. (2009) **MIGI (Move It Groove It)** Six-year-follow-up of study conducted by Van Beurden et al. (2003)	n = 1,045 (Original Sample) n = 276 (Follow-Up Sample) (16.4 yrs) Australia	1 academic year (pre & post-test)	5 FMS (Get Skilled Get Active) (catch, kick, overhand throw, vertical jump and side gallop) PA (Adolescent Physical Activity Recall Questionnaire)	**FMS:** INT ↑ catch ability relative to C (OR= 5.51; $p = 0.001$) **PA:** No significant difference between the INT and C
Chen et al. (2017) **CATCH (Child and Adolescent Trial for**	n = 1,223-1,588 (5.5 yrs) United States	2 year program	FMS (running, underhand catch,	**Year 2 > Year 1** 4 skills ↑ Year 2 compared to Year 1

Cardiovascular Health) School-based intervention			weight transfer and hand-dribbling)	Competency levels of 4 skills ↑ Year 2 compared to Year 1
Cliff et al. (2011)	n = 165 (5.5-9 yrs) **INT:** **Group 1:** n = 63 **Group 2:** n = 42 **Group 3:** n = 60	6 month program (pre-test, post-test (6 months) & retention (12 months)	FMS (TGMD-2) PA measured using accelerometer (8 days) Perceived Competence (The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children was used for 5-7 yr olds and the Self-Perception Profile for Children was used for 8-9 yr olds) Screen Behaviours (CLASS was completed by parents)	**Post-Test (6 months):** **FMS:** ↑ Group 1 and Group 3 for LOC and OC skill subtests ($p < 0.001$) compared to Group 2 **PA:** No significant differences between groups was observed **Perceived Competence:** ↑ in Group 1 ($p < 0.05$) and Group 3 ($p < 0.01$) **Sedentary Behaviours:** ↓in all groups for total ST ($p < 0.001$), TV or DVD viewing ($p < 0.001$) and electronic game use ($p = 0.007$) **Retention (12 months):** **FMS:** Improvements were not maintained **PA:** No significant differences between groups was observed **Perceived Competence:** Group 3 ↑ ($p < 0.01$)

				Sedentary Behaviours: Group 3 ↑ ($p < 0.001$)
Cohen et al. (2015) **SCORES (Supporting Children's Outcomes using Rewards, Exercise and Skills)**	(8.5 ± 0.6 yrs) **INT:** n = 199 (4 schools) **C:** n = 261 (4 schools) Australia	1 year program (Assessed at baseline, mid-point (6 mths) & post-test)	FMS (TGMD-2) PA measured using accelerometer (7 days) CRF (20m multi-stage fitness test)	**Mid-Point (6 mths):** No significant intervention effects **Post-Test:** **INT > C** **Total FMS:** Total FMS ↑ INT compared to the C ($p = 0.045$) **PA:** MVPA ↑ INT compared to the C ($p = 0.008$) **CRF:** CRF ↑ INT compared to the C ($p = 0.003$)
Johnstone et al. (2017) **Go2PlayActive Play** School-based intervention	n = 172 (7 yrs) (11 classes) Scotland	5 month program (pre & post-test)	FMS (TGMD-2) (n = 123) PA measured using accelerometer (4 days) (n = 189)	**INT > C** **FMS:** **LOC Skills:** There was a significant interaction effect between time and group for LOC score ($p = 0.02$) and LOC percentile ($p = 0.02$) **OC Skills:** There was no significant interaction between time and group for OC score and OC percentile ($p = 0.1$ and $p = 0.3$, respectively) **GMQ:**

				INT ↑ GMQ score and GMQ percentile ($p < 0.01$, respectively) **PA:** **INT:** ↓ percent time in SB (-18.6 %; $p < 0.01$); ↑ in total PA (+ 258 cpm; $p < 0.01$) ↑ time in LPA (+ 15.7 %; $p < 0.01$) and ↑ MVPA (+ 2.8%; $p < 0.01$) **C:** ↓ mean counts/min. (- 65 cpm; $p = 0.1$), ↑ in percent time in SB (0.1%; $p = 1.0$) ↑ LPA (1.7%; $p = 0.5$) and ↓ percent time in MVPA (-1.8%; $p = 0.04$)
Morano et al. (2014) Multi-modal training program from outpatient hospital clinic	n = 41 (9.2 ± 1.2 yrs) Italy	8 month program (pre & post-test)	Body Composition (BMI (Centers for Disease Control and Prevention Growth Charts)) 12 FMS (TGMD) PA (PAQ-C) Perceived Physical Ability (Perceived Physical Ability Scale for Children)	**BMI:** BMI value, z-score and percentile ↓ ($p < 0.001$, respectively) **FMS:** GMQ ↑ ($p < 0.001$), LOC standard scores ↑ ($p = 0.001$) and OC standard scores ↑ ($p < 0.001$) **PA:** ↑ PA levels ($p < 0.001$) **Perceived Physical Ability:** ↑ perceived physical ability scores ($p < 0.001$)
Van Beurden et al. (2003)	n = 1,045 (10.1 yrs) (Years 3 and 4)	1 academic year (pre & post-test)	8 FMS	**FMS:** 7 FMS ↑ for INT compared to the C

MIGI (Move It Groove It) Quasi-experimental School-based multi-component intervention	**INT:** 9 schools **C:** 9 schools Australia		(static balance, sprint run, vertical jump, kick, hop, catch, overhand throw and side gallop) PE Observation Tool (System for Observing Fitness Instruction Time to assess PA levels and lesson context)	Overall improvement of 16.8% for all FMS (z = 9.64; p < 0.001) **Boys:** Sprint (26%; p < 0.001) Side Gallop (22%; p < 0.001) Kick (21%; p < 0.001) Vertical Jump (14%; p = 0.004) Overhand Throw (14%; p = 0.03) Catch (11%; p < 0.001) **Girls:** Side Gallop (22%; p < 0.001) Kick (12%; p = 0.023) Overhand Throw (7%; p = 0.042) Vertical Jump (16%; p = 0.002) Hop (11%; p = 0.037) Catch (23%; p < 0.001) **PA:** INT showed 3.3% ↑ in VPA compared to the C (z = 2.43; p = 0.008)

Correlation values (r) of > 0.60 is large, 0.30-0.60 is moderate and 0-0.30 is small (Waltz, 2010).
BMI: Body Mass Index. C: Control Group. CLASS: Children's Leisure Activities Study Survey. CRF: Cardio-Respiratory Fitness. FMS: Fundamental Movement Skills. GMQ: Gross-Motor Quotient. INT: Intervention Group. LOC: Locomotor Skills. LPA: Light Physical Activity. OC: Object Control Skills. MVPA: Moderate-Vigorous Physical Activity. PA: Physical Activity. PAQ-C: Physical Activity Questionnaire for Older Children. ST: Screen Time. TGMD: Test of Gross Motor Development. ↑: Increase. ↓: Decrease.

2.6. Summary

Current research has demonstrated that FMS proficiency has been positively associated with PA participation in both childhood and adolescence, and is considered an important prerequisite for participation in sport and PA (Barnett et al., 2009). However, most of the research has been conducted from an international perspective (Okely and Booth, 1999; Okely and Booth, 2004; Barnett et al., 2009), therefore results cannot be generalised to Irish primary school children due to the cultural, environmental and curriculum differences between countries. In addition, no research has examined the relationship between FMS and SB. Research has shown that independent of PA levels, SB is associated with increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems (Katzmarzyk et al., 2009; Owen et al., 2009; Treuth et al., 2007). Therefore, reducing SB will increase overall PA levels. In addition, effective intervention programmes have been shown to increase FMS proficiency and PA levels, but no research in Ireland has examined the effectiveness of an FMS intervention in primary school children. Therefore, it is important to understand the relationship between FMS, PA and SB levels for the design and implementation of effective intervention programmes for a child's sustained involvement in PA and sport.

Chapter 3: Methodology

3.1. Research Questions

- Does a relationship exist between PA levels and FMS proficiency in Irish primary school children?
- Does a relationship exist between SB and FMS proficiency in Irish primary school children?
- Is an FMS intervention effective at improving FMS, PA levels and SB in Irish primary school children?

3.2. Research Design

Figure 3.1 gives a brief overview of the testing protocol. The first phase was the recruitment of schools and participants. Once schools, participants and parents had agreed to participate, pre-testing took place. Schools were assigned to either an FMS intervention group or a control group. Following the eight-week intervention, the schools took part in post-testing.

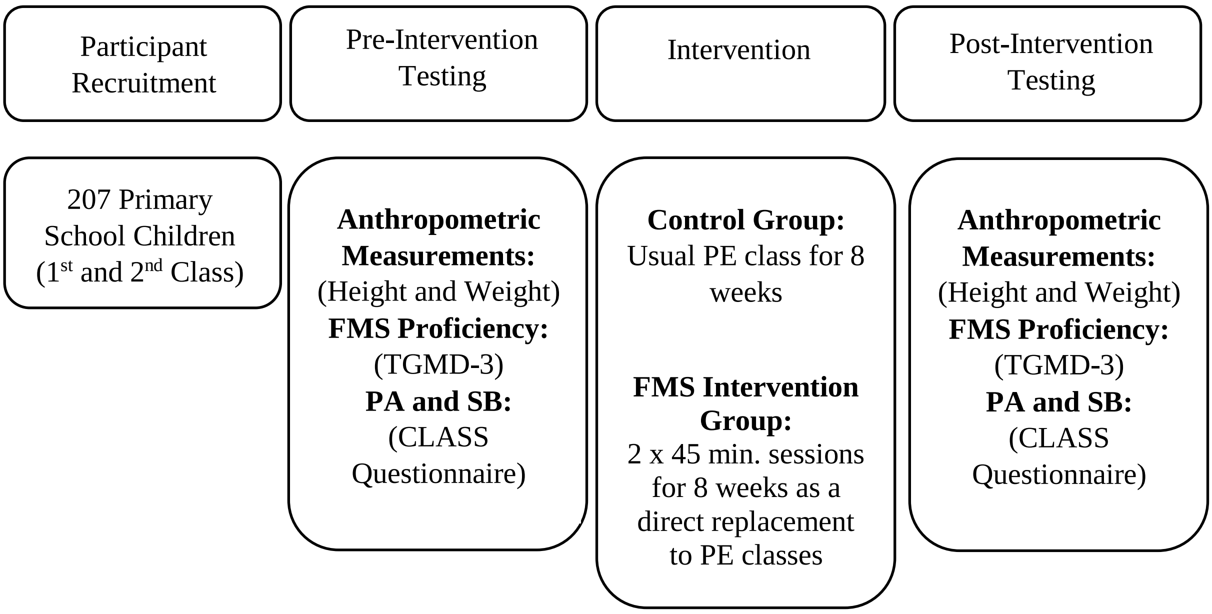

Figure 3.1: Testing Protocol Overview

3.3. Participants and Recruitment

A sample size calculation was used to establish the suitable number of participants. Research conducted by Aye et al. (2017) which examined a similar group (5 yrs) and used a similar FMS assessment tool (TGMD-2) was used to identify the sample size required (Equation 3.1). With a standard deviation (s) value of 1.77 and a difference to be detected (d) of 1, the projected sample required per group was 50. Therefore, a sample size of 100 participants, with group sizes of 50, was decided.

$$n = 16 \times \frac{s^2}{d^2}$$

Equation 3.1: Sample Size Calculation (s = standard deviation; d = difference to be detected)

Participants were eligible to be included in the study if they were in 1st or 2nd class, free of any diagnosed musculoskeletal injuries or disabilities, which may hinder their ability to participate in PA, and provided parental consent and participant assent. Participants were excluded if they were in junior infants, senior infants, 3rd class, 4th class, 5th class or 6th class, had any diagnosed musculoskeletal injuries or disabilities, which may hinder their ability to participate in PA, and if parental consent or participant assent were not provided.

Two hundred and seven participants from four primary schools in the midlands region of Ireland were originally invited to participate in the study, with full consent received from 150 participants (72% of total sample; mean age = 7.7 ± 0.6 years). One hundred and fifty participants had full data available for FMS assessment and the CLASS questionnaire, however 100 parents had fully available data for the CLASS questionnaire so the final sample number was 100 (Figure 3.2).

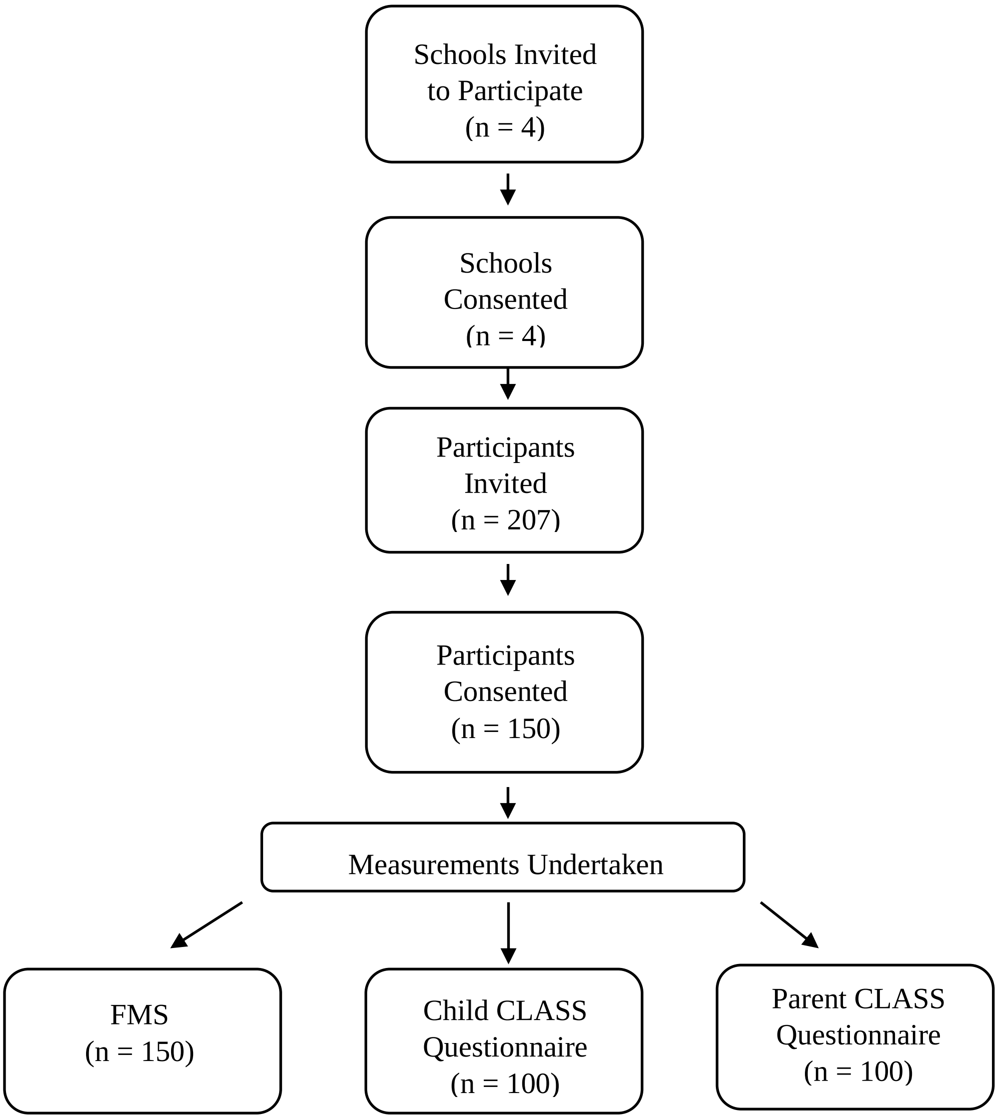

Figure 3.2: Flow Chart of Data Collection

Ethical approval was granted by the Athlone Institute of Technology Research Ethics Committee. Primary schools were contacted through email (Appendix I) and word of mouth and the outline of the study was explained to the school principal. One week later, a follow up email was sent to identify interested schools. Once the school principal granted permission, an information evening was offered to each school for parents, legal guardians, school teachers and the school principal. The principal investigator explained details of the study, the potential risks and benefits associated with the study and provided opportunities for any queries to be answered at this information session. A plain language statement (Appendix II) and an informed consent form (Appendix III) were given to parents to take home. Parents were asked to return the consent form, signed by both the parent and child to the school teacher. The principal investigator collected the consent forms from the participating schools and screened them prior to testing.

3.4. Facilitators

Third and fourth year students from the BSc. (Hons) Sport and Exercise Physiology and BSc. (Hons) Athletic and Rehabilitation Therapy undergraduate degree courses in Athlone Institute of Technology volunteered to assist with the testing. Facilitators were required as it was not possible for the principal investigator to conduct testing on their own due to the different testing stations that were involved. To test one class group it would take approximately one hour, therefore stations where 8 children could be tested for time efficiency was required. Eight to ten facilitators were recruited for the testing phase and in order to ensure inter-reliability was controlled the facilitators would follow the same protocol for each testing session. Prior to the commencement of testing, all facilitators completed an FMS training session (1-hour session) to practice their roles for testing (setting up their specific station, getting the camera ready, demonstrating each skill and recording each skill). The facilitators were taught the specific instructions for the administration of each skill and were shown the warm-up protocol. The instructions were given to the facilitators on a hand-out and then a demonstration of the test was conducted. During the training session, the facilitators set up an area in the Sports Arena in Athlone Institute of Technology as a demonstration and went through each station and the requirements of each station. If a facilitator was unsure of anything during the test then the test was restarted. During the training session, the facilitators were also shown how to use the cameras for recording the skills and each facilitator demonstrated how to record one skill in front of the principal investigator. Each facilitator was given a set of skills for each testing session.

3.5. Measurements

3.5.1. Anthropometric Measurements

Before testing commenced each participant was allocated a personal ID number which was placed on their chest so as it was in full view of the video camera for recording. Height, weight and age of each participant were recorded on a standardised data sheet (Appendix IV). A designated screened off area was used to measure height and weight (Figure 3.3). Standing height was measured to the nearest 0.1cm using a SECA Leicester Portable Height Measure (SHCA 799, SHCA Ltd.). Participants removed their shoes and stood with feet together and heels against the base of the stadiometer. The participant was asked to stand straight with their head, buttocks and scapulae resting against the backboard with the arms rested down by their side. The participant was asked to take a deep breath in and height was measured. Weight was measured to the nearest 0.1kg using a portable SECA heavy duty scales (SECA 799, SHCA Ltd.). BMI was then calculated using the following equation (Equation 3.2). BMI percentile were calculated using the cut-off points from the WHO-UK growth charts (Royal College of Paediatrics and Child Health, 2013). Those below the 2nd percentile were classified as very thin, between the 2nd and 9th percentile as low BMI, between the 9th and 91st percentile as normal, above the 91st percentile as overweight and those above the 98th percentile as obese. Participants were then classified as non-overweight and overweight. Non-overweight participants were classified as those ranging from below the 2nd percentile to the 91st percentile and overweight participants were classified as those ranging from the 91st percentile to the 98th percentile or above.

$$\text{BMI} = \text{Weight}/\text{Height}^2 \ (\text{kg/m}^2)$$

Equation 3.2: BMI Calculation

3.5.2. Fundamental Movement Skills

FMS are comprised of LOC and OC skills. The TGMD-3 (Ulrich and Webster, 2015), was used to assess 13 FMS namely: run, gallop, hop, skip, horizontal jump, slide (LOC); and two-hand strike of a stationary ball, one-hand forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kicking a stationary ball, overhand throw and underhand throw (OC) (Table 3.1 and Table 3.2). The TGMD-3 assessment has been found to be reliable (Estevan et al., 2016; Rintala et al., 2017; Simons and Eyitayo, 2016; Wagner et al., 2015; Webster and Ulrich, 2017) (Table 2.4) and valid (Estevan et al., 2016; Simons and Eyitayo, 2016) for assessing FMS in 3-10 year old children.

Testing was conducted in the PE hall/gymnasium of each school. The hall was set up into three different stations (Figure 3.3) with the equipment required (batting tees, tennis balls, footballs, basketballs, cones, soft balls, bats and tennis rackets) for the TGMD-3. Participants were divided into three equal sized groups. Once all participants completed the skills at the required station, the group moved to the next station in a clockwise direction until all groups completed each station. Testing of each class group (n = 22-34) took approximately one hour to complete. Station one assessed six skills including the run, gallop, hop, skip and slide. A maximum space of 60 feet was required for this station (Figure 3.3). Station two assessed four skills including the two-hand strike of a stationary ball, one-hand forehand strike of a self-bounced ball, two-hand catch and kicking a stationary ball. A maximum of 20 feet from a wall located in the school hall/gymnasium is proposed as the ideal location for this station to get a full view of each skill (Ulrich and Webster, 2015) (Figure 3.3). Station three assessed four skills including the horizontal jump, overhand throw, underhand throw and one-hand stationary dribble. This station was set up a maximum of 15 feet from a wall in the school hall/gymnasium for a full view of each skill (Ulrich and Webster, 2015) (Figure 3.3). Feet was used as the standard measurement protocol for each station (Ulrich and Webster, 2015). Performance criteria, equipment and instructions for each FMS are outlined below (Table 3.1 and Table 3.2).

Participants were then split into three groups and a 5-10 minute warm-up (Appendix V), adapted from the principles outlined by Faigenbaum and M^c^Farland (2007), was conducted under the guidance of the principal investigator. All exercises of the warm-up were demonstrated by the principal investigator (low jacks, high-knee marches, standing flutters, standing toe touches, stepping trunk turns, crunches, marching lateral shuffles, high-knee skips, partial push-ups, run, and go). Following the warm-up FMS testing took place.

An accurate demonstration and verbal description of the skill was given to each participant prior to testing each skill. Each skill was performed three times, consisting of one familiarisation trial and two test trials. If the participant was unsure of how to perform the skill after the familiarisation trial, a further demonstration was provided. No verbal feedback or prompts were given when the participant performed the skill (Ulrich, 2000). All participants were video-recorded performing two trials of each skill to allow for retrospective analysis and scoring. The ID numbers were read aloud to the camera as each participant performed the skills. The 13 FMS were assessed at pre-test and post-test following an eight-week intervention.

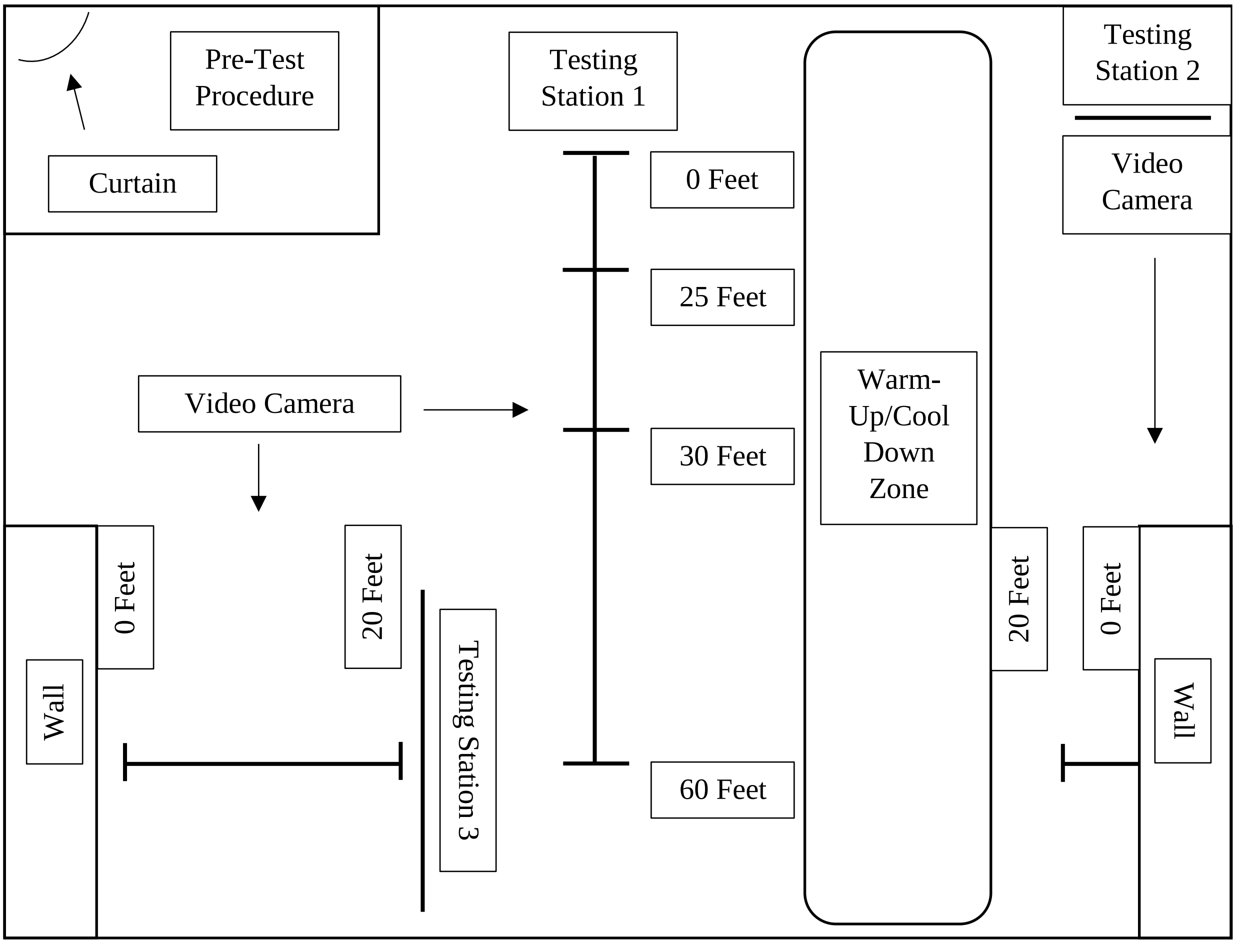

Figure 3.3: Set Up for Testing in the School Hall/Gymnasium

Table 3.1: Performance Criteria, Equipment and Instructions for Assessing Locomotor Skills in the TGMD-3 Protocol (Ulrich and Webster, 2015)

Locomotor Skills			
Skill	**Instructions**	**Performance Criteria**	**Equipment**
Run	'Run fast from cone 1 to cone 2' (Cones placed 50 feet apart)	Arms move in opposition to legs with elbows bent Brief period where both feet are off the surface Narrow foot placement landing on heel or toe (not flat footed) Non-support leg bent about 90 degrees so foot is close to buttocks	Measuring Tape Cones
Gallop	'Gallop from cone 1 to cone 2 and stop' (Cones placed 25 feet apart)	Arms flexed and swinging forward A step forward with lead foot followed with the trailing foot landing beside or a little behind the lead foot (Not in front of the lead foot) Brief period where both feet come off the surface Maintains a rhythmic pattern for four consecutive gallops	Measuring Tape Cones
Hop	'Hop 4 times on your preferred foot' (Cones placed 15 feet apart)	Non-hopping leg swings forward in pendular fashion to produce force Foot of non-hopping leg remains behind hopping leg (does not cross in front of) Arms flex and swing forward to produce force Hops 4 consecutive times on preferred foot before stopping	Measuring Tape Cones
Skip	'Skip from cone 1 to cone 2' (Cones placed 30 feet apart)	A step forward followed by a hop on the same foot Arms flexed and move in opposition to the legs to produce force Completes 4 consecutive rhythmical alternating skips	Measuring Tape Cones
Slide	'Slide from cone 1 to cone 2, stop and slide from cone 2 to cone 1' (Cones placed 25 feet apart)	Body is turned sideways so shoulders remain aligned with the line on the floor (score on the preferred side only) A step sideways with the lead foot, followed by a slide with trailing foot where both feet come off the surface briefly (score preferred side only) Four continuous slides to preferred side Four continuous slides to non-preferred side	Measuring Tape Cones
Horizontal Jump	'Stand behind the line and jump as far as you can'	Prior to take-off, both knees are flexed and arms are extended behind the back Arms extend forcefully forward and upward, reaching above the head	White Masking Tape

		Both feet come off the floor together and land together Both arms are forced downwards during landing	

Table 3.2: Performance Criteria, Equipment and Instructions for Assessing Object-Control Skills in the TGMD-3 Protocol (Ulrich and Webster, 2015)

Object Control Skills			
Skill	**Instructions**	**Performance Criteria**	**Equipment**
Two-hand Strike of a Stationary Ball	'Hit the ball hard with this bat. Straight ahead towards the wall'	Child's preferred hand grips the bat above the non-preferred hand Child's non-preferred hip-shoulder faces straight ahead Hip and shoulders rotate and derotate during the swing Steps with the non-preferred foot Hits the ball sending it straight ahead	Batting Tee Plastic Bat 4 Inch Plastic Ball
One-Hand Forehand Strike of a Self-Bounced Ball	'Hold the ball up and drop it (so that it bounces to waist height), once it bounces, hit it with the paddle towards the wall straight ahead'	Child takes back swing with the paddle once the ball is bounced Steps with the non-preferred foot Strikes the ball towards the wall Paddle follows through toward the non-preferred shoulder	Tennis Ball Light Plastic Racket
One-Hand Stationary Dribble	'Bounce the ball four times without moving your feet, using one hand and then catch the ball to stop'	Contacts the ball with one hand at about waist level Pushes the ball with the fingertips (not slapping the ball) Maintains control of the ball for at least 4 consecutive bounces without moving the feet to retrieve the ball	Basketball
Two-Hand Catch	'Stand at the line and catch the ball with two hands when I throw it to you'	Child's hands are positioned in front of the body with the elbows flexed Arms extend, reaching for the ball as it arrived Ball is caught by the hands only	Soft Ball White Masking Tape
Kicking a Stationary Ball	'Starting at line 1 (cone placed 28 feet from the wall), run up to the ball (cone placed 20 feet from the wall) and kick it hard against the wall'	Rapid, continuous approach to the ball Child takes an elongated stride or leap just prior to ball contact Non-kicking foot is placed close to the ball Kicks the ball with the in-step or inside of the preferred foot (not with the toes)	Football Cones Wall
Overhand Throw	'Stand behind the tape (placed 20 feet from the wall) and throw the ball hard at the wall'	Wind-up is initiated with a downward movement of the hand and arm Rotates the hip and shoulder to a point where the non-throwing side faces the wall	Tennis Ball

		Steps with the foot opposite the throwing hand towards the wall Throwing hand follows through after the ball release across the body towards the hip of the non-throwing side	
Underhand Throw	‘Stand behind the tape (placed 20 feet from the wall) and throw the ball underhand to hit the wall	Preferred hand reaches down and back reaching behind the trunk Step forward with the foot opposite the throwing hand Ball is tossed forward hitting the wall without a bounce Hand follows through after the ball is released to at least chest level	Tennis Ball

3.5.2.1. Video Recording

Participants were video recorded (Panasonic V260 Full HD Camcorder, hc-v260eb-k, Panasonic, UK) performing all 13 FMS with one camera set up for each of the three stations. The video camera was positioned from the side for each skill to be recorded. Once testing was complete in each school, the video tapes were stored on an encrypted hard-drive. The hard-drive was transported to Athlone Institute of Technology and stored in a locked filing cabinet only accessible to the principal investigator. The principal investigator pixelated each participant's face immediately after testing to remove identification.

3.5.2.2. Scoring of the TGMD-3

Analysis of each FMS was conducted by the principal investigator. A score of 1 was given for each performance criteria correctly performed and 0 for any absent or incorrectly performed criteria, with three to five performance criteria being analysed for each skill (Table 3.1 and Table 3.2). No partial marks were provided. This procedure was carried out for each of the two test trials and the scores from both trials were summed to provide a total score of each FMS. LOC and OC subtest scores were calculated by summing the total score of each FMS within each subtest. A maximum score of 46 points and 54 points is attainable for the LOC subtest and OC subtest, respectively. The maximum overall score possible is known as the total gross motor test score and is calculated by summing the total LOC subtest score and total OC skills subtest score (100 points). "Mastery" was defined as the successful execution of all performance criteria in both trials, while "Near Mastery" was defined as the successful execution of all performance criteria except one in both trials. "Poor" was identified as having more than one performance criteria incorrectly performed or absent over both trials.

3.5.2.3. Reliability

Prior to assessing FMS proficiency for all participants, reliability of the principal investigator was established using an online reliability test completed on the TGMD-3 website (Ulrich and Webster, 2015). Four participants were observed and scored performing two trials of each LOC and OC skill and results were submitted to a TGMD-3 expert for analysis. This expert was part of the development of the TGMD-3 website (https://sites.google.com/a/umich.edu/tgmd-3/home). From the analysis, a reliability score of 95% was returned.

For intra-rater reliability a random sample (n = 32) of participants performing all LOC and OC skills on two occasions were scored, two weeks apart. A one-way random effects model was used to calculate ICC and was classified according to Fleiss (1999) (Table 3.3). All skills demonstrated excellent reliability ranging from 0.89 for the run to 0.98 for the two-hand strike and two-hand catch, with narrow confidence intervals reported for each skill (Table 3.4).

Table 3.3: Intraclass Correlation Coefficient Classification (Fleiss, 1999)

Classification	ICC
Poor	< 0.40
Good	0.40-0.75
Excellent	> 0.75

3.5.3. Physical Activity and Sedentary Behaviour

3.5.3.1. Children's Leisure Activities Study Survey

The CLASS, developed in Australia for primary school aged children, was used to determine PA and SB levels. PA and SB levels were reported by both the child (self-report) (Appendix VI) and the parent (proxy-report) (Appendix VII). Both questionnaires examined PA under three dimensions including the type (structured/unstructured; PE/school sport; play; games/sport), intensity (sedentary, light; moderate; vigorous), and frequency (times per week) and consisted of an extended checklist of 30 physical activities. An open-ended question also allowed both the parent and child to record any other PA that was not listed (e.g. Irish specific sports such as Gaelic Games). For both the parent and child, the questionnaire details information on the frequency of activities during a typical week (Monday-Friday) and weekend (Saturday and Sunday), with the duration of each activity (hours/minutes per week/weekend) present in the parent questionnaire only. For both the parent and child, activities are classified as light, moderate or vigorous by assigning the metabolic equivalent units (METS) at rest with 1 activity classified as light intensity (< 3 METS), 18 activities classified as moderate intensity (3-5.9 METS) and 11 classified as vigorous (> 6 METS). The product of the frequency and MET value was summed across each activity to create a total LPA, MPA and VPA value for both the parent and child questionnaire. MPA (METS) and VPA (METS) were summed to create a total MVPA (METS) for both the parent and child. In addition, the total duration was summed across each activity to create a total LPA, MPA and VPA value from the parent questionnaire only. In addition, MPA (mins.) and VPA (mins.) were summed to create a total MVPA (mins.) from the parent questionnaire only. For children only, a question on their enjoyment of the activities was included where the child coloured in an appropriate face corresponding to their enjoyment level.

SB was also assessed by both the parent and child during the week (Monday-Friday) and weekend (Saturday and Sunday) and consisted of a list of 12 sedentary activities. An open-ended question also allowed both the parent and child to record any other sedentary activity that was not listed. The total amount of time spent in each sedentary activity during a typical weekday and weekend was summed to give a total weekday and weekend SB value.

The percentage of children involved in each PA and SB both during the weekdays and weekend was also calculated from both the parent and child questionnaire with the mean and standard deviation for each PA level (METS, mins.) and SB level (mins.) reported. MVPA recommendations were calculated by adding each child's total PA levels for the week as reported by the parent and dividing it by seven to get the minutes/day spent in MVPA. For the ST recommendations each child's total ST for the week as reported by the child and parent was added and divided by seven to get the hours/day spent engaging in ST.

Both questionnaires were distributed at FMS pre-testing and repeated at FMS post-testing. The details of the questionnaire were explained to the class teacher. Participants completed the questionnaire within their class groups under the supervision of their class teacher. If a participant was unsure of any component of the questionnaire or had difficulty completing the questionnaire, they were assisted upon request by the class teacher. Parents of the participants examined and completed the questionnaire at home. The parent questionnaires were returned to the school where the principal investigator collected them. The questionnaires were collected one week after being distributed. To ensure anonymity each participant's ID number was placed at the top of the questionnaire.

3.6. FMS Intervention

Following the pre-test, an eight-week FMS intervention was implemented. Two schools took part in the intervention (n = 80) and two schools acted as the controls (n = 70). The FMS intervention, designed as part of another Athlone Institute of Technology project, involved the principal investigator and another postgraduate student attending the intervention schools for two forty-five minute sessions per week for a period of eight weeks, during the participant's usual PE class. This meant that the intervention group would have had two FMS intervention classes a week as a direct replacement for PE, whereas the control group only had their two PE classes per week. The class teacher was also in attendance and supervised participants unable to participate. The participants were required to wear their normal PE clothes (e.g. tracksuit bottoms or shorts, t-shirt and jumper) and suitable running shoes during the intervention. The intervention utilised regular PE equipment (e.g. footballs, tennis balls, basketballs, hula-hoops, beanbags etc.) (Appendix VIII). The control schools continued with their usual PE class for eight weeks. Each FMS intervention class followed a specific procedure which included; a warm-up (full body dynamic warm-up) (10 minutes), introduction of the skill and practice drills (1-2 skills were targeted for each session) (15 minutes), skill exploration (circuit format, drills that incorporated the specific skills being taught for the session (15 minutes) and a cool down/conclusion (full body static cool down with stretches and a recap of the main teaching points for each skill (5 minutes). Each session is detailed in Appendix VIII. Each FMS intervention class focused on three specific skills with the drills progressed each week to give the children the best opportunity to practice each FMS.

3.7. Statistical Analysis

Data was analysed using IBM Corp. Released 2016 IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp). Statistical significance was set at $p < 0.05$. Descriptive characteristics were used to present the mean and standard deviation for age, height, weight, BMI, each FMS skill, LOC subtest, OC subtest, total TGMD-3 score, PA level, SB level and ST. The percentage of participants that achieved mastery, near mastery and poor mastery in each FMS was calculated. Chi-squared test for independence was used to investigate if there was a relationship between gender and those achieving mastery, near mastery and poor execution. The phi coefficient was calculated to measure the strength of the relationship with values classified as small ($\varphi = 0.10$), medium ($\varphi = 0.30$) and large ($\varphi = 0.50$) (Cohen, 1988). Independent samples t-tests were conducted to identify any significant differences between males and females for each skill, LOC subtest, OC subtest, total TGMD-3 score, LPA, MPA, VPA, SB, physical activities, sedentary activities and ST. Differences in FMS, PA and SB levels between overweight (> 91^{st} percentile) and non-overweight participants (< 91^{st} percentile) was also investigated using an independent samples t-test. Effect sizes were calculated using Cohen's d classified according to Cohen (1988) (trivial < 0.10; small effect > 0.10; medium effect > 0.30 and large effect > 0.50). Pearson product-moment correlation coefficients were used to evaluate the strength of the relationship between FMS proficiency and PA levels and FMS proficiency and SB levels. In addition, Pearson product-moment correlation coefficients were used to evaluate the strength of the relationship between BMI and FMS proficiency, BMI and PA levels and BMI and SB levels. The strength of the relationship (r) was classified according to Cohen (1988) (weak = 0.10-0.29; moderate = 0.30-0.49; strong = 0.50-1.0). A mixed between-within ANOVA was implemented for time (pre to post) and group (intervention group vs control group) to analyse any interaction effects and main effects for FMS proficiency, PA levels and SB levels. Effect sizes were calculated using partial eta squared (n_p^2) calculations classified according to Cohen (1988) (small > 0.01; moderate > 0.06 and large > 0.14).

Chapter 4: Results

4.1. Results

4.1.1. Reliability

For intra-rater reliability all skills demonstrated excellent reliability ranging from 0.89 for the run to 0.98 for the two-hand strike and two-hand catch, with narrow confidence intervals reported for each skill (Table 4.1).

Table 4.1: Intra-Rater Reliability for Each FMS

Skill	ICC	95% Confidence Interval
Run	0.89	0.77-0.95
Gallop	0.90	0.81-0.95
Hop	0.90	0.81-0.95
Skip	0.94	0.88-0.97
Horizontal Jump	0.93	0.87-0.97
Slide	094	0.88-0.97
Two-Hand Strike	0.98	0.96-0.99
One-Hand Forehand Strike	0.96	0.92-0.98
Stationary Dribble	0.93	0.87-0.97
Two-Hand Catch	0.98	0.96-0.99
Kick	0.94	0.88-0.97
Overhand Throw	0.91	0.82-0.95
Underhand Throw	0.94	0.88-0.97

ICC's of > 0.75 is excellent, 0.40-0.75 is good and < 0.40 is poor (Fleiss, 1999).

4.1.2. Baseline Data

4.1.2.1. Participant Information

Descriptive characteristics (n = 150; 69 males; 81 females) are presented in Table 4.2. PA levels, SB levels and ST levels (watching TV, playing video games and using the computer) (n = 100) are presented in Table 4.3. The percentage of participants in each BMI percentile (n = 150) using the cut-off points from the WHO-UK growth charts (Royal College of Paediatrics and Child Health, 2013) is demonstrated in Table 4.4. Seventy percent of participants were classed as normal weight and 11.3% were classed as overweight/obese (Table 4.4).

Table 4.2: Descriptive Characteristics for the Children

Variable	Mean ± SD	Male	Female
Age (years)	7.7 ± 0.6	7.8 ± 0.7	7.7 ± 0.6
Height (cm)	126.7 ± 5.8	128.1 ±6.0	126.5 ± 5.2
Weight (kg)	27.1 ± 5.0	27.3 ± 4.1	27.1 ± 5.7
BMI (kg/m^2)	16.7 ± 2.4	16.6 ± 2.0	16.8 ± 2.8

BMI: Body Mass Index. SD: Standard Deviation.

Table 4.3: PA and SB levels for the Entire Group as Reported by the Parent and Child

	Parent (Proxy-Reported)			Child (Self-Reported)		
Variable	**All**	**Male**	**Female**	**All**	**Male**	**Female**
LPA (METS)	7.4 ± 10.3	6.6 ± 10.3	9.3 ± 9.1	11.6 ± 13.7	6.9 ± 11.1	12.6 ± 12.4
MPA (METS)	84.7 ± 65.0	98.7 ± 57.7	192.7 ± 212.9	170.0 ± 116.0	185.5 ± 133.9	203.7 ±129.4
VPA (METS)	48.1 ± 47.3	63.0 ± 42.3	48.0 ± 50.9	112.0 ± 83.5	137.6 ± 111.5	104.7 ± 89.7
MVPA (METS)	132.9 ± 104.2	159.4 ± 84.9	240.6 ± 237.1	281.9 ± 183.2	323.1 ± 229.9	308.4 ± 207.0
LPA (mins./day)	52.6 ± 100.0	36.5 ± 77.0	62.4 ± 87.5			
MPA (mins./day)	480.7 ± 327.8	488.5 ±351.8	605.2 ± 279.3			
VPA (mins./day)	218.5 ± 205.9	305.5 ± 234.6	200.0 ± 163.3			
MVPA (mins./day)	699.2 ± 471.9	794.6 ± 520.5	806.6 ± 372.6			
Weekday SB (mins./day)	1209.4 ± 785.9	1325.0 ± 903.9	1124.6 ± 678.4	1738.7 ± 1696.7	2166.8 ± 2232.8	1364.5 ± 979.8
Weekend SB (mins./day)	846.0 ± 463.5	868.8 ± 472.2	828.4 ± 464.3	1103.5 ± 1332.1	1374.3 ± 1799.1	897.1 ± 752.7
Weekday ST (mins./day)	436.0 ± 414.4	478.2 ± 516.9	408.0 ± 313.0	527.3 ± 545.3	616.9 ± 581.7	456.6 ± 513.8
Weekend ST (mins./day)	364.4 ± 224.1	385.7 ± 220.0	349.6 ± 229.5	439.4 ± 562.5	521.9 ± 619.2	371.6 ± 514.2

LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. SB: Sedentary Behaviour. SD: Standard Deviation. ST: Screen Time. VPA: Vigorous Physical Activity.

Table 4.4: Percentage of Participants in Each BMI Percentile

BMI Classification	Total		Male		Female	
	N	**%**	**N**	**%**	**N**	**%**
Very Thin (< 2)	2	1.3	1	0.7	1	0.7
Low BMI (2-9)	26	17.3	8	5.3	18	12
Normal BMI (9-91)	105	70	52	34.7	53	35.3
Overweight (> 91)	9	6	4	2.7	5	3.3
Obese (> 98)	8	5.3	4	2.7	4	2.7

BMI: Body Mass Index. N: Number of Participants. %: Percentage.

4.1.2.2. FMS Proficiency

FMS proficiency of each skill, LOC subtest, OC subtest and total TGMD-3 score for all participants (n = 150) are presented in Table 4.5. FMS proficiency ranged from 2.8 ± 2.1 for the underhand throw to 6.1 ± 0.8 for the slide (Table 4.5).

Table 4.5: FMS Proficiency Levels of the Entire Group

	Variable	Mean ± SD	Maximum Score Attainable
LOC Subtest	Run	5.1 ± 1.5	8
	Gallop	3.7 ± 1.2	8
	Hop	3.9 ± 1.7	8
	Skip	3.2 ± 1.6	6
	Horizontal Jump	4.1 ± 1.8	8
	Slide	6.1 ± 0.8	8
	LOC Subtest Total	26.0 ± 4.3	46
OC Subtest	Two-Hand Strike	5.2 ± 2.2	10
	One-Hand Forehand Strike	3.6 ± 2.3	8
	Stationary Dribble	3.1 ± 2.2	6
	Two-Hand Catch	4.3 ± 1.3	6
	Kick	5.4 ± 1.8	8
	Overhand Throw	2.8 ± 2.1	8
	Underhand Throw	6.0 ± 1.4	8
	OC Subtest Total	30.2 ± 7.3	54
Total TGMD-3 Score		56.2 ± 9.4	100

LOC: Locomotor. OC: Object-Control. SD: Standard Deviation. TGMD-3. Test of Gross Motor Development-3.

4.1.2.3. Gender Differences in FMS Proficiency

Males performed significantly better than females in 3 of the OC skills examined, with large and medium effect sizes reported for the two-hand strike ($p < 0.001$; $d = 0.8$), kick ($p < 0.05$; $d = 0.4$) and overhand throw ($p < 0.001$; $d = 0.6$) (Table 4.6). Females were significantly better than males in the two-hand catch, with a medium effect size reported ($p < 0.05$; $d = -0.4$) (Table 4.6). No significant gender differences were reported for any of the LOC skills ($p > 0.05$) (Table 4.6). Males performed significantly better than females in the OC subtest ($p < 0.001$; $d = 0.6$) and total TGMD-3 score ($p < 0.05$; $d = 0.4$) (Table 4.6).

Table 4.6: Gender Differences in FMS Proficiency (Mean ± SD) between Males (n = 69) and Females (n = 81)

	Skill	G	Mean ± SD	P-value	ES
LOC Subtest	Run	M F	5.0 ± 1.5 5.1 ± 1.5	0.647	0.1
	Gallop	M F	3.5 ± 1.6 3.8 ± 0.7	0.117	0.3
	Hop	M F	3.9 ± 1.8 3.9 ± 1.7	0.979	0
	Skip	M F	3.0 ± 1.6 3.4 ± 1.5	0.069	0.3
	Horizontal Jump	M F	4.0 ± 1.6 4.2 ± 1.9	0.500	0.1
	Slide	M F	6.1 ± 0.7 6.1 ± 0.9	0.938	0
	LOC Subtest Total	M F	25.4 ± 4.3 26.5 ± 4.3	0.127	0.3
OC Subtest	Two-Hand Strike	M F	6.1 ± 2.0 4.5 ± 2.1	**< 0.001**	0.8
	One-Hand Forehand Strike	M F	3.8 ± 2.6 3.3 ± 2.1	0.174	0.2
	Stationary Dribble	M F	3.3 ± 2.4 2.8 ± 2.1	0.192	0.2
	Two-Hand Catch	M F	4.0 ± 1.3 4.5 ± 1.3	**0.024***	0.4
	Kick	M F	5.8 ± 2.1 5.1 ± 1.5	**0.013****	0.4
	Overhand Throw	M F	3.4 ± 2.2 2.2 ± 2.0	**0.001****	0.6
	Underhand Throw	M F	6.1 ± 1.4 5.8 ± 1.4	0.136	0.2
	OC Subtest Total	M F	32.6 ± 7.6 28.2 ± 6.4	**< 0.001**	0.6
Total TGMD-3 Score		M F	58.0 ± 9.7 54.7 ± 8.9	**0.028***	0.4

F: Female. ES: Effect Size. G: Gender. LOC: Locomotor. M: Male. OC: Object-Control. SD: Standard Deviation. TGMD-3: Test of Gross Motor Development-3.
Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).
*p < 0.05, **p < 0.01.

4.1.2.4. FMS Mastery

The percentage of mastery, near mastery and poor mastery for all participants (n = 150) are presented in Figure 4.1. Mastery levels of the 13 skills ranged from 1% (n = 2) for the hop to 26% (n = 39) for the two-handed catch (Figure 4.1). The highest number of skills that one child achieved mastery in was six skills (run, slide, two-hand strike and catch, kick and overhand throw). Near mastery levels of the 13 skills ranged from 2% (n = 3) for the hop, two-hand strike and overhand throw to 16% (n = 24) for the underhand throw (Figure 4.1). Over 60% of participants (n = 90) demonstrated poor levels of mastery across all 13 skills including; the run (87%; n = 131), gallop (100%; n = 150), hop (97%; n = 146), skip (95%; n = 143), slide (83%; n = 125), horizontal jump (93%; n = 140), two-hand strike (96%; n = 144), one-hand forehand strike (94%; n = 141), kick (77%; n = 116), stationary dribble (68%; n = 102), two-hand catch (63%; n = 95), overhand throw (95%; n = 143) and underhand throw (67%; n = 101) (Figure 4.1).

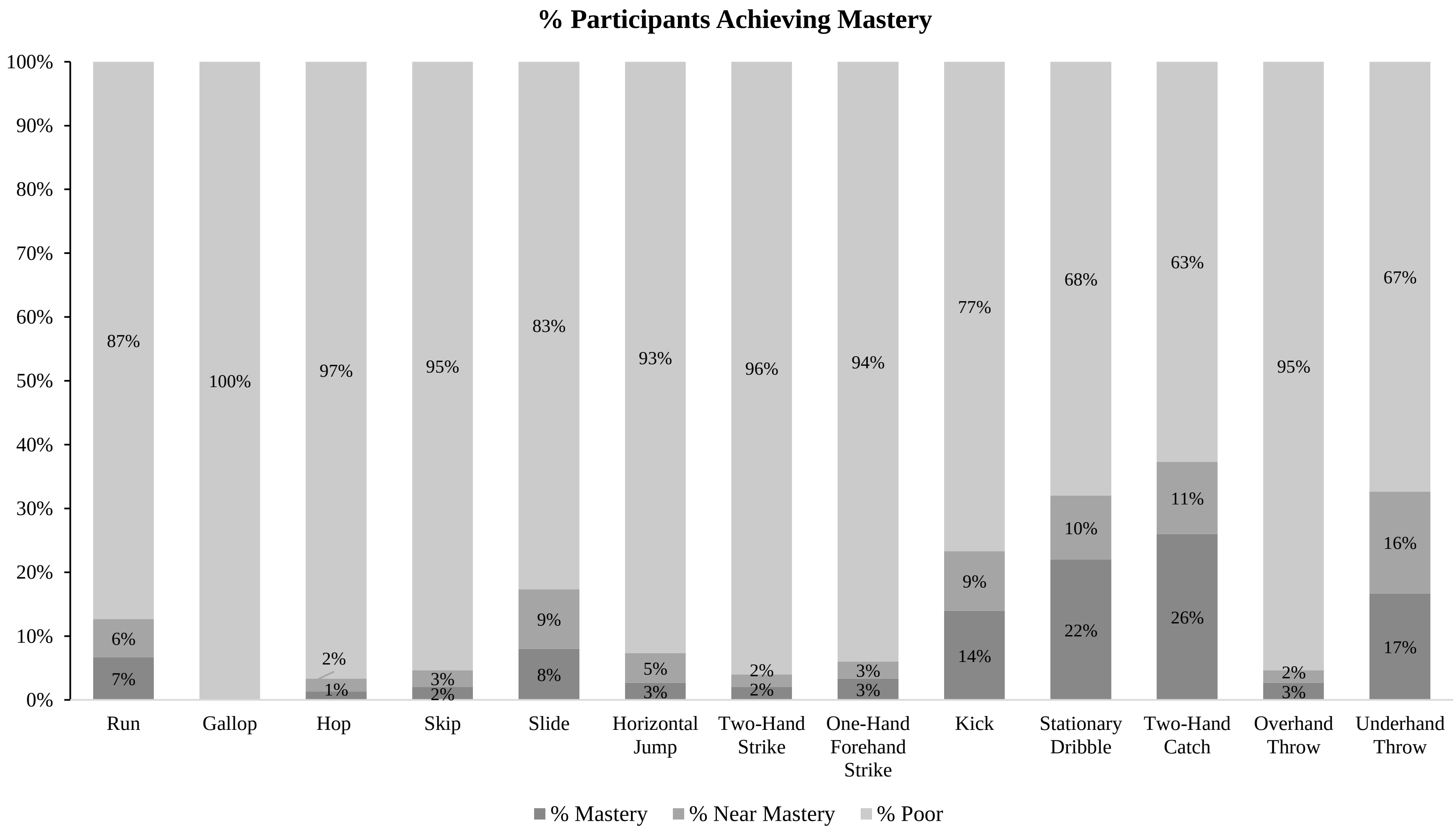

Figure 4.1: Percentage of Participants (n = 150) Achieving Mastery, Near Mastery and Poor in Each FMS

4.1.2.5. Gender Differences in FMS Mastery

Table 4.7 shows the results for the Chi-squared test of independence examining the relationship between gender and those achieving mastery, near mastery or poor execution. There were no gender differences in the prevalence of mastery in any LOC skills, but a higher prevalence of mastery with a medium association was observed in boys for the kick ($p < 0.001$; $\varphi = 0.43$), with a small association observed for the one-hand forehand strike ($p = 0.004$; $\varphi = 0.27$) and the two-hand strike ($p = 0.026$; $\varphi = 0.22$) (Table 4.7).

Table 4.7: Chi-Squared Test for Independence Examining the Relationship between Gender (Males = 69; Females = 81) and Skill Proficiency (% Mastery, Near Mastery and Poor)

	Skill	G	% M	% NM	% P	P-value	Φ
LOC Subtest	Run	M F	5.8 7.4	2.9 7.4	91.3 85.2	0.422	0.11
	Hop	M F	1.4 1.2	0 3.7	98.6 95.1	0.270	0.13
	Skip	M F	1.4 2.5	2.9 2.5	95.7 95.1	0.895	0.04
	Horizontal Jump	M F	1.4 3.7	4.3 4.9	94.2 91.4	0.680	0.07
	Slide	M F	5.8 7.4	10.1 9.9	84.1 82.7	0.925	0.03
OC Subtest	Two-Hand Strike	M F	4.3 0	4.3 0	91.3 100	**0.026***	0.22
	One-Hand Forehand Strike	M F	7.2 0	5.8 0	87 100	**0.004****	0.27
	Stationary Dribble	M F	29 16	13 7.4	58 76.5	0.052	0.20
	Two-Hand Catch	M F	20.3 30.9	10.1 12.3	69.6 56.8	0.255	0.14
	Kick	M F	26.1 2.5	15.9 3.7	58 93.8	**< 0.001**	0.43
	Overhand Throw	M F	4.3 1.2	1.4 2.5	94.2 96.3	0.457	0.10
	Underhand Throw	M F	20.3 13.6	20.3 12.3	59.4 74.1	0.160	0.16

F: Female. G: Gender. LOC: Locomotor. M: Male. OC: Object-Control. % M: Percentage Mastery. % NM: Percentage Near Mastery. % P: Percentage Poor.
Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).
Phi coefficient (φ) small = 0.10; medium = 0.30 and large = 0.50.
*p < 0.05, **p < 0.01.

4.1.2.6. FMS Proficiency and Weight Status

Non-overweight participants (n = 133) scored significantly better than overweight participants (n = 17) in the hop ($p = 0.015$; $d = 0.4$) (Table 4.8). No differences were reported between non-overweight and overweight participants for OC skills, LOC subtest, OC subtest or total TGMD-3 score (Table 4.8).

Table 4.8: Differences between Non-Overweight and Overweight Participants FMS

Skill	Weight Status	Mean ± SD	P-value	ES
Run	Non-Overweight Overweight	5.1 ± 1.5 4.9 ± 1.5	0.726	0.1
Gallop	Non-Overweight Overweight	3.7 ± 1.2 3.8 ± 1.0	0.781	0.1
Hop	Non-Overweight Overweight	4.0 ± 1.7 2.9 ± 1.4	**0.015***	0.7
Skip	Non-Overweight Overweight	3.2 ± 1.5 3.4 ± 1.7	0.682	0.1
Horizontal Jump	Non-Overweight Overweight	4.2 ± 1.8 3.7 ± 1.8	0.305	0.3
Slide	Non-Overweight Overweight	6.1 ± 0.8 5.9 ± 0.8	0.511	0.2
LOC Subtest	Non-Overweight Overweight	26.2 ± 4.2 24.7 ± 5.1	0.166	0.3
Two-Hand Strike	Non-Overweight Overweight	5.2 ± 2.2 5.5 ± 2.2	0.614	0.1
One-Hand Forehand Strike	Non-Overweight Overweight	3.5 ± 2.3 4.0 ± 2.7	0.405	0.2
Stationary Dribble	Non-Overweight Overweight	3.0 ± 2.2 3.9 ± 2.2	0.084	0.4
Two-Hand Catch	Non-Overweight Overweight	4.3 ± 1.3 4.1 ± 1.5	0.634	0.1
Kick	Non-Overweight Overweight	5.4 ± 1.8 5.4 ± 1.7	0.990	0
Overhand Throw	Non-Overweight Overweight	2.8 ± 2.1 2.1 ± 2.4	0.201	0.3
Underhand Throw	Non-Overweight Overweight	6.0 ± 1.4 5.9 ± 1.3	0.953	0.1
OC Subtest	Non-Overweight Overweight	30.1 ± 7.2 31.0 ± 8.2	0.634	0.1
Total TGMD-Score	Non-Overweight Overweight	56.3 ± 9.1 55.7 ± 11.2	0.790	0.1

ES: Effect Size. SD: Standard Deviation.
Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).
*p < 0.05.

Pearson correlation analysis revealed a weak, negative correlation between BMI and the LOC subtest (r = -0.211; p = 0.001) and total TGMD-3 score (r = -0.235; p = 0.018), suggesting the higher the BMI the lower the FMS score (Table 4.9). No significant association was reported between BMI and the OC subtest (Table 4.9). For males, no significant associations were reported between BMI and the LOC subtest, OC subtest and total TGMD-3 score (Table 4.9). For females a moderate, negative correlation between BMI and the LOC subtest (r = -0.458; p < 0.001) and total TGMD-3 score (r = -0.464; p < 0.001) was reported, suggesting the higher the BMI the lower the FMS score (Table 4.9). No association was reported between BMI and the OC subtest (Table 4.9).

Table 4.9: Relationship between FMS and BMI

Skill	**Overall (n = 150)**		**Male (n = 69)**		**Female (n = 81)**	
	r	**P-value**	**r**	**P-value**	**R**	**P-value**
Run	-0.224	**0.041***	-0.317	**0.034***	-0.304	**0.024***
Gallop	-0.010	0.922	-0.111	0.468	-0.215	0.116
Hop	-0.251	**< 0.001**	-0.000	0.467	-0.154	0.261
Skip	-0.072	0.146	-0.301	**0.045***	-0.021	0.879
Horizontal Jump	-0.211	**0.020***	-0.284	0.059	-0.375	**0.005****
Slide	0.045	0.654	-0.203	0.181	-0.075	0.587
LOC Subtest	-0.211	**0.001****	-0.131	0.389	-0.458	**< 0.001**
Two-Hand Strike	-0.014	0.891	-0.171	0.261	-0.083	0.549
One-Hand Forehand Strike	-0.094	0.124	-0.120	0.433	0.207	0.129
Stationary Dribble	-0.096	0.343	-0.118	0.441	-0.288	**0.033***
Two-Hand Catch	-0.034	0.737	-0.105	0.492	0.032	0.814
Kick	-0.138	0.169	-0.184	0.226	0.110	0.466
Overhand Throw	-0.034	0.737	-0.193	0.205	-0.231	0.089
Underhand Throw	-0.020	0.840	-0.124	0.416	-0.046	0.739
OC Subtest	-0.117	0.246	-0.072	0.639	-0.083	0.549
Total TGMD-3 Score	-0.235	**0.018***	-0.004	0.981	-0.464	**< 0.001**

LOC: Locomotor. OC: Object-Control. TGMD-3: Test of Gross Motor Development-3.
Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong). *p < 0.05, **p < 0.01.

4.1.2.7. PA and SB Levels

Parents reported that 75% of children are meeting the Irish recommendations of at least 60 minutes of MVPA daily. Seventy-seven percent of males and 75% of females were reported to be meeting the MVPA recommendations, with no significant differences reported between males and females meeting these recommendations.

The percentage of participants (n = 100) taking part in a variety of sporting activities reported by both the parent and child are presented in Table 4.10 and Table 4.11. The 5 highest reported sporting activities by the children were playing outside (98%; n = 98), jogging/running (82%; n = 82), household chores (77%; n = 77), bike riding (75%; n = 75) and tag/chase (75%; n = 75) (Table 4.10). As reported by the parent the 5 highest reported sporting activities for their children were bike riding (93%; n = 93), household chores (74%; n = 74), trampoline (73%; n = 73), playing on playground equipment (72%; n = 72) and tag/chase (70%; n = 70) (Table 4.11).

The sedentary activities participants (n = 100) took part in during the weekdays and weekend reported by both the parent and child are presented in Table 4.12 and Table 4.13. The highest reported sedentary activities during the weekdays reported by the children were doing homework (100%; n = 100), watching TV/videos (89%; n = 89), playing indoors with toys (79%; n = 79) and sitting and talking (78%; n = 78) (Table 4.12). The highest reported sedentary activities during the weekdays reported by the parent for their children were doing homework (94%; n = 94), playing indoors with toys (89%; n = 89), reading a book/magazine (88%; n = 88) and watching TV/videos (86%; n = 86) (Table 4.12).

At the weekend, the highest reported sedentary activities reported by the child were watching TV/videos (87%; n = 87), playing indoors with toys (68%; n = 68), sitting and talking (67%; n = 67) and listening to music (62%; n = 62) (Table 4.13). The highest reported sedentary activities at the weekend reported by the parent for their children were watching TV/videos (90%; n = 90), playing indoors with toys (79%; n = 79) and reading a book/magazine (66%; n = 66) (Table 4.13).

Table 4.10: Percentage of Participants (n = 100) Taking Part in Each Sporting Activity Reported by the Child

Sporting Activity	Child Reported PA	Child Reported METS
	%	Mean ± SD
Playing Outside	98	28.2 ± 20.3
Jogging/Running	82	31.6 ± 27.1
Household Chores	77	19.5 ± 15.7
Bike Riding	75	14.2 ± 14.6
Tag/Chase	75	15.1 ± 18.6
Walking for Exercise	72	14.8 ± 15.4
PE Class	72	6.6 ± 4.7
Playing with Pets	69	11.6 ± 13.7
Trampoline	67	10.7 ± 13.3
Swimming for Fun	65	8.2 ± 12.5
Playing on Playground Equipment	58	8.5 ± 13.1
Scooter	53	7.8 ± 10.4
Dance	48	9.2 ± 12.5
Swimming Laps	47	6.4 ± 10.1
Skipping Rope	43	9.8 ± 14.9
Soccer	42	13.9 ± 22.8
Walking the Dog	39	4.5 ± 7.5
Basketball	37	9.9 ± 25.3
Gymnastics	37	5.2 ± 9.4
Aerobics	33	12.9 ± 22.1
Rollerblading	33	9.6 ± 17.0
Playing in a Tree House	27	2.5 ± 5.5
Tennis	27	5.5 ± 12.3
Walking to School	27	5.2 ± 12.3
Skateboarding	24	2.7 ± 6.7
GAA	16	4.0 ± 12.8
Cycling to School	5	0.4 ± 2.5
Hockey	3	0.3 ± 2.0
Playing Indoors	2	0.3 ± 2.4
Rugby	2	0.2 ± 1.4
Climbing Trees	1	0.1 ± 0.5
Cycling	1	0.1 ± 0.8
Horse Riding	1	0.1 ± 0.4
Irish Dancing	1	0.1 ± 0.9
Sprinting	1	0.1 ± 1.4

METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. %: Percentage.

Table 4.11: Percentage of Participants (n = 100) Taking Part in Each Sporting Activity Reported by the Parent

Sporting Activity	Parent Reported PA	Parent Reported METS	Parent Reported mins/day
	%	Mean ± SD	Mean ± SD
Bike Riding	93	12.7 ± 14.8	83.6 ± 101.5
Household Chores	74	12.6 ± 13.8	36.5 ± 59.6
Trampoline	73	7.5 ± 8.4	53.1 ± 90.5
Playing on Playground Equipment	72	5.8 ± 8.3	57.1 ± 95.2
Tag/Chase	70	9.0 ± 14.4	38.4 ± 64.7
Walking for Exercise	66	6.3 ± 11.2	37.4 ± 68.9
Playing with Pets	63	7.1 ± 9.2	53.4 ± 104.6
Scooter	59	6.9 ± 11.0	32.0 ± 55.7
Jogging/Running	58	8.3 ± 15.6	34.2 ± 68.1
Swimming for Fun	55	3.5 ± 5.1	34.6 ± 57.9
PE	53	5.5 ± 0.4	45.5 ± 0.5
Soccer	53	14.6 ± 26.3	61.1 ± 128.6
Dance	52	6.4 ± 11.5	40.5 ± 63.1
Swimming Laps	48	3.9 ± 6.2	28.3 ± 54.8
Walking the Dog	34	2.1 ± 5.7	17.4 ± 53.8
Skipping Rope	32	4.2 ± 11.9	12.8 ± 35.9
Rollerblading	31	5.9 ± 14.1	19.7 ± 45.7
Gymnastics	30	2.2 ± 6.8	11.3 ± 33.9
Playing in a Tree House	29	1.4 ± 4.7	15.8 ± 88.1
Walking to School	28	4.8 ± 10.9	15.5 ± 42.9
Aerobics	27	0.2 ± 2.0	0.4 ± 4.0
Basketball	27	1.8 ± 5.8	7.8 ± 24.0
Tennis	25	0.9 ± 4.3	4.5 ± 19.9
Skateboarding	17	1.3 ± 7.4	3.4 ± 15.9
GAA	15	4.1 ± 13.6	30.6 ± 15.5
Cycling to School	5	0.6 ± 3.9	1.9 ± 11.8
Karate	5	4.1 ± 1.2	1.2 ± 0.2
Horse Riding	3	0.4 ± 1.2	10.5 ± 1.0
Kickboxing	3	1.2 ± 0.3	0.5 ± 1.3
Hockey	2	0.4 ± 3.0	1.2 ± 0.3

METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. %: Percentage.

Table 4.12: Percentage of Participants (n = 100) Taking Part in Sedentary Activities during Weekdays Reported by the Child and Parent

Sedentary Activity	Child Reported Sedentary Activity		Parent Reported Sedentary Activity	
	Child Reported (%)	Child Reported mins/day (Mean ± SD)	Parent Reported (%)	Parent Reported mins/day (Mean ± SD)
Doing Homework	100	199.9 ± 504.8	94	129.7 ± 91.3
Watching TV/Videos	89	279.0 ± 292.4	86	277.9 ± 271.1
Playing Indoors with Toys	79	169.4 ± 238.3	89	196.0 ± 191.8
Sitting and Talking	78	288.2 ± 453.4	76	145.6 ± 187.4
Doing Art and Craft	73	116.4 ± 311.1	59	70.8 ± 96.5
Reading a Book/Magazine	73	138.1 ± 314.1	88	106.9 ± 99.0
Listening to Music	70	147.4 ± 337.8	41	65.7 ± 92.1
Using the Computer/Internet	55	116.7 ± 258.3	48	72.1 ± 136.0
Video Games	51	131.6 ± 235.7	40	86.0 ± 168.6
Playing Board Games/Cards	50	61.2 ± 131.2	50	41.5 ± 73.0
Talking on the Phone	42	64.7 ± 158.7	29	3.8 ± 10.9
Playing a Musical Instrument	29	26.1 ± 95.6	22	13.6 ± 30.9

METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. %: Percentage.

Table 4.13: Percentage of Participants (n = 100) Taking Part in Sedentary Activities during the Weekend Reported by the Parent

Sedentary Activity	Child Reported Sedentary Activity		Parent Reported Sedentary Activity	
	Child Reported (%)	Child Reported mins/day (Mean ± SD)	Parent Reported (%)	Parent Reported mins/day (Mean ± SD)
Watching TV/Videos	87	209.4 ± 189.9	90	211.2 ± 155.1
Playing Indoors with Toys	68	116.2 ± 170.3	79	150.6 ± 141.3
Sitting and Talking	67	144.2 ± 283.7	64	98.0 ± 136.8
Listening to Music	62	118.5 ± 334.8	53	51.6 ± 72.2
Video Games	59	131.6 ± 235.7	60	93.0 ± 118.1
Reading a Book/Magazine	55	70.4 ± 135.5	66	54.6 ± 67.8
Playing Board Games/Cards	51	45.5 ± 80.0	60	56.2 ± 92.9
Doing Art and Craft	47	97.8 ± 383.3	52	58.8 ± 80.7
Using the Computer/Internet	41	99.2 ± 258.9	47	60.3 ± 91.3
Talking on the Phone	37	51.0 ± 148.8	10	1.8 ± 7.5
Playing a Musical Instrument	24	14.5 ± 49.8	18	3.4 ± 11.8
Doing Homework	0	0	3	6.7 ± 29.8

METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. %: Percentage.

4.1.2.8. Differences in PA and SB Levels Reported by the Child and Parent

Children reported higher levels of LPA (p = 0.005; d = 0.3), MPA (p = 0.000; d = 0.9), VPA (p = 0.000; d = 0.9) and MVPA (p = 0.000; d = 1.0) compared to the parent. No significant difference was reported for SB levels reported by the child and the parent (p > 0.05) (Table 4.14).

Table 4.14: Differences in PA and SB Levels Reported by the Child and the Parent

Variable	Questionnaire	Mean ± SD	P-value	ES
LPA (METS/min)	Child Parent	11.6 ± 13.7 7.4 ± 10.3	**< 0.001**	0.3
MPA (METS/min)	Child Parent	170.0 ± 116.0 84.7 ± 65.0	**< 0.001**	0.9
VPA (METS/min)	Child Parent	112.0 ± 83.5 48.1 ± 47.3	**< 0.001**	0.9
MVPA (METS/min)	Child Parent	281.9 ± 183.2 132.9 ± 104.2	**< 0.001**	1.0
SB (mins/day)	Child Parent	2346.1 ± 1262.1 2748.1 ± 2842.3	0.198	0.2

LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. VPA: Vigorous Physical Activity. SB: Sedentary Behaviour. SD: Standard Deviation.

Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).

4.1.2.9. Gender Differences in PA and SB Levels Reported by the Child and Parent

Despite males demonstrating a higher MPA, VPA and MVPA, and females presenting with a higher LPA and SB in the children reported questionnaires, no significant gender differences were noted (Table 4.15). As reported by the parent, gender differences in VPA were found with males showing higher levels of VPA ($p < 0.001$; $d = 0.8$) (Table 4.15).

Table 4.15: Gender Differences in LPA, MPA, VPA and SB (Mean ± SD) between Males (n = 45) and Females (n = 55) Reported by the Child and Parent

Variable	G	Mean ± SD	P-value	ES
Child LPA (METS/min)	M F	9.3 ± 14.3 13.4 ± 13.1	0.136	0.3
Child MPA (METS/min)	M F	174.3 ± 142.7 166.5 ± 90.3	0.743	0.1
Child VPA (METS/min)	M F	123.4 ± 95.1 102.8 ± 72.4	0.224	0.2
Child MVPA (METS/min)	M F	297.7 ± 224.3 269.3 ± 143.0	0.447	0.2
Child SB (mins/day)	M F	2269.2 ± 1176.7 2409.0 ± 1335.3	0.584	0.1
Parent LPA (METS/min)	M F	7.1 ± 12.2 7.7 ± 8.5	0.791	0.1
Parent MPA (METS/min)	M F	80.1 ± 41.3 88.4 ± 79.2	0.530	0.1
Parent VPA (METS/min)	M F	62.5 ± 39.9 36.7 ± 49.9	**0.006***	0.6
Parent MVPA (METS/min)	M F	142.6 ± 71.5 125.1 ± 124.5	0.410	0.2
Parent LPA (mins/day)	M F	52.7 ± 118.3 52.5 ± 83.8	0.989	0
Parent MPA (mins/day)	M F	477.3 ± 374.6 483.4 ± 288.6	0.927	0
Parent VPA (mins/day)	M F	302.4 ± 240.5 151.4 ± 143.4	**< 0.001**	0.8
Parent MVPA (mins/day)	M F	779.7 ± 578.3 634.8 ± 358.3	0.130	0.3
Parent SB (mins/day)	M F	2269.2 ± 1176.7 2409.0 ± 1335.3	0.584	0.1

F: Female. ES: Effect Size. G: Gender. LPA: Light Physical Activity. M: Male. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. SB: Sedentary Behaviour. SD: Standard

Deviation. VPA: Vigorous Physical Activity. Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large). * p < 0.05. ** p < 0.01.

4.1.2.10. Gender Differences in Physical Activities Reported by the Child and Parent

Both the child and parent reported gender differences in dance and soccer with females showing a higher PA level in dance while males showed a higher level of PA in soccer (Table 4.16). According to child reported PA a gender difference was reported for skateboarding with males showing a higher level of PA (Table 4.16). Also, according to parent reported PA gender differences were reported for jogging/running ($p = 0.005$; $d = 0.6$) and using a skipping rope ($p = 0.016$; $d = 0.5$) with males showing a higher PA level (Table 4.16).

Table 4.16: Gender Differences in Physical Activities Reported by the Child and Parent

		Child METS			Parent METS			Parent mins/day		
Physical Activities	**G**	**Mean ± SD**	**P-value**	**ES**	**Mean ± SD**	**P-value**	**ES**	**Mean ± SD**	**P-value**	**ES**
Aerobics	M F	12.5 ± 19.0 13.2 ± 24.5	0.874	0.03	0.0 ± 0.0 0.4 ± 2.7	0.368	0.2	0.0 ± 0.0 5.4 ± 0.7	0.368	10.9
Basketball	M F	11.2 ± 26.6 8.9 ± 24.4	0.650	0.1	1.4 ± 4.3 2.2 ± 6.8	0.516	0.1	6.2 ± 20.6 9.0 ± 26.5	0.567	0.1
Bike Riding	M F	15.0 ± 18.2 13.5 ± 10.9	0.612	0.1	13.8 ± 10.2 11.7 ± 17.8	0.472	0.1	102.9 ± 113.3 67.7 ± 88.7	0.085	0.3
Cycling to School	M F	0.8 ± 3.7 0.0 ± 0.0	0.168	0.3	1.1 ± 5.6 0.3 ± 1.3	0.331	0.2	3.6 ± 17.2 0.5 ± 3.0	0.252	0.3
Dance	M F	11.5 ± 1.7 12.5 ± 1.7	**0.006****	0.6	4.1 ± 9.0 8.2 ± 13.0	0.066	0.4	18.4 ± 39.9 58.5 ± 72.6	**0.001****	0.7
Gymnastics	M F	3.4 ± 7.9 6.7 ± 10.3	0.071	0.4	1.5 ± 5.9 2.8 ± 7.4	0.359	0.2	4.9 ± 16.5 16.5 ± 42.8	0.069	0.4
Household Chores	M F	17.7 ± 16.8 20.9 ± 14.7	0.309	0.2	10.8 ± 13.0 14.1 ± 14.4	0.234	0.2	33.0 ± 66.0 39.4 ± 54.3	0.598	0.1
Jogging/Running	M F	34.4 ± 29.8 29.4 ± 24.7	0.363	0.2	11.7 ± 18.2 5.5 ± 12.5	0.057	0.4	56.7 ± 88.8 15.8 ± 36.2	**0.005****	0.6
PE Class	M F	9.0 ± 3.9 9.5 ± 3.9	0.566	0.1	4.3 ± 4.8 5.5 ± 6.1	0.319	0.2	36.2 ± 37.4 40.9 ± 38.9	0.543	0.1
Playing in a Tree House	M F	1.9 ± 4.6 3.0 ± 6.2	0.304	0.2	1.4 ± 5.3 1.5 ± 4.3	0.973	0.02	26.0 ± 129.4 7.4 ± 20.6	0.344	0.2
Playing on Playground Equipment	M F	10.3 ± 17.7 7.0 ± 7.5	0.242	0.2	5.2 ± 7.6 6.1 ± 8.9	0.578	0.1	61.3 ± 111.0 53.6 ± 81.0	0.690	0.1
Playing with Pets	M F	9.5 ± 14.2 13.4 ± 13.1	0.149	0.3	5.9 ± 9.9 8.0 ± 8.6	0.264	0.2	42.4 ± 103.1 62.3 ± 106.0	0.348	0.2
Rollerblading	M	6.2 ± 12.8	0.063	0.4	3.1 ± 10.3	0.064	0.4	10.2 ± 33.5	0.051	0.4

	F	12.3 ± 19.6			8.1 ± 16.3			27.4 ± 52.7		
Scooter	M F	7.7 ± 11.0 7.8 ± 10.1	0.943	0.0	6.3 ± 10.0 7.3 ± 11.9	0.673	0.1	32.0 ± 59.5 31.9 ± 53.0	0.994	0.0
Skateboarding	M F	4.8 ± 8.8 0.9 ± 3.5	**0.007****	0.6	1.4 ± 5.4 1.2 ± 8.8	0.861	0.0	5.6 ± 19.5 1.6 ± 12.1	0.244	0.2
Skipping Rope	M F	9.9 ± 17.6 9.6 ± 12.5	0.933	0.01	1.2 ± 3.7 6.5 ± 15.4	**0.016***	0.5	6.9 ± 28.0 17.5 ± 40.8	0.126	0.3
Soccer	M F	22.9 ± 29.0 6.5 ± 12.1	**0.001****	0.7	28.4 ± 30.2 3.3 ± 15.4	**< 0.001**	1.0	126.0 ± 168.4 7.9 ± 29.0	**< 0.001**	1.0
Sport Class	M F	9.0 ± 4.1 10.1 ± 4.0	0.183	0.3	2.4 ± 3.5 2.5 ± 3.3	0.882	0.02	27.2 ± 30.7 30.6 ± 34.0	0.613	0.1
Swimming for Fun	M F	9.7 ± 16.9 6.9 ± 7.2	0.259	0.2	4.3 ± 6.2 2.9 ± 4.0	0.221	0.3	41.3 ± 75.5 29.1 ± 37.8	0.325	0.2
Swimming Laps	M F	6.7 ± 10.9 6.2 ± 9.5	0.825	0.04	4.4 ± 6.6 3.6 ± 5.9	0.525	0.1	30.8 ± 59.4 26.2 ± 51.3	0.679	0.1
Tag/Chase	M F	16.6 ± 21.7 13.9 ± 15.7	0.474	0.1	9.0 ± 12.2 8.9 ± 16.1	0.975	0.0	43.9 ± 73.1 33.9 ± 57.3	0.446	0.2
Tennis	M F	4.7 ± 10.7 6.2 ± 13.5	0.528	0.1	1.4 ± 4.9 0.5 ± 3.8	0.305	0.2	8.6 ± 27.9 1.1 ± 8.1	0.089	0.4
Trampoline	M F	11.1 ± 15.7 10.4 ± 11.0	0.799	0.1	6.5 ± 7.8 8.3 ± 8.8	0.303	0.2	47.3 ± 80.9 57.7 ± 98.1	0.570	0.1
Walking for Exercise	M F	15.2 ± 15.1 14.5 ± 15.8	0.831	0.04	6.2 ± 10.0 6.3 ± 12.2	0.982	0.0	38.8 ± 69.6 36.2 ± 69.0	0.852	0.03
Walking the Dog	M F	3.2 ± 6.3 5.5 ± 8.2	0.112	0.3	1.9 ± 6.2 2.2 ± 5.2	0.798	0.1	20.1 ± 71.6 15.2 ± 33.3	0.651	0.1
Walking to School	M F	5.2 ± 10.5 5.2 ± 13.7	0.997	0	5.7 ± 12.3 4.1 ± 9.7	0.475	0.1	16.2 ± 36.9 14.9 ± 47.5	0.880	0.03

F: Female. G: Gender. M: Male. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large). * p < 0.05. ** p < 0.01.

4.1.2.11. Gender Differences in Sedentary Activities Reported by the Child and Parent during the Week and Weekend

During the week, as reported by both the parent and children, gender differences existed for video games, with males showing a higher level of SB ($p < 0.001$; $d = 0.7$) (Table 4.17). As reported by the parent females participated in art and craft more than males ($p = 0.050$; $d = 0.4$) (Table 4.17). Child reported sedentary activities during the week showed that males reported a higher level of SB in nine out of the twelve sedentary activities examined in comparison to females (Table 4.17).

At the weekend, as reported both the parent and child, gender differences existed for playing video games with males showing a higher level of SB ($p < 0.01$) (Table 4.18). Gender differences were reported by the parent for playing a musical instrument and doing art and craft with females showing a higher level of SB (Table 4.18). Child reported sedentary activities reported males as more sedentary with males participating in nine out of the twelve sedentary activities examined whereas parent reported sedentary activities reported females as taking part in more sedentary activities (Table 4.18).

Table 4.17: Gender Differences in Sedentary Activities Reported by the Child and Parent during the Week

		Child SB (mins/day)			Parent SB (mins/day)		
Sedentary Activities	**G**	**Mean ± SD**	**P-value**	**ES**	**Mean ± SD**	**P-value**	**ES**
Watching TV/Videos	M	262.8 ± 231.5	0.618	0.1	255.9 ± 243.0	0.466	0.1
	F	292.3 ± 335.7			295.9 ± 293.1		
Video Games	M	215.8 ± 305.9	**0.003****	0.7	150.4 ± 221.8	**< 0.001**	0.7
	F	62.7 ± 121.9			33.4 ± 75.6		
Using the Computer/Internet	M	129.3 ± 239.2	0.663	0.1	65.8 ± 148.7	0.676	0.1
	F	106.5 ± 274.6			77.3 ± 125.8		
Doing Homework	M	245.2 ± 609.4	0.419	0.2	124.7 ± 108.0	0.620	0.1
	F	162.7 ± 401.8			133.8 ± 75.7		
Playing Indoors with Toys	M	177.3 ± 293.7	0.764	0.1	204.7 ± 220.4	0.683	0.1
	F	162.9 ± 183.7			188.8 ± 166.5		
Sitting and Talking	M	245.7 ± 344.9	0.399	0.2	133.6 ± 209.3	0.565	0.1
	F	323.0 ± 526.6			155.4 ± 168.7		
Talking on the Phone	M	53.7 ± 104.7	0.533	0.1	4.1 ± 11.5	0.797	0.04
	F	73.7 ± 192.4			3.6 ± 10.3		
Listening to Music	M	169.4 ± 480.5	0.559	0.1	58.9 ± 85.5	0.506	0.1
	F	129.5 ± 142.6			71.3 ± 97.6		
Playing a Musical Instrument	M	37.0 ± 135.7	0.305	0.2	9.3 ± 26.5	0.202	0.3
	F	17.2 ± 39.6			17.1 ± 33.9		
Playing Board Games/Cards	M	70.0 ± 156.0	0.547	0.1	38.8 ± 66.1	0.742	0.1
	F	54.0 ± 107.8			43.6 ± 78.7		
Reading a Book/Magazine	M	183.4 ± 446.2	0.193	0.3	99.9 ± 97.9	0.527	0.1
	F	101.0 ± 124.7			112.6 ± 100.4		
Art and Craft	M	119.3 ± 444.7	0.933	0.01	49.9 ± 79.6	**0.050***	0.4
	F	114.0 ± 127.5			87.8 ± 106.0		

F: Female. G: Gender. M: Male. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large). * p < 0.05. ** p < 0.01.

Table 4.18: Gender Differences in Sedentary Activities Reported by the Child and Parent during the Weekend

		Child SB (mins/day)			Parent SB (mins/day)		
Sedentary Activities	**G**	**Mean ± SD**	**P-value**	**ES**	**Mean ± SD**	**P-value**	**ES**
Watching TV/Videos	M F	234.1 ± 196.5 189.1 ± 183.7	0.240	0.2	187.1 ± 119.2 230.8 ± 177.8	0.162	0.3
Video Games	M F	205.2 ± 252.3 69.9 ± 179.4	**0.003****	0.6	150.2 ± 132.3 46.1 ± 79.6	**< 0.001**	1.0
Using the Computer/Internet	M F	119.4 ± 262.8 82.7 ± 256.9	0.484	0.1	45.3 ± 76.7 72.5 ± 100.7	0.130	0.3
Doing Homework	M F	9.2 ± 45.9 3.1 ± 17.4	0.363	0.2	8.0 ± 32.9 5.6 ± 27.3	0.695	0.1
Playing Indoors with Toys	M F	125.2 ± 211.6 108.8 ± 128.6	0.635	0.1	136.7 ± 135.6 162.0 ± 146.0	0.375	0.2
Sitting and Talking	M F	153.1 ± 326.0 137.0 ± 246.8	0.779	0.1	84.3 ± 158.4 109.1 ± 116.5	0.371	0.2
Talking on the Phone	M F	34.3 ± 80.0 64.7 ± 187.0	0.312	0.2	0.9 ± 3.1 2.6 ± 9.7	0.235	0.2
Listening to Music	M F	79.3 ± 158.7 150.6 ± 427.3	0.292	0.2	38.1 ± 55.0 62.6 ± 82.5	0.079	0.3
Playing a Musical Instrument	M F	16.8 ± 57.1 12.6 ± 43.3	0.680	0.1	0.9 ± 6.0 5.5 ± 14.7	**0.039***	0.4
Playing Board Games/Cards	M F	52.6 ± 92.0 39.7 ± 69.0	0.428	0.2	50.4 ± 98.3 60.9 ± 88.9	0.578	0.1
Reading a Book/Magazine	M F	78.6 ± 181.9 63.7 ± 81.1	0.585	0.1	48.4 ± 63.4 59.6 ± 71.3	0.414	0.2
Art and Craft	M F	94.5 ± 445.9 100.7 ± 327.6	0.936	0.01	31.7 ± 60.5 80.9 ± 88.6	**0.002****	0.6

F: Female. G: Gender. M: Male. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large). * $p < 0.05$. $p < 0.01$.

4.1.2.12. ST Recommendations

ST guidelines have been established and it is recommended that the use of electronic media (e.g. TV, electronic games and computer use) is limited to < 2 hours/day (Australian Government Department of Health, 2014; Canadian Society for Exercise Physiology, 2011; Davies et al., 2011; US Department of Health and Human Services, 2011). As reported by the child 36% (25% boys and 11% girls) exceeded the ST recommendations during the week, whilst at the weekend this increased to 60% (32% boys and 28% girls). Parents reported similar findings during the week with 24% (18% boys and 6% girls) of children exceeding the recommendations, with this increasing to 77% (40% boys and 37% girls) at the weekend.

4.1.2.13. Gender Differences in Screen Time Reported by the Child and Parent

According to both child and parent reported ST, males reported higher levels of ST during the week and at the weekend, however, there was no statistically significant difference between genders (Table 4.19).

Table 4.19: Gender Differences in Screen Time Reported by the Child and Parent

Variable	G	Mean ± SD	P-value	ES
Child Weekday ST (mins/day)	M F	607.8 ± 570.6 461.5 ± 519.6	0.183	0.3
Child Weekend ST (mins/day)	M F	558.7 ± 574.9 341.7 ± 537.8	0.055	0.4
Parent Weekday ST (mins/day)	M F	472.1 ± 454.2 406.5 ± 380.4	0.433	0.2
Parent Weekend ST (mins/day)	M F	382.7 ± 206.2 349.4 ± 238.7	0.463	0.1

F: Female. G: Gender. M: Male. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). SD: Standard Deviation. ST: Screen Time.
Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).

4.1.2.14. PA Levels, SB Levels and Weight Status

No differences were reported between non-overweight and overweight participants for LPA, MPA, VPA, MVPA or SB (p > 0.05) (Table 4.20).

Table 4.20: Differences between Non-Overweight and Overweight Participants for LPA, MPA, VPA and SB Reported by the Child and Parent

Variable	Weight Status	Mean ± SD	P-Value	ES
Child LPA (METS/min)	Non-Overweight Overweight	11.0 ± 13.3 18.9 ± 16.6	0.117	0.5
Child MPA (METS/min)	Non-Overweight Overweight	168.4 ± 114.0 187.2 ± 114.1	0.664	0.2
Child VPA (METS/min)	Non-Overweight Overweight	110.4 ± 85.3 130.1 ± 60.1	0.524	0.3
Child MVPA (METS/min)	Non-Overweight Overweight	278.8 ± 184.2 317.3 ± 178.5	0.572	0.2
Child SB (mins/day)	Non-Overweight Overweight	2343.4 ± 1266.9 2377.5 ± 1288.2	0.942	0
Parent LPA (METS/min)	Non-Overweight Overweight	7.1 ± 10.4 11.6 ± 8.5	0.238	0.5
Parent MPA (METS/min)	Non-Overweight Overweight	84.7 ± 66.6 85.3 ± 45.9	0.982	0
Parent VPA (METS/min)	Non-Overweight Overweight	48.4 ± 47.3 45.1 ± 49.9	0.852	0.1
Parent MVPA (METS/min)	Non-Overweight Overweight	133.1 ± 106.0 130.4 ± 86.0	0.944	0
Parent LPA (mins/day)	Non-Overweight Overweight	52.0 ± 102.6 58.8 ± 69.2	0.857	0.1
Parent MPA (mins/day)	Non-Overweight Overweight	484.3 ± 331.8 438.8 ± 294.4	0.708	0.1
Parent VPA (mins/day)	Non-Overweight Overweight	220.4 ± 203.5 196.9 ± 246.1	0.758	0.1
Parent MVPA (mins/day)	Non-Overweight Overweight	704.8 ± 471.4 635.6 ± 493.2	0.693	0.1
Parent SB (mins/day)	Non-Overweight Overweight	2343.4 ± 1266.9 2377.5 ± 1288.2	0.942	0

LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. SD: Standard Deviation. VPA: Vigorous Physical Activity.
Effect Size (Cohen's d) of < 0.10 (trivial), > 0.10 (small), > 0.30 (medium) and > 0.50 (large).

4.1.2.15. Relationship between FMS and Child and Parent Reported PA Levels

LPA (METS) as reported by the children showed a weak, negative association the OC subtest ($r = -0.247$; $p = 0.014$) and total TGMD-3 score ($r = -0.211$; $p = 0.036$) (Table 4.21). A weak, positive association was also reported between VPA (METS) and the OC subtest ($r = 0.271$; $p = 0.007$) and LOC subtest ($r = 0.260$; $p = 0.009$) (Table 4.21). In addition, VPA (METS) showed a moderate, positive association with the total TGMD-3 score ($r = 0.333$; $p = 0.001$) (Table 4.21).

PA levels as reported by the parent is detailed below (Table 4.22). LPA (METS) and MPA (METS) and MVPA (METS) showed no association with any FMS variables (Table 4.22). VPA (METS) showed a weak, positive association with the OC subtest ($r = 0.224$; $p = 0.026$) (Table 4.22). LPA (mins.), MPA (mins.), VPA (mins.) and MVPA (mins.) showed no association with any FMS variables (Table 4.23).

Table 4.21: Relationship between FMS and Child Reported PA Levels (LPA, MPA, VPA and MVPA) (METS)

Skill	**LPA (METS)**		**MPA (METS)**		**VPA (METS)**		**MVPA (METS)**	
	R	P-value	R	P-value	r	P-value	r	P-value
Run	0.103	0.309	0.123	0.225	0.169	0.094	0.155	0.125
Gallop	-0.027	0.789	0.005	0.959	-0.061	0.546	-0.025	0.809
Hop	-0.035	0.728	0.036	0.725	0.210	**0.037***	0.118	0.244
Skip	0.071	0.483	0.114	0.263	0.153	0.130	0.142	0.162
Horizontal Jump	-0.103	0.312	0.084	0.407	0.099	0.329	0.099	0.332
Slide	-0.124	0.221	0.039	0.703	0.161	0.111	0.098	0.335
LOC Total	-0.027	0.789	0.147	0.146	0.260	**0.009****	0.212	**0.035***
Two-Hand Strike	0.210	**0.037***	-0.054	0.593	0.305	**0.002****	0.104	0.304
One-Hand Forehand Strike	-0.193	0.056	-0.091	0.371	0.128	0.205	0.001	0.992
Stationary Dribble	-0.233	**0.020***	-0.076	0.454	0.150	0.137	0.020	0.841
Two-Hand Catch	0.224	**0.026***	0.243	**0.015***	0.179	0.076	0.235	**0.019***
Kick	-0.158	0.118	0.052	0.606	0.266	**0.008****	0.154	0.127
Overhand Throw	-0.186	0.066	-0.183	0.069	-0.007	0.944	-0.119	0.239
Underhand Throw	-0.009	0.927	0.053	0.603	0.022	0.830	0.043	0.669
OC Subtest	-0.247	**0.014***	-0.055	0.588	0.271	**0.007****	0.089	0.383
Total TGMD-3 Score	-0.211	**0.036***	0.021	0.837	0.333	**0.001****	0.165	0.103

LOC: Locomotor. LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. MVPA: Moderate-Vigorous Physical Activity. OC: Object-Control. SD: Standard Deviation. TGMD-3: Test of Gross Motor Development-3. VPA: Vigorous Physical Activity.

Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong).

*$p < 0.05$, **$p < 0.01$.

Table 4.22: Relationship between FMS and Parent Reported PA Levels (LPA, MPA, VPA and MVPA) (METS)

Skill	**LPA (METS)**		**MPA (METS)**		**VPA (METS)**		**MVPA (METS)**	
	R	P-value	r	P-value	r	P-value	r	P-value
Run	0.059	0.564	-0.082	0.422	-0.018	0.862	-0.059	0.562
Gallop	-0.149	0.141	0.065	0.525	-0.022	0.830	0.030	0.765
Hop	0.087	0.391	-0.086	0.398	0.033	0.744	-0.038	0.705
Skip	0.040	0.693	0.095	0.350	-0.037	0.720	0.043	0.675
Horizontal Jump	0.048	0.636	-0.010	0.918	0.076	0.457	0.028	0.785
Slide	0.011	0.911	0.016	0.879	0.004	0.970	0.011	0.911
LOC Subtest	0.054	0.598	-0.011	0.917	0.021	0.839	0.003	0.978
Two-Hand Strike	-0.127	0.211	-0.092	0.366	0.138	0.172	0.005	0.957
One-Hand Forehand Strike	-0.128	0.209	-0.133	0.190	-0.002	0.986	-0.084	0.411
Stationary Dribble	-0.059	0.559	0.052	0.611	0.172	0.088	0.110	0.276
Two-Hand Catch	0.033	0.748	-0.052	0.611	-0.122	0.230	-0.088	0.389
Kick	0.033	0.743	0.068	0.502	0.291	**0.004****	0.175	0.084
Overhand Throw	-0.014	0.887	0.022	0.828	0.214	**0.033***	0.111	0.275
Underhand Throw	0.071	0.487	0.060	0.558	0.108	0.287	0.086	0.396
OC Subtest	-0.071	0.486	-0.027	0.791	0.224	**0.026***	0.085	0.403
Total TGMD-3 Score	-0.033	0.744	-0.026	0.796	0.189	0.060	0.069	0.494

LOC: Locomotor. LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. MVPA: Moderate-Vigorous Physical Activity. OC: Object-Control. SD: Standard Deviation. TGMD-3: Test of Gross Motor Development-3. VPA: Vigorous Physical Activity.
Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong).
*p < 0.05, **p < 0.01.

Table 4.23: Relationship between FMS and Parent Reported PA Levels (LPA, MPA, VPA and MVPA) (mins.)

Skill	**LPA (mins/day)**		**MPA (mins/day)**		**VPA (mins/day)**		**MVPA (mins/day)**	
	R	P-value	r	P-value	r	P-value	r	P-value
Run	0.038	0.705	-0.039	0.700	-0.130	0.199	-0.084	0.408
Gallop	0.047	0.648	0.047	0.642	0.064	0.530	0.061	0.550
Hop	-0.078	0.445	-0.186	0.066	-0.106	0.298	-0.175	0.083
Skip	-0.054	0.593	0.037	0.717	-0.100	0.325	-0.018	0.860
Horizontal Jump	-0.111	0.273	0.005	0.964	0.117	0.249	0.054	0.594
Slide	-0.009	0.927	-0.015	0.879	-0.031	0.760	-0.024	0.811
LOC Subtest	-0.075	0.462	-0.060	0.554	-0.064	0.532	-0.070	0.494
Two-Hand Strike	-0.101	-0.322	-0.142	0.160	0.062	0.540	-0.072	0.481
One-Hand Forehand Strike	-0.251	**0.012***	-0.122	0.230	-0.142	0.160	-0.147	0.148
Stationary Dribble	-0.113	0.266	-0.025	0.810	0.121	0.234	0.036	0.727
Two-Hand Catch	-0.034	0.742	-0.029	0.779	-0.082	0.422	-0.055	0.585
Kick	-0.155	0.127	-0.056	0.585	0.119	0.239	0.013	0.895
Overhand Throw	0.056	0.582	-0.080	0.432	0.111	0.276	-0.007	0.944
Underhand Throw	-0.034	0.737	-0.042	0.678	0.047	0.643	-0.009	0.932
OC Subtest	-0.178	0.078	-0.137	0.178	0.065	0.525	-0.067	0.512
Total TGMD-3 Score	-0.176	0.082	-0.136	0.179	0.024	0.815	-0.084	0.407

LOC: Locomotor. LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. MVPA: Moderate-Vigorous Physical Activity. OC: Object-Control. SD: Standard Deviation. TGMD-3: Test of Gross Motor Development-3. VPA: Vigorous Physical Activity.
Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong).
*p < 0.05, **p < 0.01.

4.1.2.16. Relationship between FMS and Child and Parent Reported SB Levels

SB as reported by the children showed a weak, negative association between the slide (r = -0.268; p = 0.007), total TGMD-3 score (r = -0.231; p = 0.021), OC subtest (r = -0.207; p = 0.039) and the two-hand strike was reported (r = 0202; p = 0.043) (Table 4.24). No association between FMS and SB as reported by the parent were found (Table 4.24).

Table 4.24: Relationship between FMS and Child and Parent Reported SB Levels

Skill	Child SB (mins/day)		Parent SB (mins/day)	
	R	P-value	r	P-value
Run	-0.181	0.071	-0.116	0.249
Gallop	0.169	0.092	-0.021	0.835
Hop	0.034	0.736	-0.073	0.472
Skip	-0.159	0.115	0.084	0.408
Horizontal Jump	-0.054	0.590	-0.037	0.711
Slide	-0.268	**0.007***	-0.034	0.738
LOC Subtest	-0.145	0.151	-0.067	0.506
Two-Hand Strike	-0.202	**0.043***	0.051	0.617
One-Hand Forehand Strike	-0.149	0.139	-0.005	0.960
Stationary Dribble	-0.123	0.224	0.063	0.537
Two-Hand Catch	-0.148	0.143	-0.096	0.341
Kick	-0.124	0.220	-0.049	0.630
Overhand Throw	-0.079	0.434	-0.103	0.310
Underhand Throw	0.069	0.496	0.124	0.217
OC Subtest	-0.207	**0.039***	-0.002	0.982
Total TGMD-3 Score	-0.231	**0.021***	-0.032	0.754

LOC: Locomotor. OC: Object-Control. TGMD-3: Test of Gross Motor Development-3. SB: Sedentary Behaviour.
Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong).
*p < 0.05, **p < 0.01.

4.1.2.17. Relationship between BMI and Child and Parent Reported PA and SB Levels

For the overall sample (n = 100) child reported LPA (METS) showed a weak, positive association with BMI (Table 4.25). For males (n = 45) no correlation was reported between PA and BMI. Eight out of the twelve PA variables assessed for males showed a negative association with BMI suggesting the lower the level of PA the higher the BMI (Table 4.25). For females (n = 55) child reported LPA (METS), MPA (METS) and MVPA (METS) showed a moderate, positive association with BMI (Table 4.25), suggesting that the higher the level of PA the lower the BMI.

Table 4.25: Relationship between BMI and Child and Parent Reported PA and SB Levels

Variable	Overall (n = 100)		Male (n = 45)		Female (n = 55)	
	R	**P-value**	**R**	**P-value**	**R**	**P-value**
Child LPA (METS/min)	0.239	**0.017***	0.147	0.342	0.298	**0.027***
Child MPA (METS/min)	0.150	0.138	0.003	0.984	0.310	**0.021***
Child VPA (METS/min)	0.071	0.486	-0.098	0.527	0.216	0.113
Child MVPA (METS/min)	0.127	0.209	-0.040	0.799	0.305	**0.023***
Child SB (mins/day)	-0.103	0.306	-0.025	0.871	0.149	0.277
Parent LPA (METS/min)	0.009	0.932	-0.107	0.488	0.105	0.447
Parent MPA (METS/min)	-0.057	0.578	-0.154	0.319	-0.032	0.818
Parent VPA (METS/min)	-0.038	0.708	-0.046	0.766	-0.019	0.893
Parent MVPA (METS/min)	-0.053	0.605	-0.114	0.459	-0.028	0.841
Parent LPA (mins/day)	-0.047	0.645	-0.140	0.366	0.025	0.859
Parent MPA (mins/day)	0.021	0.838	0.015	0.922	0.026	0.852
Parent VPA (mins/day)	0.022	0.831	0.009	0.953	0.078	0.569
Parent MVPA (mins/day)	0.024	0.814	0.014	0.930	0.052	0.705
Parent SB (mins/day)	-0.081	0.423	-0.214	0.159	0.032	0.819

LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. SB: Sedentary Behaviour. SD: Standard Deviation. VPA: Vigorous Physical Activity.

Correlation values (r) of 0.10-0.29 (weak), 0.30-0.49 (moderate) and 0.50-1.0 (strong).

*$p < 0.05$, **$p < 0.01$.

4.1.3. Intervention Data

4.1.3.1. Participant Information

Table 4.26 shows the descriptive characteristics, FMS scores, PA levels and SB levels for the intervention group (n = 80) and the control group (n = 70) both pre and post-test the eight week intervention.

Table 4.26: Descriptive Characteristics, FMS Scores, PA Levels and SB Levels for both Experimental Groups

Variable	Intervention			Control		
	Pre	Post	% Change	Pre	Post	% Change
BMI (kg/m^2)	16.7 ± 2.4	17.4 ± 2.5	4.2	16.6 ± 2.4	17.6 ± 2.7	6
Child LPA (METS/min)	10.4 ± 9.2	8.7 ± 8.2	-16.3	12.7 ± 16.9	11.4 ± 14.9	-10.2
Child MPA (METS/min)	144.0 ± 66.5	190.5 ± 121.5	32.3	194.4 ± 144.7	200.5 ± 140.5	3.1
Child VPA (METS/min)	123.2 ± 69.0	131.4 ± 105.1	6.7	101.5 ± 94.5	108.0 ± 96.1	6.4
Child MVPA (METS/min)	267.1 ± 122.6	321.9 ± 209.7	20.5	295.9 ± 226.3	308.5 ± 224.5	4.3
Parent LPA (METS/min)	9.0 ± 11.3	10.7 ± 9.8	18.8	6.0 ± 9.0	5.7 ± 9.1	-5
Parent MPA (METS/min)	82.7 ± 81.4	206.1 ± 227.2	149.2	86.7 ± 45.2	98.9 ± 44.0	14.1
Parent VPA (METS/min)	52.2 ± 55.3	65.1 ± 55.4	24.7	44.3 ± 38.4	44.9 ± 36.9	1.4
Parent MVPA (METS/min)	134.9 ± 129.8	269.1 ± 247.9	99.5	131.0 ± 73.6	143.8 ± 67.9	9.8
Parent LPA (mins/day)	57.5 ± 108.7	62.5 ± 81.1	8.7	47.9 ± 92.0	39.9 ± 85.2	-16.7
Parent MPA (mins/day)	404.4 ± 253.0	520.9 ± 259.5	28.8	552.5 ± 373.7	583.8 ± 363.5	5.7
Parent VPA (mins/day)	213.4 ± 165.9	263.3 ± 194.6	23.4	223.3 ± 239.1	230.9 ± 213.3	3.4
Parent MVPA (mins/day)	617.8 ± 374.2	787.0 ± 375.9	27.4	775.8 ± 540.9	814.7 ± 499.8	5
Child SB (mins/day)	2763.7 ± 3374.0	2378.9 ± 3325.6	-13.9	3067.9 ± 2894.8	2580.0 ± 2286.7	-15.9
Parent SB (mins/day)	2082.3 ± 764.2	1656.4 ± 715.4	-20.5	2572.8 ± 1344.6	2234.6 ± 1148.2	-13.1

LOC: Locomotor. LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. OC: Object-Control. SB: Sedentary Behaviour. TGMD-3: Test of Gross Motor Development-3. VPA: Vigorous Physical Activity.

4.1.3.2. FMS Proficiency

Table 4.27 presents an overview of the changes in FMS proficiency variables from pre to post-test in both the intervention and control group. There was a significant interaction between group and time (pre- to post-intervention) for the LOC subtest score, with a large effect size found (Wilk's Lambda = 0.70, F (1,148) = 62.43, p = 0.000, partial eta squared = 0.297). There was a main effect for time found with a large effect size (Wilk's Lambda = 0.70, F (1, 148) = 63.27, p = 0.000, partial eta squared = 0.299), and group (F (1, 148) = 4.87, p = 0.029, partial eta squared = 0.002), with the intervention group showing a greater increase in the LOC subtest score over time compared to the control group (Table 4.27).

There was no significant interaction between group and time (pre- and post-intervention) for the OC subtest score (Wilk's Lambda = 1.0, F (1, 148) = 0.84, p = 0.361, partial eta squared = 0.006). There was a main effect for time found with a large effect size (Wilk's Lambda = 0.76, F (1, 148) = 47.08, p = 0.000, partial eta squared = 0.241). The intervention group demonstrated significantly greater scores than the control group, with a medium effect size (F (1, 148) = 12.68, p = 0.000, partial eta squared = 0.079) (Table 4.27).

There was a significant interaction between group and time (pre- to post-intervention) for total TGMD-3 score, with a large effect size reported (Wilk's Lambda = 0.87, F (1, 148) = 21.79, p = 0.000, partial eta squared = 0.128). There was a main effect for time found with a large effect size (Wilk's Lambda = 0.61, F (1, 148) = 94.75, p = 0.000, partial eta squared = 0.390), and group (F (1, 148) = 13.78, p = 0.000, partial eta squared = 0.390), with the intervention group showing the greatest improvement compared to the control group (Table 4.27).

Table 4.27: Changes in FMS Proficiency from Pre to Post-Test for Both the Intervention and Control Group

Measurement	Intervention			Control			Interaction Effect	Main Effect of Time for Group	Main Effect of Group
	Pre	Post	% Change	Pre	Post	% Change	P-value	P-value	P-value
Run	4.9 ± 1.5	5.7 ± 1.7	16.3	5.2 ± 1.4	5.2 ± 1.4	0	**< 0.001†**	**< 0.001**	0.647
Gallop	3.5 ± 1.3	3.9 ± 1.0	11.4	3.9 ± 1.1	3.7 ± 1.0	-5.4	**0.020***	0.306	0.769
Hop	4.0 ± 1.9	4.4 ± 1.6	10	3.8 ± 1.5	4.0 ± 1.4	5.3	0.481	**0.011***	0.269
Skip	3.2 ± 1.7	4.0 ± 1.7	25	3.3 ± 1.4	3.5 ± 1.3	6.1	**0.010***	**< 0.001**	0.264
Horizontal Jump	4.0 ± 1.7	5.9 ± 1.4	47.5	4.3 ± 1.9	4.0 ± 1.9	-7	**< 0.001**	**< 0.001†**	**0.001****
Slide	6.2 ± 0.9	6.1 ± 0.6	-1.6	6.0 ± 0.7	6.1 ± 0.7	1.6	0.187	0.930	0.265
Two-Hand Strike	5.6 ± 2.1	6.1 ± 5.7	8.9	4.8 ± 2.3	5.7 ± 2.1	18.8	0.441	**0.001**	0.265
One-Hand Forehand Strike	3.8 ± 2.3	4.7 ± 2.0	23.7	3.2 ± 2.4	3.8 ± 2.0	18.8	0.505	**< 0.001**	**0.021***
Stationary Dribble	3.5 ± 2.1	4.4 ± 1.7	25.7	2.5 ± 2.3	3.2 ± 2.2	28	0.476†	**< 0.001†**	**0.001****
Two-Hand Catch	4.3 ± 1.3	4.6 ± 1.2	7	4.3 ± 1.4	4.4 ± 1.2	2.3	0.376	0.057	0.582
Kick	5.4 ± 1.8	5.9 ± 2.0	9.3	5.5 ± 1.8	4.9 ± 1.7	-10.9	**< 0.001**	0.879	0.132
Overhand Throw	3.1 ± 2.0	3.5 ± 2.5	12.9	2.3 ± 2.3	3.2 ± 2.4	39.1	0.172	**0.001**	0.095
Underhand Throw	6.1 ± 1.3	6.3 ± 1.4	3.3	5.8 ± 1.4	5.9 ± 1.6	1.7	0.970	0.402	0.059
LOC Subtest Score	25.7 ± 4.5	30.0 ± 4.7	16.7	26.4 ± 4.1	26.4 ± 4.0	0	**< 0.001†**	**< 0.001†**	**0.029***
OC Subtest Score	31.8 ± 6.3	35.3 ± 6.3	11	28.4 ± 8.0	31.2 ± 7.5	9.9	0.361†	**< 0.001†**	**< 0.001**

Total TGMD-3 Score	57.5 ± 8.8	65.3 ± 9.0	13.6	54.8 ± 9.8	57.6 ± 9.2	5.1	**< 0.001†**	**< 0.001†**	**< 0.001**

LOC: Locomotor. OC: Object-Control. TGMD-3: Test of Gross Motor Development-3. %: Percentage.

*Data is presented as mean ± standard deviation. *p < 0.05, ** p < 0.01, † large partial eta squared. Partial Eta Squared = Trivial < 0.01, Small > 0.01, Moderate > 0.06, Large > 0.14.*

4.1.3.3. FMS Mastery

The percentage of mastery, near mastery and poor mastery for both the intervention group (n = 80) and control group (n = 70) at pre and post-test are presented below (Table 4.28). A total of 9 skills improved for the intervention group following the intervention. These skills included the run (6.3% vs 18.8%); skip (3.8% vs 20%); horizontal jump (0% vs 15%); one-hand forehand strike (2.5% vs 6.3%); kick (26.3% vs 35%); stationary dribble (26.3% vs 38.8%); two-hand catch (25% vs 30%); overhand throw (0% vs 7.5%) and underhand throw (12.5% vs 26.3%) (Table 4.28). For the control group only two skills showed an increase in mastery following the intervention, the slide (2.9% vs 7.1%) and the stationary dribble (17.1% vs 22.9%) (Table 4.28). For the intervention group, the least mastered skills following the intervention were the gallop (100%); hop (100%); and slide (88.8%) (Table 4.28). For the control group, the poorest mastered skills reported were the run (88.6%); gallop (100%); hop (100%); skip (100%) and one-hand forehand strike (95.7%) (Table 4.28).

Table 4.28: Percentage of Participants in the Intervention Group (n = 80) and the Control Group (n = 70) Achieving Mastery, Near Mastery and Poor at Pre and Post-Test

Variable	Mastery						Near Mastery						Poor					
	Intervention			Control			Intervention			Control			Intervention			Control		
	Pre	Post	% △	Pre	Post	% △	Pre	Post	% △	Pre	Post	% △	Pre	Post	% △	Pre	Post	% △
Run	6.3	18.8	12.5	7.1	7.1	0	7.5	10	2.5	4.3	4.3	0	86.3	71.3	-15	88.6	88.6	0
Gallop	0	0	0	0	0	0	0	0	0	0	0	0	100	100	0	100	100	0
Hop	2.5	0	-2.5	0	0	0	3.8	0	-3.8	0	0	0	93.8	100	6.2	100	100	0
Skip	3.8	20	16.2	0	0	0	5	13.8	8.8	0	0	0	91.3	66.3	-25	100	100	0
Slide	11.3	3.8	-7.5	2.9	7.1	4.2	13.8	7.5	-6.3	5.7	2.9	-2.8	75	88.8	13.8	91.4	51.4	-40
Horizontal Jump	0	15	15	5.7	4.3	-1.4	3.8	8.8	5	5.7	5.7	0	96.3	76.3	-20	88.6	90	1.4
Two-Hand Strike	3.8	3.8	0	0	0	0	2.5	3.8	1.3	1.4	5.7	4.3	93.8	82.5	-11.3	98.6	94.3	-4.3
One-Hand Forehand Strike	2.5	6.3	3.8	4.3	2.9	-1.4	2.5	7.5	5	2.9	1.4	-1.5	95	86.3	-8.7	92.9	95.7	2.8
Kick	26.3	35	8.7	15.7	12.9	-2.8	7.5	6.3	-1.2	11.4	7.1	-4.3	66.3	58.8	-7.5	72.9	80	7.1
Stationary Dribble	26.3	38.8	12.5	17.1	22.9	5.8	11.3	11.3	0	8.6	8.6	0	62.5	50	-12.5	74.3	68.6	-5.7
Two-Hand Catch	25	30	5	27.1	22.9	-4.2	10	20	10	12.9	18.6	5.7	65	50	-15	60	58.6	-1.4
Overhand Throw	0	7.5	7.5	4.3	4.3	0	2.5	6.3	3.8	1.4	2.9	1.5	96.3	86.3	-10	94.3	92.9	-1.4
Underhand Throw	12.5	26.3	13.8	14.3	14.3	0	18.8	16.3	-2.5	12.9	24.3	11.4	62.5	57.5	-5	72.9	61.4	-11.5

% △ = Percentage Change.

4.1.3.4. PA and SB Levels

Table 4.29 presents an overview of the changes in PA variables from pre to post-test in both the intervention and control group. There was a significant interaction between group and time (pre- to post-intervention) for parent reported MPA (METS), with a large effect size found (Wilk's Lambda = 0.84, F (1, 81) = 14.995, p = 0.000, partial eta squared = 0.156). There was a main effect for time found with a large effect size (Wilk's Lambda = 0.81, F (1, 81) = 19.172, p = 0.000, partial eta squared = 0.168) and group (F (1, 81) = 7.85, p = 0.009, partial eta squared = 0.088), with the intervention group improving the greatest (Table 4.29). There was a significant interaction between group and time (pre- to post-intervention) for parent reported MVPA (METS), with a large effect size found (Wilk's Lambda = 0.83, F (1, 97) = 20.264, p = 0.000, partial eta squared = 0.173). There was a main effect for time found with a moderate effect size (Wilk's Lambda = 0.88, F (1, 97) = 13.833, p = 0.000, partial eta squared = 0.125) and group (F (1, 97) = 6.90, p = 0.010, partial eta squared = 0.066).

There was no significant interaction effect noted between group and time (pre- and post-intervention) for parent reported SB (mins.) (Wilk's Lambda = 0.998, F (1, 81) = 79376.373, p = 0.693, partial eta squared = 0.129). There was a main effect for time found with a large effect size (Wilk's Lambda = 0.87, p = 0.001, partial eta squared = 0.129). The main effect for group was significant with the intervention group demonstrating a significantly greater reduction in SB than the control, with a trivial effect size (F (1, 81) = 79376.373, p = 0.005, partial eta squared = 0.002) (Table 4.29).

Table 4.29: Changes in LPA, MPA, VPA and SB Levels from Pre to Post-Test for Both the Intervention and Control Group

Measurement	Intervention			Control			Interaction Effect	Main Effect of Time for Group	Main Effect of Group
	Pre	Post	% △	Pre	Post	% △	P-value	P-value	P-value
Child LPA (METS/min)	10.4 ± 9.2	8.7 ± 8.2	-16.3	12.7 ± 16.9	11.4 ± 14.9	-10.2	0.113	0.836	0.319
Child MPA (METS/min)	144.0 ± 66.5	190.5 ± 121.5	32.3	194.4 ± 144.7	200.5 ± 140.5	3.1	**0.008****	**0.039***	0.187
Child VPA (METS/min)	123.2 ± 69.0	131.4 ± 105.1	6.7	101.5 ± 94.5	108.0 ± 96.1	6.4	0.353	0.915	0.182
Child MVPA (METS/min)	267.1 ± 122.6	321.9 ± 209.7	20.5	295.9 ± 226.3	308.5 ± 224.5	4.3	**0.036***	0.185	0.837
Parent LPA (METS/min)	9.0 ± 11.3	10.7 ± 9.8	18.8	6.0 ± 9.0	5.7 ± 9.1	-5	0.421	0.237	**0.027***
Parent MPA (METS/min)	82.7 ± 81.4	206.1 ± 227.2	149.2	86.7 ± 45.2	98.9 ± 44.0	14.1	**< 0.001†**	**< 0.001†**	**0.009****
Parent VPA (METS/min)	52.2 ± 55.3	65.1 ± 55.4	24.7	44.3 ± 38.4	44.9 ± 36.9	1.4	**0.045***	0.067	0.116
Parent MVPA (METS/min)	134.9 ± 129.8	269.1 ± 247.9	99.5	131.0 ± 73.6	143.8 ± 67.9	9.8	**< 0.001†**	**< 0.001**	**0.010**
Parent LPA (mins/day)	57.5 ± 108.7	62.5 ± 81.1	8.7	47.9 ± 92.0	39.9 ± 85.2	-16.7	0.881	0.521	0.304
Parent MPA (mins/day)	404.4 ± 253.0	520.9 ± 259.5	28.8	552.5 ± 373.7	583.8 ± 363.5	5.7	**0.021***	0.180	0.062
Parent VPA (mins/day)	213.4 ± 165.9	263.3 ± 194.6	23.4	223.3 ± 239.1	230.9 ± 213.3	3.4	0.141	0.277	0.758
Parent MVPA (mins/day)	617.8 ± 374.2	787.0 ± 375.9	27.4	775.8 ± 540.9	814.7 ± 499.8	5	**0.019***	0.138	0.253
Child SB (mins/day)	2763.7 ± 3374.0	2378.9 ± 3325.6	-13.9	3067.9 ± 2894.8	2580.0 ± 2286.7	-15.9	0.829	0.070	**0.047***

Parent SB (mins/day)	2082.3 ± 764.1	1656.4 ± 715.4	-20.5	2572.8 ± 1344.6	2234.6 ± 1148.2	-13.1	0.693	**0.001****	**0.005****

LPA: Light Physical Activity. METS: Metabolic Equivalent Units (Metabolic Equivalent for Physical Activity Multiplied by the Activity Time in Minutes – METS/min.). MPA: Moderate Physical Activity. VPA: Vigorous Physical Activity. SB: Sedentary Behaviour. %: Percentage.

Data is presented as mean ± standard deviation.

**$p < 0.05$, ** $p < 0.01$, † large partial eta squared.*

Partial Eta Squared = Trivial < 0.01, Small > 0.01, Moderate > 0.06, Large > 0.14.

Chapter 5: Discussion, Conclusion, Future Recommendations

The aim of the current study was to evaluate the relationship between PA, FMS and SB in Irish primary school children. Research has shown that there is a relationship between FMS and PA, however no research has been conducted to examine the relationship between FMS and SB. This study found that a low percentage of Irish primary school children are achieving mastery across the 13 FMS examined with notable gender differences evident across 4 FMS. An inverse association between FMS and weight status was also reported. Twenty-five percent of children did not meet the MVPA Irish recommendations and SB levels were high with children spending 5.6 hours per day engaged in sedentary activities. Higher levels of PA were shown to have a positive association with FMS whereas high levels of SB was shown to have a negative association with FMS. Following the 12 week intervention programme FMS mastery, FMS proficiency, MPA levels (METS) and MVPA (METS) increased. SB levels decreased but this was not shown to be significant.

5.1. FMS Proficiency

Similar to previous national (Bolger et al., 2017; Farmer et al., 2017) and international studies (Bryant et al., 2014; Hardy et al., 2015; Okely and Booth, 1999; Spessato et al., 2013; Valentini et al., 2007; Van Beurden et al., 2002), this study showed that FMS proficiency levels and mastery levels among Irish primary school children are low.

In the current study, the proportion of Irish primary school children achieving mastery across 13 FMS was very low, ranging from 1% (n = 2) for the hop to 26% (n = 39) for the two-hand catch (Figure 3.1). Bolger et al. (2017) reported higher levels of mastery among senior infant and 4th class Irish primary school children with mastery levels ranging from 12.4% for the horizontal jump to 78.8% for the run. Compared to the current study, Bolger et al. (2017) reported higher mastery levels across 9 skills including the run (7% vs 78.8%), gallop (0% vs 52.8%), hop (1% vs 28.1%), slide (8% vs 43.9%), horizontal jump (3% vs 12.4%), two-hand strike (2% vs 19.7%), kick (14% vs 60.7%), stationary dribble (22% vs 50.5%) and overhand throw (3% vs 31.1%). The only skill to show similar findings was the two-hand catch (22.3% vs 26%). When the current students are compared to those in Bolger et al. (2017), the mastery levels should be higher than the senior infant students and lower than the 4th class students. However this is not the case. Senior infants have higher levels of mastery in 8 skills including the run (80.4% vs 7%), gallop (43.1% vs 0%), hop (19.6% vs 1%), slide (38.2% vs 8%), horizontal jump (10.8% vs 3%), two-hand strike (18.6% vs 2%), kick (39.2% vs 14%) and overhand throw (16.7% vs 3%). The only skills to show higher levels of mastery in the current study compared to senior infants were the stationary dribble (22% vs 0%) and two-hand catch (26% vs 5.9%).

The reason for the differences reported between the two studies is unclear but may be due to potential differences in the definition of 'mastery' used in both studies. The current study defined 'mastery' as the successful execution of all performance criteria in both trials whereas Bolger et al. (2017) did not provide a clear definition of the term 'mastery and may have defined 'mastery' as the successful execution of all performance criteria over one of two trials. In addition, subjective differences can lead to investigators scoring each FMS differently. For example, some aspects of the run (e.g. non-support leg bent at 90 degrees so foot is close to buttocks) are difficult to determine if a performance criteria is present or absent making the scoring of the skill very difficult. However, the TGMD-3 website now offers information on scoring each FMS and a video tutorial with the most common errors and how to score them, which may have led to a stricter scoring system in the present study compared to the TGMD-2 used by Bolger et al. (2017).

In contrast to the low levels of FMS mastery reported in the current study, Irish primary school children (n = 63; 9.9 ± 1.3 years) that took part in Gaelic games (6.4 ± 2.7 hours/week), sport (6.43 ± 2.75 hours/week) and recreational activities (5.80 ± 3.73 hours/week) also displayed far higher mastery in all 13 TGMD-3 skills than the current study (O'Connor et al., 2018). However, participants were recruited from Gaelic Clubs (Hurling and Gaelic Football) and were a highly active population, hence the findings are not comparable due to the different cohorts examined.

In Australia (Hardy et al., 2015; Okely and Booth, 1999; Van Beurden et al., 2002), Brazil (Spessato et al., 2013; Valentini et al., 2007), England (Bryant et al., 2014) and Singapore (Mukherjee et al., 2017) similar trends are evident among primary school children with low FMS proficiency and mastery levels reported. Regardless of the country, age of the cohort examined, and assessment tool used mastery levels worldwide show that children are performing below their developmental potential. The reason for this may be that very little time is devoted to FMS instruction within the PE curriculum (Bolger et al., 2017), but encouraging children to partake in organised sports such as soccer or Gaelic football may provide better opportunities for FMS development (O'Connor et al., 2018). However, it is important to note that not all children enjoy partaking in organised sports and options should be made available to allow each child to develop their FMS. Therefore, developing methods to improve FMS in Irish primary schools is warranted.

5.2. Gender Differences in FMS Proficiency/Mastery

Notable differences in FMS proficiency are evident between males and females with findings reporting males to be more proficient in OC related skills (Bolger et al., 2017; Bardid et al., 2016; Foulkes et al., 2015; Hardy et al., 2010; Hardy et al., 2015; O'Connor et al., 2018; Van Beurden et al., 2003). Some studies have reported no gender differences within LOC (Goodway et al., 2003; Hume et al., 2008; O'Brien et al., 2015; O'Connor et al., 2018; Van Beurden et al., 2003), while others have reported boys (Hardy et al., 2015; Spessato et al., 2013) or girls (Bolger et al., 2017; Foulkes et al., 2015; Hardy et al., 2010, Van Beurden et al., 2002) as more proficient. In the current study, males performed significantly better than females in the OC subtest ($p < 0.001$; $d = 0.6$), with differences found in the two-hand strike ($p < 0.001$; $d = 0.8$), kick ($p < 0.05$; $d = 0.4$) and overhand throw ($p < 0.001$; $d = 0.6$) and similarly males demonstrated a higher level of mastery in the two-hand strike (4.3% vs 0%), one-hand forehand strike (7.2% vs 0%) and kick (26.1% vs 2.5%). These findings are consistent with previous studies and are likely attributable to and explained by biological, environmental and/or sociocultural factors (Garcia, 1994; Thomas and French, 1985). Males are biologically bigger and stronger than females following puberty, therefore they possess a greater advantage in FMS which require strength (e.g. throwing a ball) (Thomas and French, 1985). Also, males tend to be more influenced by competitiveness and they also partake in more activities that involve object manipulation such as soccer, Gaelic football, hurling and rugby which allows for a greater exposure to, and practice of, these skills (Booth et al., 2006; Woods et al., 2010). Unfortunately, from a female perspective females are less likely to avail of these practice opportunities.

In addition, research has shown that the PE curriculum in Ireland focuses on the games strand of the curriculum (Woods et al., 2010) which is more suited to males specifically due to their competitive nature, which facilitates them to improve their OC skills (Woods et al., 2010). However, females tend to interact in a co-operative and caring manner (Hardy et al., 2010) and so are less likely to engage in these competitive style games (Hardy et al., 2010). Thus, females may not be receiving the same opportunities as males to practice and improve their OC skill proficiency. Targeted interventions which focus on OC skills has been shown to improve OC skills among preschool girls over a 9-week period (Veldman et al., 2017).

In contrast, no significant gender differences were reported for the LOC subtest score ($p > 0.05$; $d = 0.3$). These findings are similar to national (O'Connor et al., 2018) and international (Bardid et al., 2016; Goodway et al., 2003; Van Beurden et al., 2003) studies. The reason for this may be due to the fact that LOC skills are part of everyday movement and both males and females engage in these activities (Thomas and French, 1985). On the contrary, other studies have reported female superiority within the LOC subtest from a national (Bolger et al., 2017) and international (Foulkes et al., 2015; Hardy et al., 2010; Van Beurden et al., 2002) perspective. These differences may be due to the types of activities girls are more likely to participate in such as dance, which have a greater emphasis on LOC skills (Booth et al., 2006).

Therefore, tailoring interventions for males and females to provide quality instruction in teaching the skills (Mitchell et al., 2013) and feedback (Gallahue & Ozmun, 2006) are essential to improve their FMS. In addition, it is essential that intervention programmes for children are fun and enjoyable as the primary aim is to sustain their involvement in PA throughout the lifespan. The implementation of FMS intervention programmes at the primary school level along with guidance and assistance for teachers may be the most effective strategy. It is important that both males and females receive equal encouragement, instruction and opportunities to practice and develop their FMS.

5.3. FMS Proficiency and Weight Status

This study supports existing research suggesting that weight status is inversely associated with FMS proficiency (Cliff et al., 2009; D'Hondt et al., 2009; Graf et al., 2004; Hume et al., 2008; McKenzie et al., 2002; Morano et al., 2011; Southall et al., 2004; Siahkouhian et al., 2011; Williams et al., 2008). In the current study, weak, negative correlations were reported between BMI and the LOC subtest ($r = -0.211$; $p < 0.01$) and total TGMD-3 score ($r = -0.199$; $p < 0.01$), with no associations reported between BMI and the OC subtest. The only research in Irish participants that examined FMS proficiency and weight status was completed in 12-14 year old adolescents (O'Brien et al., 2016) and found medium, negative correlations between BMI and the LOC subtest ($r = -0.367$; $p < 0.01$ and $r = -0.341$; $p < 0.05$) and total TGMD-3 score ($r = -0.449$; $p < 0.01$ and $r = -0.272$; $p < 0.05$) for males and females respectively. The findings in the current study were not as strong as the medium, negative correlations reported by O'Brien et al. (2016) and the difference may be due to the percentage of children classified as overweight. The children classified as overweight in the current study was smaller than those reported as overweight by O'Brien et al. (2016) (11.3% vs 26%).

High BMI may be related to a poor score on the LOC skills due to increased discomfort associated in moving the limbs (Bryant et al., 2014). Overweight participants carry a heavier body mass and as a result the execution of complex body movements such as the run becomes difficult (Bryant et al., 2014). Secondly, LOC skills are difficult to master particularly for overweight individuals due to the increased adipose tissue surrounding the leg joint limiting the range of motion present (Bryant et al., 2014). The criteria 'non-hopping leg swings forward in pendular fashion to produce force' for the hop is an example of one component that may be largely affected by a higher BMI and increased adipose tissue surrounding the joints. Thirdly, overweight and obese children can demonstrate abnormal gait patterns, which contributes to an increase in energy cost leading to an earlier onset of fatigue (Foweather et al., 2010).

No association was reported between BMI and the OC subtest and no significant difference was observed between non-overweight and overweight participants for the OC subtest. These findings are similar to national (O'Brien et al., 2016) and international studies (Okely et al., 2004; Southall et al., 2004; Spessato et al., 2012). The reason for this is that OC skills examined in this study are primarily stationary in nature and the skills are more directed towards controlling an implement or ball whereas LOC skills require a greater movement of body mass against gravity.

Thus, increasing a child's LOC skills may be an important factor in reducing BMI in children. Participation in PA from a young age may reduce the onset of obesity allowing children to develop more proficient FMS, however children in Ireland are becoming less physically active (Woods et al., 2010). Therefore, primary schools are the ideal environment for the implementation of an FMS intervention, where FMS can be taught and practiced to reduce BMI and allow children to become more physically active.

5.4. PA and SB Levels

In the current study, the 5 highest reported sporting activities by the children were playing outside (98%), jogging/running (82%), household chores (77%), bike riding (75%) and tag/chase (75%). Surprisingly, considering a cohort of Irish primary school children was examined GAA participation as reported by the parents and children was low (15% and 16%, respectively) compared to national research (Woods et al., 2010), with Woods et al. (2010) reporting that 34% of children participated in GAA. The differences noted between the current study and Woods et al. (2010) may be due to the fact that GAA was listed as a PA option in the CSPPA questionnaire. In the CLASS questionnaire GAA is not listed as a PA option as the questionnaire is based on Australian PA and it is unknown if the children in the current study would have recalled GAA as an option in the 'other' section of the CLASS questionnaire unless they were prompted to do so. Therefore, if the CLASS questionnaire is being used in an Irish primary school setting in the future it is imperative that GAA is included as an option for PA.

In Ireland, the Department of Health and Children have recommended that children receive at least 60 minutes of MVPA daily (Department of Health and Children, 2009). In the current study, parents reported that 75% of children are meeting the MVPA recommendations with 25% not meeting the MVPA recommendations. The MVPA recommendations were similar for males and females (77% and 75%, respectively). These findings are far higher than those reported in previous national research (Currie et al., 2012; Layte and M^c^Crory, 2011; Woods et al., 2010). The HBSC report found that in Ireland, 31% and 43% of females and males aged 11 years old reported accumulating at least 60 minutes of MVPA daily (Currie et al., 2012). In addition, by the age of 13 a substantially lower 20% of females and 36% of males reported to be meeting the MVPA recommendations (Currie et al., 2012). Similarly, Woods et al. (2010) reported that only 19% of Irish primary school children met the minimum MVPA daily recommendations, with girls less likely than boys to meet these recommendations (10% vs 18%; $p < 0.0001$). The differences in PA recommendations between the current study and other national research may be due to the use of different methods used, making it difficult to directly compare findings from one study to another. In addition, the typical potential bias for parents over reporting children's PA levels may have been an issue (Chinapaw et al., 2010).With self-report methods there is a significant potential for recall error and research has shown that the combination of an objective and subjective method of assessment may be more accurate. The age of the cohorts examined may reflect the differences reported as it has been shown that PA decreases with increasing age (Currie et al., 2012; Woods et al., 2010). However, the self-report method conducted by Woods et al. (2010) is a better indicator of a child's PA levels as it covers all aspects of PA and SB and it is applicable to an Irish population, whereas the CLASS needs to be adapted to be specific to an Irish population particularly with the addition of GAA as an option in the PA section.

Despite national PA levels reported as being low, the current PA recommendations of ≥ 60 minutes of MVPA daily is not beyond the reach of primary school children in Ireland, with 98% achieving this amount of PA once a week, 80% achieving it three days per week, and 39% engaging in MVPA for 60 minutes on five days of the week (Woods et al., 2010). Therefore, establishing active lifestyles from a young age is an important goal in order to reduce the complications in relation to health in later life. In addition, ensuring that children develop PA habits and enjoy positive early experiences of PA is essential. This can be achieved through PE, extracurricular sport, extra-school clubs and general PA. However, it is important that both males and females are given an equal opportunity to increase their PA levels as it has been shown that males tend to have higher PA levels.

As reported by the parent, males spent significantly more time engaged in VPA compared to females (779.7 ± 578.3 vs 634.8 ± 358.3), which accumulates to 111 mins./day. A reason as to why boys participate in a higher level of VPA compared to girls may be because boys are more likely to find PA and sports games more enjoyable compared to girls and boys perceive themselves to be more physically competent (Lampinen et al., 2016; Seabra et al., 2013). In addition, boys receive more social and family support for practicing PA (Greca et al., 2016). In particular, a father's PA level has been shown to have an influence on a boys PA level, with boys 3.5 times more likely to participate in PA if their father is physically active (Ferreira et al., 2006; Gustafson and Rhodes, 2006). Therefore, girls need to be encouraged to increase their level of VPA, with equal opportunities provided for both males and females. It is also essential that sessions are conducted in a female friendly manner to keep females involved in sport and to increase their PA levels.

A sedentary lifestyle is becoming much more evident in society, primarily due to the advancements in technology, which contributes to an overall decline in PA levels and an increase in the volume of leisure time resulting in children partaking in sedentary activities (Pate et al., 2011). ST guidelines have been established and it is recommended that the use of electronic media (e.g. TV, electronic games and computer use) is limited to < 2 hours/day (Australian Government Department of

Health, 2014; Canadian Society for Exercise Physiology, 2011; Davies et al., 2011; US Department of Health and Human Services, 2011). No guidelines have been developed for Irish children, however in the 2016 Report Card on Physical Activity for Children and Youth it was proposed that new ST guidelines for Ireland should be developed (Harrington et al., 2016). In the current study, as reported by the children, 25% of boys and 11% of girls exceed the ST recommendations during the week, whilst at the weekend this increased to 32% of boys and 28% of girls. Parents reported similar findings during the week with 18% of boys and 6% of girls of children exceeding the recommendations, with this increasing to 40% of boys and 37% of girls at the weekend. Despite males reporting higher levels of ST during the week and at the weekend by both the child and parent, no statistically significant difference was reported between the genders. These findings are lower compared to research conducted by Woods et al. (2010), which reported that 99% of primary school children are exceeding the ST recommendations. The differences reported between the current study and Woods et al. (2010) may be due to the fact that ST has been shown to increase with age. Children partake in more sedentary activities to the detriment of PA (Woods et al., 2010), with males and females favoured towards certain sedentary activities. In addition the age of the cohort examined may also have been a reason for the differences reported. Woods et al. (2010) examined 5th and 6th class primary school children (11.4 ± 0.7 years) whereas the current study examined 1st and 2nd class primary school children (7.7 ± 0.6 years). In addition, levels of recall bias are a significant constraint among self-reported PA measures in children (Baranowski et al., 1994; Chinapaw et al., 2010).

In the current study, the highest reported sedentary activities during the weekdays reported by the children were doing homework (100%), watching TV/videos (89%), playing indoors with toys (79%) and sitting and talking (78%) whilst parents reported their children spending time doing homework (94%), playing indoors with toys (89%), reading a book/magazine (88%) and watching TV/videos (86%). For the sedentary activities reported, both the child and parent reported gender differences with boys spending significantly more time engaged in video games (215.8 ± 305.9 vs 62.7 ± 121.9; $p < 0.05$, as reported by the child and 150.4 ± 221.8

vs 33.4 ± 75.6; $p < 0.001$, as reported by the parent), which corresponds to 3 hrs. 35 mins./week, whereas drawing, reading, listening to music and doing arts and crafts was higher among girls, although this was not statistically significant. No gender differences existed for watching TV/videos. National research also found that boys were spending more time playing video games, such as the PlayStation, Xbox and Nintendo compared to girls (30% vs 12%, respectively) (Layte and McCrory, 2011). A higher percentage of boys (46%) were also reported to have a TV in their bedroom compared to girls (43%) (Layte and McCrory, 2011). From an international perspective, Lampinen et al. (2016) and Li et al. (2007) also reported similar findings. These findings suggest that there is a need particularly amongst boys to reduce the amount of time watching TV and playing video games. It is important that children are encouraged to enhance their level of PA to reduce these sedentary behaviours. For children, sedentary activities can have negative consequences in relation to their health such as an increase in body composition (Chen et al., 2007; Davison et al., 2006; Epstein et al., 2008), cardiometabolic diseases (Hancox et al., 2004; Lazarou et al., 2009; Martinez-Gomes et al., 2009) and a decrease in PA levels (Lobelo et al., 2009). However, lower sedentary activities reported by the parent have been associated with a decrease in sedentary activities in children (Lampinen et al., 2016). Thus, it is imperative that children are encouraged to be active and given appropriate support to allow them achieve their potential and reduce SB.

In the current study children reported higher levels of PA in comparison to parents. The findings in the current study must be examined with caution as a self-report method was used for both the child and parent. Children reported higher levels of LPA (METS) (11.6 ± 13.7 vs 7.4 ± 10.3; $p < 0.001$), MPA (METS) (170.0 ± 116.0 vs 84.7 ± 65.0; $p < 0.001$), VPA (METS) (112.0 ± 83.5 vs 48.1 ± 47.3; $p < 0.001$) and MVPA (METS) (281.9 ± 183.2 vs 132.9 ± 104.2; $p < 0.001$). The differences reported between the parent and child may be due to children's PA being spontaneous and sporadic, and children rarely engage in structured or organised PA (Telford et al., 2004). PA for children is accumulated through a combination of free play, sport, and transport in different settings throughout the day (Biddle and

Goudas, 1996; Telford et al., 2004). As a consequence, there is a significant potential for recall error when children self-report their own PA levels. An objective method such as the use of an accelerometer would have been a more appropriate technique to examine these sporadic patterns of PA for the child (Trost et al., 2007).

The findings in the current study suggest that reducing SB as well as promoting PA is key in addressing the inactivity problem amongst Irish youth. Thus, targeted interventions which focus on both of these variables would allow for a reduction in SB levels while impacting on PA levels for future participation throughout the lifespan. However, as a self-report method was used to capture PA and SB levels, the findings must be interpreted with caution due to the impact recall bias may have had on these findings. Future research should use an objective measure of PA and SB such as an accelerometer as it may provide a more accurate representation.

5.5. Relationship between PA, SB and FMS

Mastery of FMS has been proposed as contributing to children's physical, cognitive and social development and is thought to provide the foundation for a physically active lifestyle in later life (Lubans et al., 2010). It has been reported that children with lower levels of FMS tend to be less physically active which contributes to the onset of obesity and the co-morbidities associated with it (Barnett et al., 2016). If a child has a higher level of FMS this leads to a delay in the decline of PA levels throughout childhood, therefore, FMS is associated with higher levels of PA and fitness in adolescence (Barnett et al., 2016). As a result, children with poor motor proficiency may subsequently choose a more sedentary lifestyle in avoidance of difficulty in mastering high FMS levels (Wrotniak et al., 2006).

As reported by children, a weak positive association was reported between VPA (METS) and the OC subtest ($r = 0.271$; $p = 0.007$) and the LOC subtest ($r = 0.260$; $p = 0.009$), with a moderate positive association reported for total TGMD-3 score ($r = 0.333$; $p = 0.001$). Parents also reported a weak, positive association between VPA (METS) and the OC subtest ($r = 0.224$; $p = 0.026$). Similar to previous findings OC skills have been associated with PA levels (Barnett et al., 2008; Crane et al., 2015; Williams et al., 2008). In direct contrast to the current study, Williams et al. (2008) reported that correlations between the OC subtest and VPA (r = 0.24) were slightly higher than those for the LOC subtest and VPA (r = 0.21). Similar to Williams et al. (2008), the current study noted a relationship between VPA, the OC subtest and the LOC subtest was reported. A plausible explanation for the relationship reported between OC skills and VPA (METS) in the current study may be that these type of skills are often associated with PA experiences of a moderate and/or vigorous intensity. Therefore, children who are proficient at performing OC skills may participate in these activities more as they are likely to increase PA levels. Secondly, OC skills provide multiple avenues for engaging in various physical activities and sports linked to the development of increasing PA levels (Stodden et al., 2014). These suggest that the performance of OC skills may be an important element in promoting an active lifestyle in young children. Thirdly, OC skills demand high levels of physical effort, neuromuscular co-ordination and neuromuscular control, which enhances the development of PA levels (Catuzzo et al., 2016). Specifically, OC skills demand high concentric and eccentric muscle activity and the loading of body weight on the joints and muscles to enhance power output contributing to muscular strength. In addition, activities which involve LOC skills and OC skills (e.g. GAA, basketball, soccer) are often associated with repetitive movements which allows for the enhancement of PA levels and as a result children become more competent and physically active (Catuzzo et al., 2016). The association reported between VPA (METS) and the LOC subtest may be due to the fact that LOC skills are an essential part of everyday movement and as a child progresses from pre-school to primary school these skills are already developed in most cases (Gallahue and Ozmun, 2002). Once these skills become autonomous a child will begin to practice these skills at a higher level of PA intensity (e.g. VPA). While VPA showed a positive association with FMS, LPA (METS) as reported by the children showed a weak, negative association with the OC subtest ($r = -0.253$; $p < 0.05$). Therefore, the better the OC skill level of the child the lower the level of LPA. No research has examined the relationship between LPA and FMS, however the reason a negative association may have been reported could be due to the fact that OC skills require a high level of co-ordination and movement and once a child becomes proficient in OC skills then the level of LPA is reduced as a higher level is needed.

A weak, negative association between SB (mins.) and the OC subtest ($r = -0.207$; $p < 0.05$) and total TGMD-3 score ($r = -0.231$; $p < 0.05$) as reported by the child was found. This shows with a lower level of SB children may be engaging in a higher level of PA which may allow for children to reach their developmental potential over time. The reason for the lower level of SB may be that a higher level of PA is required for children to partake in OC related skills and as a result children may be engaging in a higher level of PA, which may lead to a reduction in SB levels.

It is possible that the differing findings in relation to the relationship between FMS, PA and SB may be due to individual, social and environmental factors (Hinkley et al., 2008; Hinkley et al., 2012). For example, parents can play a key role with regards a child's PA levels and also the time children are given to partake in PA. If a child is given more exposure to PA and is encouraged to participate, then it can have an effect on FMS and SB levels, hence contributing to the differing findings reported. In particular, perceptions of competence may play an important role (Barnett et al., 2008; Barnett et al., 2014), as children who perceive themselves to be more competent at certain FMS will engage in a higher level of PA, whereas children who perceive themselves to be less competent will engage in a lower level of PA (Stodden et al., 2008). As a result, children at a young age demonstrate variable levels of PA and FMS competence that are weakly related (Stodden et al., 2008). Therefore, it is essential that children are given the opportunity to practice FMS early in life particularly before leaving primary school. If these skills are not taught at a young age it can have a negative effect later in life.

5.6. Effects of an Eight-Week FMS Intervention

Following the 8-week FMS intervention programme, FMS proficiency levels showed a greater improvement in the intervention group compared to the control group. The intervention group improved significantly in the LOC subtest score (30.0 ± 4.7 vs 26.4 ± 4.0; $p < 0.001$) and total TGMD-3 score (65.3 ± 9.0 vs 57.6 ± 9.2; $p < 0.001$) compared to the control group. The greater improvement in the LOC skills subtest following the intervention may have been as a result of the warm-up for each session as it included LOC skills and then in some session's specific focus would have been given to these skills allowing for more time to practice them. Due to the amount of time given to the LOC skills children may have developed autonomy of these skills much quicker than the OC skills. In addition, across the 13 skills examined 5 skills showed an increase following the intervention with the intervention group showing the greatest improvement compared to the control group. These skills included the run (5.7 ± 1.7 vs 5.2 ± 1.4; $p < 0.001$); gallop (3.9 ± 1.0 vs 3.7 ± 1.0; $p < 0.05$); skip (4.0 ± 1.7 vs 3.5 ± 1.3; $p < 0.05$); horizontal jump (5.9 ± 1.4 vs 4.0 ± 1.9) and kick (5.9 ± 2.0 vs 4.9 ± 1.7; $p < 0.001$), with 4 of the 5 skills being LOC skills. The improvement in these skills may have been due to the amount of time given to the LOC skills throughout the intervention. For the OC skills the only skill to show a significant difference between the groups was the kick (9.3% vs -10.9%; $p < 0.001$) with the intervention group showing the greatest improvement. The reason for the improvement in the kick could be due to the fact that this FMS is associated with Gaelic Games which is a national sport most children in Ireland would partake in. In the current study 16% of children partake in Gaelic Games (Table 4.10). While there was an improvement in FMS proficiency, FMS mastery levels also improved following the intervention.

Across the 13 skills examined 9 skills showed an increase in mastery following the intervention. These skills included the run (6.3% vs 18.8%); skip (3.8% vs 20%); horizontal jump (0% vs 15%); one-hand forehand strike (2.5% vs 6.3%); kick (26.3% vs 35%); stationary dribble (26.3% vs 38.8%); two-hand catch (25% vs 30%); overhand throw (0% vs 7.5%) and underhand throw (12.5% vs 26.3%). These findings are similar to Bryant et al. (2016) who reported an increase in the number of children who were classed as having mastery for all 8 FMS that were assessed after a 6 week intervention programme. At pre-test, Bryant et al. (2016) reported similar levels of mastery (0-25.3%) to the current study (0-26.3%). However, at post-test higher levels of mastery (3.6-81.2%) were reported by Bryant et al. (2016) compared to the current study (0-38.8%). In contrast, to the current study Bryant et al. (2016) examined only 8 FMS and mastery was calculated by using the three trials whereas the current study examined 13 FMS over two trials making it more difficult to attain a higher mastery level, which may account for the differences in mastery levels reported. The findings by Bryant et al. (2016) are similar to the findings by Mitchell et al. (2013) who reported that all 12 FMS skills assessed using the TGMD were higher at pre-test (21.4-84.6%) and post-test (49.8-93.3%) following a 6 week intervention programme. Although Mitchell et al. (2013) used a similar assessment tool to the current study the age of the children tested was of a broader age range (5-12 years) compared to the current study, hence the chances of achieving mastery are higher.

In addition, only 9 of the 13 skills examined in the current study showed an increase in mastery following the intervention. This may be due to the new/correct technique for each FMS the children learnt has not yet become autonomous. For the two-hand strike, the grip required to hold the bat can be difficult for some children especially if they play hurling using a different grip. It can be difficult to teach a child to change their grip to meet the specific criteria of the TGMD-3. In addition, the gallop is a skill which is not commonly taught in Ireland and children therefore would not be familiar with the skill making it rather difficult to teach the correct technique. In particular children had difficulty understanding ‘a step forward with the lead foot followed with the trailing foot landing beside or a little behind the lead foot’, as most children were landing with the trail foot in front of the lead foot. Also the ‘arms flexed and swinging forward’ in both the gallop and hop proved difficult, as the timing and co-ordination of the upper and lower limbs was non-existent for most children. More time may have been needed to allow these skills to become autonomous and the addition of these skills to the PE curriculum in Ireland would hopefully allow for improvements to be seen over a prolonged period of time.

PA levels increased and SB levels decreased over the course of the intervention. However, as reported by the parent, only MPA (METS) and MVPA (METS) increased significantly following the intervention with the intervention group showing the greatest improvement (206.1 ± 227.2 vs 98.9 ± 44.0; 269.1 ± 247.9 vs 143.8 ± 67.9, respectively). This resulted in a 149.2% increase in MPA (METS) and a 99.5% increase in MVPA (METS) for the intervention group. This finding is similar to national research conducted by O'Brien et al. (2013), who reported that PA levels increased following a 1-year intervention programme. However the increase reported in MVPA was far higher than previous research (Bryant et al., 2016; Van Beurden et al., 2003). The reason for the differences reported may be due to the different methods used to assess PA. Bryant et al. (2016) used a pedometer whereas the current study used a self-report method. Self-report methods are subject to recall bias and therefore may explain the higher increase in MVPA reported by Bryant et al. (2016). The increase in MPA (METS) and MVPA (METS) may have occurred as a result of the intervention as the activities the children undertook would have been from a light to a moderate intensity. It is plausible to suggest that developing a child's FMS is a very important building block towards engagement in PA. If a child is competent in certain FMS then they are more likely to engage in PA of a higher intensity, hence the children in the intervention group showed an increase in FMS proficiency and PA levels following the intervention.

SB levels as reported by the parent and child decreased following the intervention, however the decrease was not significantly different between the groups (-13.9% vs -15.9% and -20.5% vs -13.1%). The difference may not have been significant as the intervention was not designed to target SB specifically. Interventions which focus on reducing SB may need to incorporate PA and education on SB into the school curriculum to make children and parents aware of the risks associated with excessive SB. Encouragement and support from parents and teachers is critical to sustain a child's involvement in PA and reduce SB.

5.7. Strengths and Limitations

There are a number of limitations to the current study. One-hundred and fifty participants agreed to participate in the study, however when the CLASS questionnaires were distributed to the parents of the children 50 questionnaires were not returned despite the school teachers sending notes home to parents requesting their return. Due to only 100 questionnaires being returned the children's questionnaires had to be reduced from 150 to 100 for direct comparison with the parent questionnaire. The CLASS questionnaire was developed in Australia and so included physical activities specific to Australia and required them to input activities not listed. This was not adapted for use in an Irish population and future research should adapt the questionnaire to make it specific to the population being examined. Secondly, the questionnaire examined SB by asking the children to recall the amount of hours/minutes they spent per week and at the weekend partaking in these sedentary activities. Parents completed a proxy-report questionnaire to overcome this issue. However, the proxy-report questionnaire also proved an issue as it was difficult for parents to know exactly what their child was doing at a given time throughout the day. In addition, due to the subjective nature of the questionnaire recall bias may have been an issue. Children have an inability to recall activities that they partake in due to the sporadic nature at which they occur. In order to reduce the errors associated with recall bias a proxy-report questionnaire was completed by parents. Also, the warm-up incorporated some of the LOC skills which may have allowed for the skills to become autonomous as the children were using them frequently. Therefore, a dynamic warm-up should be incorporated without focusing specifically on the LOC skills involved in the intervention to truly examine the impact solely of the intervention on their ability to perform the skills. Finally, the level of PA in the intervention was not measured and therefore it is unknown if an intervention of a higher or lower PA intensity would show an increase in FMS proficiency. Significant strengths of this study should also be noted. This is the first study to examine the relationship between FMS, PA and SB in an Irish primary school population, multiple schools agreed to participate in the study and the implementation of the intervention was successful in a school-based setting.

5.8. Conclusion

In conclusion, FMS proficiency and mastery among Irish primary school children is low and is similar to findings both from a national and international perspective. Gender differences particularly in the OC subtest with males being more proficient than females, suggests the need for an effective intervention programme which targets the specific needs of the child. However, this may be difficult due to time constraints within the primary school curriculum. However, no SB guidelines have been developed for Irish children and this is an area that requires development. These findings are important for parents, teachers and principals in order to encourage children to partake in PA and reduce the level of SB. A relationship between FMS and PA and SB levels was reported. Higher levels of PA were shown to have a positive, weak association with FMS suggesting the more competent a child is at FMS the more engaged they become in PA. SB levels were shown to have a negative, weak association with FMS, however it is unknown if a better FMS results in a lower level of SB or if a reduction in SB causes an increase in FMS. These findings show how critical it is that adequate time is spent developing FMS, especially during primary school years, when a "window of opportunity" arises which enhances the child's learning. In addition, the implementation of an FMS intervention has been shown to be an effective means for improving FMS mastery and FMS proficiency levels. In addition, MPA (METS) and MVPA (METS) improved following the intervention. SB also decreased but this was not significant. Therefore, in order to increase FMS and PA levels and reduce SB levels and sustain a child's development of these over time improvements in the PE curriculum in Ireland is warranted to give teachers the training and support required to increase FMS mastery to allow children to lead a more physically active lifestyle in later life.

5.9. Recommendations and Future Research

Following the completion of this research a number of recommendations for future research are proposed:

- Future research should use an objective measurement due to a child's inability to recall activities precisely. An objective measurement would provide a more robust surveillance of a child's PA and SB levels.
- A questionnaire suitable to Irish primary school children should be adapted to assess PA and SB levels. As the questionnaire used in the current study was from Australia it did not include physical activities that were suitable in an Irish context. If the CLASS questionnaire is to be used for future

research in an Irish primary school setting it is imperative that GAA is used as an option in the PA section of the questionnaire. In addition, future research should design a questionnaire suitable for Irish primary school children and it should be validated against an objective measure of PA (e.g. accelerometer) so as primary schools can track PA levels over time.

- In the current study, some FMS have been associated with different PA levels but it is unknown if FMS increased PA or vice versa; however, further research is recommended to establish causation between these two variables.
- Multi-component interventions need to be implemented as these have been shown to be effective. For a multi-component approach it is important that emphasis is placed upon the delivery of the programme with particular attention focused towards the encouragement of school principals, teachers, parents and students to maximise adherence. Specific workshops and training days are also essential with frequent feedback from the teachers allowing for the successful implementation and re-evaluation of these interventions. This would allow for more targeted PE programmes to be implemented in a primary school based setting.
- Future research should implement an FMS assessment tool for primary school children so as teachers can assess their FMS on a regular basis.
- Future research should examine if past or current FMS proficiency levels predict future PA and SB levels. More longitudinal research studies which include a baseline, FMS skill intervention, and retention period measuring PA at each time point could demonstrate if FMS competence directly influences future participation in PA.

Chapter 6: Bibliography

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Chapter 7: Appendices

Appendix I: Sample Email for Recruitment of Schools

Connect & Discover

Dear Principal,

We would like to invite your school to take part in a research project run by the Department of Sport and Health Science at Athlone Institute of Technology. For the purpose of the study fundamental movement skills (FMS), physical activity (PA) levels, and sedentary behaviour will be assessed. FMS proficiency testing will be conducted on children from senior infants to 5th class. The skills that will be tested include: run, gallop, hop, skip, slide, horizontal jump, vertical jump, two-hand strike, one-hand forehand strike, one-hand stationary dribble, two-hand catch, kick, overhand throw, underhand throw and static balance. In relation to PA levels a questionnaire will be used. After baseline testing, the schools will be divided into two groups; an FMS intervention group and a control group. The FMS intervention group will take part in an 8 week intervention programme which will be implemented in place of regular PE class. The control group will carry on with PE class as normal for the 8 week period. The intervention will run for 2 x 1 hour sessions each week for 8 weeks and will be instructed by myself as the principal investigator. Each class will target one or two specific skills and will include a warm up, skill instruction and practice drills, a non-competitive game and a cool down activity. A pre-test will take place prior to the intervention followed by a post-test after the 8 weeks. We would welcome the opportunity to discuss the project with you further and the benefits of taking part in the project for your school. I will contact the school in the coming week to further explain this research, answer any questions you may have and discuss if this would be feasible to implement in your school. Please feel free to contact any of the following should you have any questions before then.

We can be contacted at the following address:

Ms. Kelley Cunningham: (master's research student) **email:** k.cunningham@research.ait.ie
Ms. Lisa Kelly **email:** l.kelly@research.ait.ie
Dr. Niamh Ní Chéilleachair: (supervisor) **email:** nnicheilleachair@ait.ie
Dr. Siobhán O'Connor: (supervisor) **email:** siobhan.oconnor@dcu.ie

We look forward to hearing from you with the possibility of working with you in the near future.

Yours Sincerely,

Kelley Cunningham
Department of Sport and Health Science,
Athlone Institute of Technology,
Athlone

Phone: 087-3182211

Appendix II: Plain Language Statement

Connect & Discover

Supervisors: Dr. Niamh Ní Chéilleachair **Principal Investigator:** Ms. Kelley Cunningham
Dr. Siobhán O'Connor

Purpose:

This research project is an investigation into physical activity (PA) levels, sedentary behaviour and fundamental movement skills (FMS) among Irish primary school children from senior infants up to 5th class. FMS are the building blocks for movement and can be categorised as locomotor (e.g. run, hop, jump, leap), object-control (e.g. throw, catch, kick, strike) and stability (e.g. static balance) skills. For the purpose of this study the FMS that will be tested include: run, gallop, hop, skip, slide, horizontal jump, vertical jump, two-hand strike, one-hand forehand strike, one-hand stationary dribble, two-hand catch, kick, overhand throw, underhand throw and static balance. These skills can be mastered by the age of six, however many children are progressing through primary school with very poor mastery in many of the skills. It has been reported that only 11% of Irish first year students (aged 13 years old) achieved mastery in a battery test of nine FMS.

In addition, physical activity levels in Ireland are extremely low with only 19% of primary school children meeting the minimum requirements for physical activity – at least 60 minutes of moderate to vigorous physical activity (MVPA) daily. These physical inactivity levels during childhood can contribute to an overall sedentary lifestyle which can later lead to a myriad of health problems. For the purpose of this study PA levels will be assessed using a Questionnaire.

After baseline testing, the schools will be divided into two groups; an FMS intervention group and a control group. The FMS intervention group will take part in an 8 week intervention programme which will be implemented in place of regular PE class. The control group will carry on with PE class as normal for the 8 week period. The FMS intervention will run for 2 x 1 hour sessions each week for 8 weeks and will be instructed by myself Kelley Cunningham and Lisa Kelly. Each class will target one or two specific skills and will include a warm up, skill instruction and practice drills, a non-competitive game and a cool down activity. Once the intervention is completed post-testing will take place which will assess FMS, PA levels and sedentary behaviour to see if there have been any improvements.

Therefore, providing children with the opportunity to master the basic FMS will increase the potential to benefit from the associated health benefits of FMS mastery including increasing adherence to regular physical activity, increasing cardiorespiratory fitness, decreasing sedentary behavior and the subsequent social, cognitive and psychological health benefits associated with regular physical activity.

What is Required of Your Child?

This phase of the project will consist of three stages (pre-test, intervention and post-test).

What is Required of You?
As the parent you will be asked to complete a physical activity questionnaire based on your child's physical activity levels. This questionnaire will take no longer than 10-15 minutes to complete and once it is completed it must be returned to the school. The questionnaire will be completed twice, once at the start of the study and once upon the completion of the study.

Pre-Test and Post-Test:
Each participant will have their physical activity levels, sedentary behavior levels and FMS proficiency assessed before and after the intervention. The physical activity levels will be assessed using a questionnaire. FMS will test the following skills (Table 1.1).

Table 1.1 Fundamental Movement Skills that will be assessed:

Locomotor Skills	Run	Gallop	Hop	Skip	Slide	Horizontal Jump	
Object-Control Skills	Two-Hand Strike	One-Hand Forehand Strike	Stationary Dribble	Two-Hand Catch	Kick	Overhand Throw	Underhand Throw

Your child will be given a personal ID number and all information will be recorded under this ID number. Your child's height and weight will be measured on an individual basis behind a screen. Measurements will be recorded on the participant information sheet and will not be verbally announced to ensure all information is kept confidential. Your child will take part in a warm up activity before performing the skills. A demonstration and explanation of each skill will be given before asking the child to perform a practice trial. Once we are sure the child understands the task, he/she will then perform two trials of each skill which will be video recorded in order to ensure results can be measured as accurately as possible. Your child's face will be pixelated to remove identity upon first viewing by the principal investigator. Only those involved in the research will have access to the tapes. We would ask that your child wears normal PE clothes such as knee length shorts or tracksuit bottoms, a t-shirt and suitable rubber soled running shoes.

Location and Supervision:
All skills will be tested in the school hall. The principal investigator will be assisted by the class teacher and up to six students from 3rd and 4th year BSc. (Hons) Sports Science with Exercise Physiology and BSc. (Hons) Athletic and Rehabilitation Therapy undergraduate degree courses in Athlone Institute of Technology completing their final year research project. Each student has completed Garda vetting and has experience working with the public from previous placements. They will help to organise the testing stations, record participants weight and height, supervise the warm up and record results. The principal investigator has completed a 'Safeguarding 1: Child Welfare and Protection' workshop, and will ensure fair treatment of all participants is maintained throughout the study.

Intervention:

After the pre-test an intervention programme will be implemented in place of regular PE class. It will be run for 2 x 1 hour sessions each week for a period of 8 weeks. The interventions will be guided by the principal investigator but the class teacher will also be in attendance. The intervention will consist of a dynamic warm up, a skill introduction and practice session, a non-competitive game and a cool down/conclusion. The primary focus will be on developing and improving current FMS proficiency, physical activity levels and decreasing sedentary behavior and the interventions will be tailored to suit the needs of individual participants. The requirements of your child are the same for any other PE class. Participants are asked to wear suitable PE clothes and rubber soled footwear. The location will be as normal PE class such as the school hall, playground or playing field.

Potential Risks:

All the procedures used are safe, will be conducted by trained personnel and do not require anything extra in the daily routine. The risks involved are no more than what may occur in a normal PE class.

Benefits:

Your child will take part in a targeted intervention programme that will aim to improve both confidence and competence in performing basic fundamental movement skills. While many of the skills sound relatively simple, many children and even adults have never been correctly taught how to perform the skills. Your child will receive professional instruction on how to correctly perform the skills that are proving most difficult. Such skills can be utilized for future participation in physical activity both recreationally and competitively.

Confidentiality:

The results and information received from this study are regarded as confidential and will be used by the investigating team only. All video-recordings will be stored on an encrypted password protected memory stick. The memory stick will be stored in a locked filing cabinet and will not leave AIT. This will only be accessible to the principal investigator doing this study. Your child's data will be kept anonymous through a personal ID number and through pixelating faces on all videotapes which will only be viewed by the research team. Data will be destroyed 5 years after the publication of this study.

Freedom of Withdrawal:

Participation in the study is entirely voluntary and you/your child have the right to withdraw from the study at any time.

We hope you will be interested in allowing your child to participate in this project and should you have any queries please do not hesitate to get in touch.

Contact Details:

Ms. Kelley Cunningham: (master's research student) **email:** k.cunningham@research.ait.ie

Phone Number: 087-3182211

Ms. Lisa Kelly: (master's research student) **email:** l.kelly@research.ait.ie
Dr. Niamh Ní Chéilleachair: (supervisor) **email:** nnicheilleachair@ait.ie
Dr. Siobhán O'Connor: (supervisor) **email:** siobhan.oconnor@dcu.ie

Appendix III: Informed Consent Form

Connect & Discover

Informed Consent Form

To investigate physical activity levels, sedentary behavior and fundamental movement skill proficiency levels amongst primary schoolchildren.

- I have read and understand all the information in the **plain language statement.**
- I understand what the project is about and what the results will be used for.
- I am fully aware of all testing procedures and they have been verbally explained to me in detail.
- I am aware of the potential **risks and benefits** associated with this study.
- I understand that any information about my child will be kept confidential and will be coded with a subject ID.
- I understand that the results of this research study may be published but that my child's identity will not be revealed.
- I understand that the results of the study will only be used for research related to this project.
- I know that participation in this study is voluntary and that my child can withdraw/I can withdraw my child from the study at any time without giving a reason.
- I understand that if I/my child have any questions regarding any aspect of this research study I/my child can contact any of the investigators involved in this study.

Child's Name: ____________________

Parent/Guardian Signature: ________________________ Date: ________________

Appendix IV: Sample Data Sheet

School: **Date:**

ID Number		**ID Number**	
Age		**Age**	
D.O.B.		**D.O.B.**	
Height		**Height**	
Weight		**Weight**	
BMI		**BMI**	

ID Number		**ID Number**	
Age		**Age**	
D.O.B.		**D.O.B.**	
Height		**Height**	
Weight		**Weight**	
BMI		**BMI**	

ID Number		**ID Number**	
Age		**Age**	
D.O.B.		**D.O.B.**	
Height		**Height**	
Weight		**Weight**	
BMI		**BMI**	

ID Number		**ID Number**	
Age		**Age**	
D.O.B.		**D.O.B.**	
Height		**Height**	
Weight		**Weight**	
BMI		**BMI**	

ID Number		**ID Number**	
Age		**Age**	
D.O.B.		**D.O.B.**	
Height		**Height**	
Weight		**Weight**	
BMI		**BMI**	

Appendix V: Warm-Up

Dynamic Warm-Up		
Exercise	**Instructions**	**Progression**
Low Jacks	While moving feet apart and together, lift arms from the hips to shoulder level. **Do for 20 seconds**	**High Jacks:** High jacks are completed by lifting the arms from shoulder level above the head. **Do for 20 seconds**
High-Knee March	While marching in place, lift the right knee towards the left elbow and then return to the starting position and repeat on the opposite side. **Perform on the spot for 20 seconds**	**High-Knee Walking March:** While walking from one cone to a cone 20 metres apart perform the high-knee walking march. **Walk out as far as the 20 metre cone and back (x 2)**
Standing Flutter	Stand with both arms extended above the head with the feet shoulder width apart. Extend the left arm and right leg backwards a few inches while remaining in an upright position. Return to the start and perform with the opposite limbs. **Do for 20 seconds (x 2)**	**Continuous and Repetitive Flutter:** This is performed with a full extension of all the limbs. **Do for 20 seconds (x 2)**
Standing Toe Touches	Stand with both arms extended in front of the body. Lift one leg extended towards the extended arm and then return to the starting position. Alternate the movement with the other leg and repeat. **Perform on the spot for 20 seconds**	**Walking To Touches:** While walking from one cone to a cone 20 metres apart perform the walking toe touches. **Walk out as far as the 20 metre cone and back (x 2)**

Marching Lateral Shuffle	From a standing side-stance with feet hip width apart, hop and land with feet and body lowered to a semi-squat position. While maintaining this position, move laterally by taking a lead step followed by a short secondary step. **Go out as far as the 20 metre cone and back (x 2)**	**Quick Lateral Shuffle:** Do the same movement as the marching lateral shuffle only increase the speed at which it is done. **Go out as far as the 20 metre cone and back (x 2)**
High-Knee Skips	Rapidly skip forward while focusing on knee lift, arm action, and reduced ground time. **Go out as far as the 20 metre cone and back (x 2)**	**Kick Away:** Jog forward whilst kicking the heels backward with extended leg. **Go out as far as the 20 metre cone and back (x 2)**
Run and Go	From a starting position, lean forward as you run to the 10 metre mark and run through the 20 metre mark. Focus on arm action, knee height, and accelerating as fast as possible. **Go out as far as the 20 metre cone and back (x 2)**	**Run and Stop:** Lean forward sprinting through the 10 metre mark and then stop at the 20 metre mark. Focus on decelerating by lowering the body, bending the knees and increasing foot contact. **Go out as far as the 20 metre cone and back (x 2)**

Appendix VI: CLASS Questionnaire for Children

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Children's Leisure Activities Study (CLASS)

Children's Leisure Activities Study Survey

Children's Questionnaire

Important
We are interested in what you do in your leisure time during a typical week.
There are no right and wrong answers- **this is not a test**
Please answer all the questions as honestly and accurately as you can- this is very important.

Q1. Think about the last week (NOT including school holidays) tell us which of these activities you did. Tell us how many times you did it Monday-Friday and how many times you did it on Saturday and Sunday. For EACH of the activities, how much do you ENJOY doing them? (even if you do not do the activity, please circle how much you think you might enjoy it).

	Did you do this activity?	How many times **Monday-Friday?**	How many times **Saturday & Sunday?**	**How much do you enjoy doing this? (please circle a face even if you don't do this activity)**
EXAMPLE: Bike Riding	**No$_1$ Yes$_2$**	**2**	**1**	
Aerobics	No$_1$ Yes$_2$			
Dance	No$_1$ Yes$_2$			
Calisthenics/gymnastics	No$_1$ Yes$_2$			
Martial Arts eg Karate	No$_1$ Yes$_2$			
Tennis/bat tennis	No$_1$ Yes$_2$			

Q1 Think about the last week.

	Did you do this activity?	How many times **Monday-Friday?**	How many times **Saturday & Sunday?**	**How much do you enjoy doing this? (please circle a face even if you <u>don't</u> do this activity)**
Aussie Rules Football	No$_1$ Yes$_2$			
Soccer	No$_1$ Yes$_2$			
Basketball	No$_1$ Yes$_2$			
Cricket	No$_1$ Yes$_2$			
Netball	No$_1$ Yes$_2$			
Baseball/softball	No$_1$ Yes$_2$			
Swimming laps	No$_1$ Yes$_2$			
Swimming for fun	No$_1$ Yes$_2$			

Q1 Think about the last week.

	Did you do this activity?	How many times **Monday-Friday?**	How many times **Saturday & Sunday?**	**How much do you enjoy doing this? (please circle a face even if you <u>don't</u> do this activity)**
Down ball/4 square	No$_1$ Yes$_2$			
Playing outside	No$_1$ Yes$_2$			
Tag/chasey	No$_1$ Yes$_2$			
Skipping rope	No$_1$ Yes$_2$			
Roller blading	No$_1$ Yes$_2$			
Scooter	No$_1$ Yes$_2$			
Skateboarding	No$_1$ Yes$_2$			
Bike riding	No$_1$ Yes$_2$			
Household chores	No$_1$ Yes$_2$			

Q1 Think about the last week.

	Did you do this activity?	How many times **Monday-Friday?**	How many times **Saturday & Sunday?**	**How much do you enjoy doing this? (please circle a face even if you <u>don't</u> do this activity)**
Playing on playground equipment	No_1 Yes_2			
Playing in a cubby house	No_1 Yes_2			
Bouncing on the trampoline	No_1 Yes_2			
Playing with balls	No_1 Yes_2			
Playing with bats/rackets/ golf clubs	No_1 Yes_2			
Playing with toys that I run around with (eg. frisbees, water pistols, kites)	No_1 Yes_2			
Playing with pets	No_1 Yes_2			
Walking the dog	No_1 Yes_2			
Walking for exercise	No_1 Yes_2			

Q1 Think about the last week.

	Did you do this activity?	How many times **Monday-Friday?**	How many times **Saturday & Sunday?**	**How much do you enjoy doing this? (please circle a face even if you <u>don't</u> do this activity)**
Jogging or running	No_1 Yes_2			
Physical education class	No_1 Yes_2			
Sport class at school	No_1 Yes_2			
Travel by walking to school (to and from school = 2 times)	No_1 Yes_2			
Travel by cycling to school (to and from school = 2 times)	No_1 Yes_2			
Other (please state) ________________	No_1 Yes_2			

Q2 Think about the last week (NOT including school holidays) tell us which of these activities you did. Tell us the TOTAL TIME you spent doing it Monday-Friday and the TOTAL TIME

you spent doing it on Saturday and Sunday. For EACH of the activities, how much do you ENJOY doing them? (even if you do not do the activity, please circle how much you think you might enjoy it).

Notice that this question is different to the last one, because it asks you how many minutes you do each activity for the whole week or weekend.

	Did you do this activity?	Total hours/minutes **Monday-Friday**	Total hours/minutes **Saturday & Sunday**	**How much do you enjoy doing this? (please circle a face even if you don't do this activity)**
EXAMPLE: Watching TV/Videos	**No$_1$ (Yes$_2$)**	**15hrs**	**6hrs 30mins**	
Watching TV / Videos	No$_1$ Yes$_2$			
Playing Playstation/Nintendo/ XBOX / Computer games	No$_1$ Yes$_2$			
Using the Computer/Internet (not games)	No$_1$ Yes$_2$			
Doing homework	No$_1$ Yes$_2$			
Playing indoors with toys (eg. Lego, WarHammer, dolls)	No$_1$ Yes$_2$			

Q2 Think about the last week.

	Did you do this activity?	Total hours/minutes **Monday-Friday**	Total hours/minutes **Saturday & Sunday**	**How much do you enjoy doing this? (please circle a face even if you don't do this activity)**
Sitting and talking	No$_1$ Yes$_2$			
Talking on the phone	No$_1$ Yes$_2$			
Listening to music	No$_1$ Yes$_2$			
Playing a musical instrument	No$_1$ Yes$_2$			
Playing board games/cards	No$_1$ Yes$_2$			
Reading a book or magazine	No$_1$ Yes$_2$			
Doing art & craft (eg. models, beads, sewing, drawing)	No$_1$ Yes$_2$			
Other (please state) ______________	No$_1$ Yes$_2$			

Appendix VII: CLASS Questionnaire for Parents

DO NOT DISTRIBUTE WITHOUT WRITTEN PERMISSION FROM:
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Children's
Leisure Activities Study
(CLASS)

Children's Leisure Activities Study Survey

Parent Questionnaire

PLEASE NOTE: THIS QUESTIONNAIRE WILL TAKE APPROXIMATELY 10 MINUTES TO COMPLETE

Your child's name: ______________________________

Your child's teacher: ______________________________

During a typical WEEK what activities does your child **usually** do?	Does your child usually do this activity?	MONDAY - FRIDAY		SATURDAY - SUNDAY	
		How many times **Monday-Friday?**	**Total** hours/minutes **Monday-Friday**	How many times **Saturday & Sunday?**	**Total** hours/minutes **Saturday & Sunday**
Cricket	No1 Yes2				
Netball	No1 Yes2				
Baseball/softball	No1 Yes2				
Swimming laps	No1 Yes2				
Swimming for fun	No1 Yes2				
Down ball/4 square	No1 Yes2				
Tag/chasey	No1 Yes2				
Skipping rope	No1 Yes2				
Roller blading	No1 Yes2				
Scooter	No1 Yes2				
Skateboarding	No1 Yes2				
Bike riding	No1 Yes2				
Household chores	No1 Yes2				

CLASS PROXY-REPORT SURVEY: DO NOT DISTRIBUTE WITHOUT PERMISSION

The following questions relate to the child you have named on the front cover of the questionnaire.

Which of the following PHYSICAL activities does your child USUALLY do during a typical WEEK? (from the start of the current school term, do NOT include school holidays)

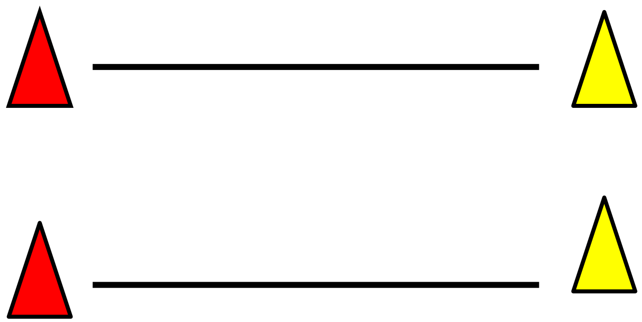
During a typical WEEK what activities does your CHILD **usually** do?	Does your child usually do this activity?	MONDAY - FRIDAY		SATURDAY - SUNDAY	
		How many times **Monday-Friday?**	**Total** hours/minutes **Monday-Friday**	How many times **Saturday & Sunday?**	**Total** hours/minutes **Saturday & Sunday**
Eg. Bike riding	No1 (Yes2)	2	40mins	1	15mins
Aerobics	No1 Yes2				
Dance	No1 Yes2				
Calisthenics/gymnastics	No1 Yes2				
Tennis/ bat tennis	No1 Yes2				
Aussie Rules Football	No1 Yes2				
Soccer	No1 Yes2				
Basketball	No1 Yes2				

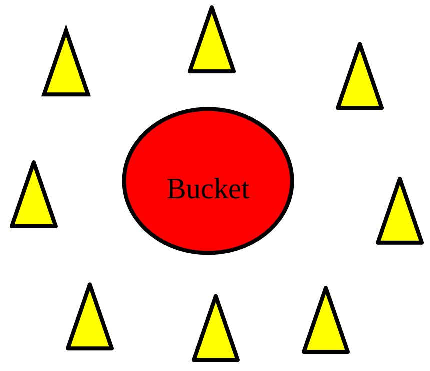
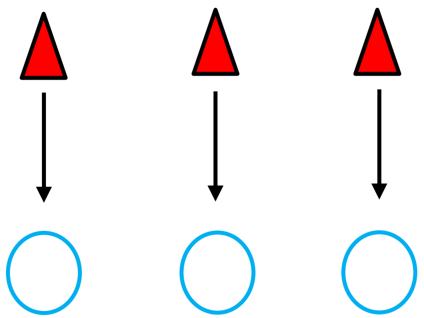
During a typical WEEK what activities does your child **usually** do?	Does your child usually do this activity?	**MONDAY - FRIDAY**		**SATURDAY - SUNDAY**	
		How many times **Monday-Friday?**	**Total** hours/minutes **Monday-Friday**	How many times **Saturday & Sunday?**	**Total** hours/minutes **Saturday & Sunday**
Play on playground equipment	No$_1$ Yes$_2$				
Play in the cubby house	No$_1$ Yes$_2$				
Bounce on the trampoline	No$_1$ Yes$_2$				
Play with pets	No$_1$ Yes$_2$				
Walk the dog	No$_1$ Yes$_2$				
Walk for exercise	No$_1$ Yes$_2$				
Jogging or running	No$_1$ Yes$_2$				
Physical education class	No$_1$ Yes$_2$				
Sport class at school	No$_1$ Yes$_2$				
Travel by walking to school (to and from school = 2 times)	No$_1$ Yes$_2$				
Travel by cycling to school (to and from school = 2 times)	No$_1$ Yes$_2$				
Other (please state) ____________________	No$_1$ Yes$_2$				

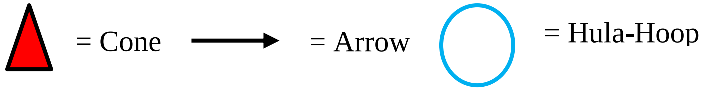
During a typical WEEK what other leisure activities does your child **usually** do?	Do you usually do this activity?	**Total** hours/minutes **Monday-Friday**	**Total** hours/minutes **Saturday & Sunday**
E.G. TV/videos	**No$_1$ Yes$_2$**	**15hrs**	**6hrs 30mins**
TV / videos	No$_1$ Yes$_2$		
Playstation / Nintendo / computer games	No$_1$ Yes$_2$		
Computer / Internet	No$_1$ Yes$_2$		
Homework	No$_1$ Yes$_2$		
Play indoors with toys	No$_1$ Yes$_2$		
Sitting talking	No$_1$ Yes$_2$		
Talk on the phone	No$_1$ Yes$_2$		
Listen to music	No$_1$ Yes$_2$		
Musical instrument	No$_1$ Yes$_2$		
Board games/cards	No$_1$ Yes$_2$		
Reading	No$_1$ Yes$_2$		
Art & craft (eg. pottery, sewing, drawing)	No$_1$ Yes$_2$		
Imaginary play	No$_1$ Yes$_2$		
Travel by car / bus (to and from school)	No$_1$ Yes$_2$		
Other (please state) ____________________	No$_1$ Yes$_2$		

Appendix VIII: FMS Intervention Lesson Plans

Session 1

Session 1: Gallop, Catch and Throw	
Time/Equipment	**Activity**
10 minutes Cones Beanbags	**Warm Up: Catch Relay:** Divide the class into groups of four, two on each side of the lines. Participants run from one side to the other and when the runner with the beanbag reaches the other side they throw the beanbag to the next runner and so on. Participants extend the space in between the group after each full rotation (Give teams an animal to imitate for each go including a horse to identify who can/can't perform the gallop). 
15 minutes Cones Different size balls Buckets	**Circuits:** Divide group into three. Each group spends 5 minutes at a station. After 5 minutes, groups rotate to the next station. **Station 1: Develop Underhand Throw:** Throwing different sized balls/beanbags into bin/buckets.

	Place a bucket/bin in the centre of a circle marked out by cones. Each child stands at a cone. Individually they practice underhand throwing balls/beanbags into the buckets/bins.  **Station 2: Develop Overhand Throw:** Throwing beanbags at targets. Divide group into 2-3 groups. Set up targets using the cones or hula-hoops. Child overhand throws beanbag towards the target whilst being instructed on correct technique. After throwing, each child collects their own beanbag and passes to the next in line. 

	 **Station 3: Develop Catching Technique:** Place a selection of balls inside a hula hoop. Form a line approximately 2 metres between each person – the person at the start picks a ball and throws it to the next person until it reaches the end of the line. The last person with the ball stands inside the hoop at the end. If the ball is dropped they must start again.
15 minutes Cones Hula-Hoops Tennis Balls	**Obstacle Course:** Divide into 2-3 teams so that's a relay style course. **Obstacle 1: Overarm Throw:** Throw beanbag into a target area using overarm throw to start. First attempt should be made from line 1.If they fail move closer, and if they fail again move closer. Go after the third attempt regardless. **Obstacle 2: Gallop:** Gallop from the start to obstacle 3. Have tennis balls placed on top of the cones. **Obstacle 3: Underarm Throw:** Child picks up tennis ball and throws it using the underarm technique against the wall. Encourage the child to catch it without letting it bounce. If the child fails to catch it they must fetch the ball and return it to the cone before galloping back to the start. Continue as relay. Give advice on how to perform the correct technique for the different skills.
5 minutes	**Cool Down:** Gentle jog and full body stretch.

Session 2

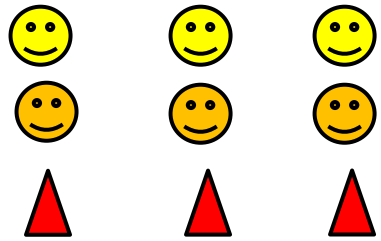
Session 2: Horizontal Jump, Skip and Kick	
Time/Equipment	**Activity**
10 minutes	**Warm Up: Animal Moves:** Participants move around the allocated area as a designated animal e.g. if asked to be a bunny the participants should hop. Other animals could be a seal, snake, kangaroo or crab. Allow participants to choose their own animal movements once they have come to terms with the game. Dynamic stretch.
15 minutes Cones Bibs Poly Spots	**Activity 1: Skipping/Jumping Tag:** Set up poly spots around the school hall/gymnasium and get the taggers to wear bibs. Taggers skip/jump to tag other participants who are also skipping/jumping within the designated area. When a person is tagged, the tagger gives their bib to that person, who then becomes the tagger, while the previous tagger joins the rest of the group. Participants cannot be tagged if they are standing in a stork balance on one of the poly spots in the designated area.
15 minutes Cones Hula-Hoops Hurdles Footballs	**Obstacle Course:** **Station 1: Develop Horizontal Jump:** Place four hula-hoops in a line. Children jump from one hoop to the next. Encourage the children to use the correct technique. **Station 2: Develop Horizontal Jump:** Set up two poly spots per group and two mini hurdles. **Station 3: Develop Kicking:** Place a football on top of the cones to elevate the ball. Place a target on the wall for the children to aim at. Once a child has kicked the football, they collect the football and place it on the cone for the next person.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 3

Session 3: Horizontal Jump, Skip and Kick	
Time/Equipment	**Activity**
10 minutes	**Warm Up: Animal Moves:** Participants move around the allocated area as a designated animal e.g. if asked to be a bunny the participants should hop. Other animals could be a seal, snake, kangaroo or crab. Allow participants to choose their own animal movements once they have come to terms with the game. Dynamic stretch.
15 minutes Cones Hula-Hoops Hurdles Poly Spots	**Activity 1: Shark Attack Obstacle Course: Develop Horizontal Jumping Technique:** Assign three teams and line up behind each cone. Place pictures of sharks, fish, frogs and lily pads on the floor to create an imaginary ocean. **Set Up:** **Obstacle 1:** Two hula-hoops. **Obstacle 2:** Two mini hurdles. **Obstacle 3:** Two poly-spots. **Instructions:** Children must take their time performing the jumps. Tell them to stop and resume the correct starting position before each jump. Hula hoops emphasise horizontal jump and min hurdles/poly spots emphasise vertical jump. After obstacle 3 they skip back to the back of the line and sit with their hands on their head until all team members have completed the course.
15 minutes Cones Bowling Pins Hula-Hoops	**Activity 2: Bowling Pins and Target Practice for Kicking:** Use the same teams from game 1. Set up the bowling pins for each team.

Footballs	Place the footballs approximately 4 metres from the football. Each team member takes a turn at running to kick the ball to try and knock as many bowling pins as possible. Each team adds up their score (1 point per pin knocked over (until all members have gone). Repeat 3-4 times. If time allows repeat the same activity using hula-hoops propped u against the wall.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 4

Session 4: Forehand Strike, Dribble and Slide	
Time/Equipment	**Activity**
10 minutes	**Warm-Up: Stuck in the Mud:** Assign three taggers and give them a bib for identification. If caught by a tagger, the child must stand with their arms and legs out wide. They can be freed when another child crawls under their legs or runs under their arms. Incorporate different locomotor skills e.g. run, gallop, hop, skip and slide. Dynamic stretch.
15 minutes Cones Baskets Soft Balls/Tennis Balls	**Activity 1: Forehand Strike: Striker's vs Catchers:** Strikers must use the forehand strike technique to strike the ball using their hands aiming for the catcher's basket. Arrange the group into equal sized teams and line up behind a cone. The first member is the catcher and picks up the basket and faces their team. The remaining members in the team aim to strike the ball into the catcher's basket using the correct forehand strike technique. The catcher can move to try and catch the ball in their basket. Alternate the catcher once everyone has had a go at striking. 

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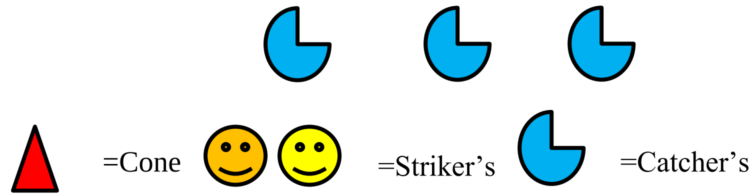
<td>
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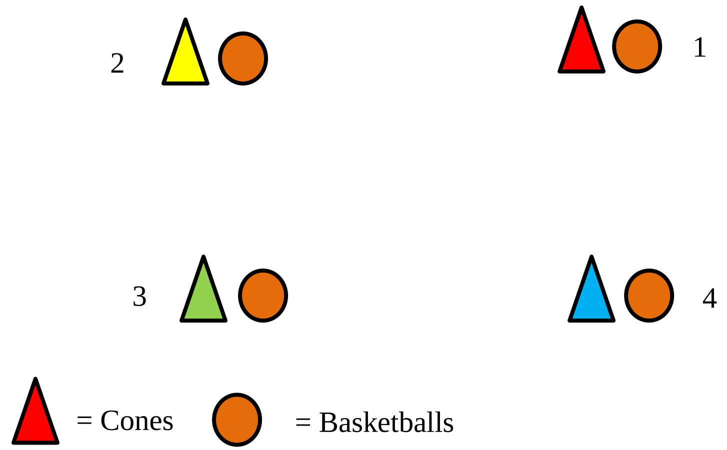
<tr>
<td>15 minutes
Cones
Basketballs
Playground Balls</td>
<td>Activity 2: Dribble:
Set up 3-4 squares with equal numbers at each station. Number the cones 1-4. Place a basketball/playground ball on each cone. Players start at cone 1 and bounce the ball 5-6 times at each cone. Players will be asked to use different dribble techniques at each cone.
Cone 1: Dribble with the right hand 5-6 times.
Cone 2: Dribble with the left hand 5-6 times.
Cone 3: Dribble alternating hands 5-6 times.
Cone 4: Dribble with their preferred hand 5-6 times.

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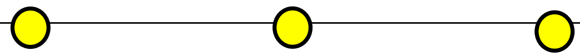
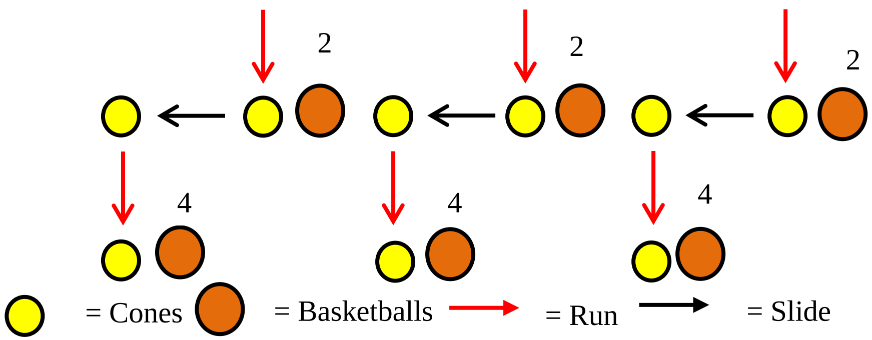
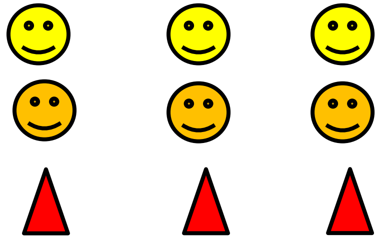
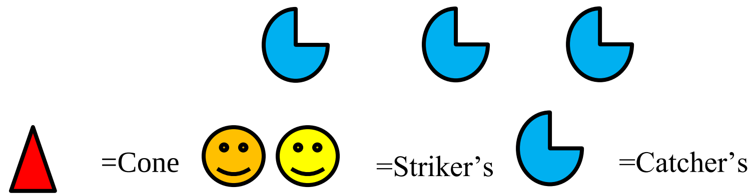
	Activity 3: Slide: Keep the same set up as in the dribble. Call a number and children must slide around the cones to the number cone that is called and then return to the start. Allow the children to do it first on their own and then in pairs facing each other.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 5

Session 5: Forehand Strike, Dribble and Slide	
Time/Equipment	**Activity**
10 minutes Cones	**Warm Up: Animal Moves:** Participants move around the allocated area as a designated animal e.g. if asked to be a bunny the participants should hop. Other animals could be a seal, snake, kangaroo or crab. Allow participants to choose their own animal movements once they have come to terms with the game. **Side Gallop Challenge:** Divide the group into two teams. Team one have no bibs and team two have bibs. In a designated area marked out by white cones scatter different coloured cones randomly. Allow the children to side gallop in the designated area. The coach calls out one or two colours. Children must side gallop to the cone that was called out by the coach with only one cone allowed per person. The team who picks the most gets the point. Repeat a few times, changing direction of the side gallop each time. Dynamic stretch.
15 minutes Cones Basketballs Playground Balls	**Activity 1: Slide and Dribble:** Divide the class into 2-3 groups. Get children to run the straight and slide the sides. Once they have gone from one side to the other get them to sit on their knees with their hands on their head. Incorporate dribbling by placing a basketball at cone 2 and cone 4. Once the children have become proficient at the drill then incorporate a relay style.

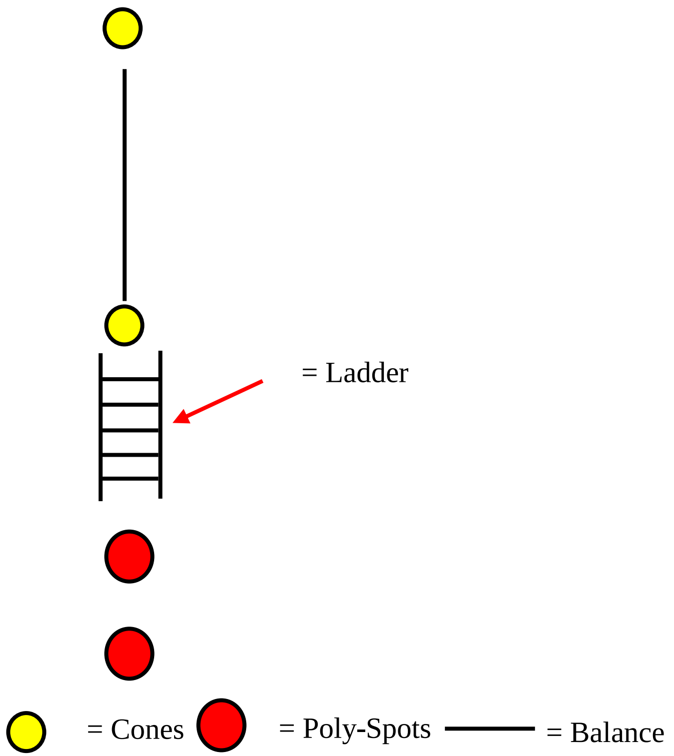


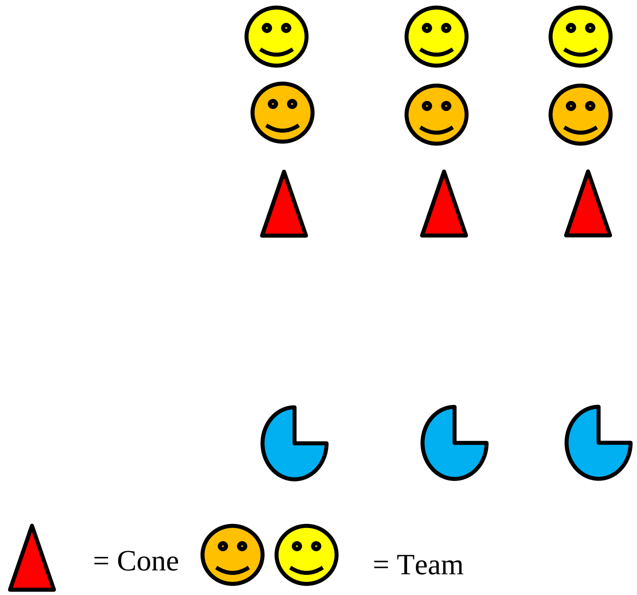
	
15 minutes Cones Rackets Tennis Balls Hula-Hoops	**Activity 2: Forehand Strike: Striker's vs Catchers:** Strikers must use the forehand strike technique to strike the ball using their rackets aiming for the catcher's hula-hoop. Arrange the group into equal sized teams and line up behind a cone. The first member is the catcher and picks up the hula-hoop and faces their team. The remaining members in the team aim to strike the ball into the catcher's hula-hoop using the correct forehand strike technique. The catcher can move to try and catch the ball in their hula-hoop. Alternate the catcher once everyone has had a go at striking. 

	
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 6

Session 6: Two-Hand Strike, Balance and Hop	
Time/Equipment	**Activity**
10 minutes	**Warm Up: Animal Moves:** Participants move around the allocated area as a designated animal e.g. if asked to be a bunny the participants should hop. Other animals could be a seal, snake, kangaroo or crab. Allow participants to choose their own animal movements once they have come to terms with the game. When the whistle is blown, children freeze and balance in different positions. Dynamic stretch.
15 minutes Cones Ladders Poly-Spots	**Activity 1: Balance and Hopping Obstacle Course:** Divide the class into 2-3 groups. There will be three obstacles as part of this activity which include: **Obstacle 1: Straight Line Walking to Maintain Balance:** Place white tape along the floor for about 10-15 metres. If there is lines on the school hall floor use them. **1.** Walk backwards. **2.** Place beanbag on their head. **3.** Hop along the line. **Obstacle 2: Hop Through the Ladders:** **1.** Hop with the right foot. **2.** Hop with the left foot. **3.** Hop sideways. **4.** Hopscotch. **Obstacle 3: Hop for Distance:** Get the child to stand on one foot on a poly-spot and hop as far as they can on one leg. Once the three obstacles are complete the child returns to their team and high fives the next person.

	
15 minutes Cones Targets Batting Tee Bats Tennis Balls	**Activity 2: Target Practice using Two-Hand Strike:** Keep the same 3 teams as in activity 1. Each player takes it in turns to strike at a target on the wall.

	
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 7

Session 7: Two-Hand Strike, Balance and Hop	
Time/Equipment	**Activity**
10 minutes Hula-Hoops Soft Balls	**Warm Up: Balance Tag:** Place four hula-hoops around the school hall/gymnasium. Standing in a hoop on one leg is the den. Two taggers hold a ball. When a person is tagged, they take the ball and become the tagger. Incorporate different locomotor skills e.g. gallop, hop, skip and slide. Dynamic stretch.
15 minutes Cones Beanbags Soft Balls	**Activity 1: Balance Relays:** Divide the class into 2-3 groups. There will be two obstacles as part of this activity which include: **Obstacle 1: Beanbag on the Head Relay:** Get the first person in the group to place a beanbag on their head. They then run out to the first cone and back in, passing the beanbag to the next person in the line. **Obstacle 2: Balance the Ball Relay:** Children work in pairs to balance a soft ball between their foreheads. They work it out as far as the cone and back in. **Variations:** **1.** Balance the soft ball between their backs. **2.** Wheelbarrow race.
15 minutes Cones Targets Batting Tee Bats Tennis Balls	**Activity 2: Hopping and Target Practice:** Keep the same 3 teams as in activity 1. **Obstacle 1: Hopping through Ladders:** Each person must hop through the ladders using: **1.** Right foot. **2.** Left foot. **3.** Hopping sideways.

	4. Hopscotch. **Obstacle 2: Two-Hand Strike at Targets:** Each player takes it in turns to strike at the target at the wall.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 8

Session 8: Gallop, Underhand Throw, Overhand Throw and Catch	
Time/Equipment	**Activity**
10 minutes Cones	**Warm Up: Cups and Saucers:** Divide the class into two teams. One team will be the cups and the other team will be the saucers. Randomly spread out cones with equal numbers turned upright (saucers) and upside down (cups). The cup team turn as many cones upside down as possible and the saucers team turn as many cones upright as possible. The team with the most cones turned their way wins. Dynamic stretch.
15 minutes Cones Variety of Balls Buckets Hula-Hoops	**Activity 1: Underhand Throw, Catch and Gallop:** Divide the class into 4 groups. Place the variety of balls in the centre of the floor within a hula-hoop. The first member of each team gallops to the centre to collect a ball. The person who collects the ball must underhand throw to the next team member who catches it and places it into their team bucket. If it is not caught, they must return to the centre with the ball and try again. Once the ball is catch the thrower returns to the end of their line to allow the next player to go. Once all the balls are gone from the centre, the team with the most balls in their bucket wins.
15 minutes Cones Hula-Hoops Beanbags Tennis Balls	**Activity 2: Overhand Throw:** Divide the class into 3 groups. Place 3 hula-hoops in front of each team. 1. Hula-Hoop 1 (10 points) 2. Hula-Hoop 2 (20 points) 3. Hula-Hoop 3 (30 points)

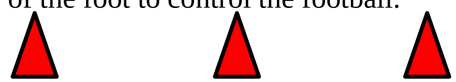
	Each team member must overhand throw the tennis ball/beanbag towards the hula-hoops and aim to score as many points as possible by the end of the game.
5 minutes	**Cool Down:** Gentle jog and stretch.

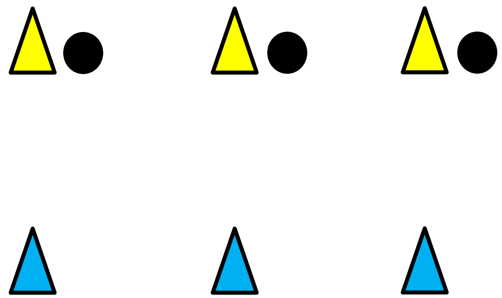
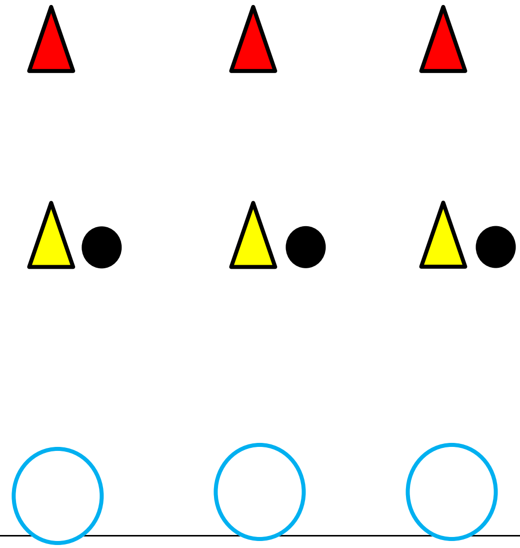
Session 9

Session 9: Gallop, Overhand Throw, Underhand Throw and Catch	
Time/Equipment	**Activity**
10 minutes Bibs Soft Ball	**Warm Up: Zombie Tag:** Two players are given bibs and one player is given a soft ball. The players with the bibs are the taggers. If a person gets tagged, they walk around like a zombie. The player with the soft ball can free the zombies by touching them with the ball. Start with running then incorporate other locomotor skills (e.g. gallop, skip and slide). Dynamic stretch.
10 minutes Cones Variety of Balls Buckets Hula-Hoops	**Activity 1:Overhand Throw with Targets:** Divide the class into 2 groups. Place targets on the wall with points allocated to each target. Leave a bucket with a variety of balls beside the targets at the end of the hall. Players must run to the bucket, choose a ball of their choice and return to a poly-spot of their choice and aim for a target. Incorporate different locomotor skills whilst going to retrieve the ball (e.g. gallop, skip and slide). After a player throws they must collect their ball and pass it to the next player who will then return it to the bucket and choose a different ball.
10 minutes Cones Hurdles Poly-Spots Small Balls Beanbags	**Activity 2: Horserace Relays:** Divide the class into 3 groups. Place three hurdles in front of each team. Teams line up behind their cones. Players must gallop over the hurdles and around the cone at the end before returning to their team. Allow the children to practice first and once they become better at it using the correct galloping technique then incorporate a relay.
10 minutes Cones	**Activity 3: Relays:**

Hurdles Poly-Spots Small Balls Beanbags Buckets	Use the same setup as the horserace relays only this time take away the first hurdle and place a poly-spot in its place. Place a bucket at the start of the line for each team. At the end cone place a second bucket with a variety of balls. As before players must gallop out, jumping the two hurdles along the way to their bucket. They can choose any ball/beanbag, gallop back to the poly-spot and then underhand throw to the next person. The ball can only be placed in the basket if it is caught cleanly. If the ball is not caught, players keep trying until the ball is caught. Once the ball is caught, the next player can go.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 10

Session 10: Horizontal Jump, Kick and Skip	
Time/Equipment	**Activity**
10 minutes Cones Bibs	**Warm Up: Skipping Under the Bridge:** Place four cones around the hall. Students skip around the designated area in pairs. Two students are nominated as ‘taggers’. These two students wear bibs. When pairs of students are tagged, they face each other and form a bridge by joining hands and holding them above their heads. To release these students, a free pair of students must skip under the bridge. Dynamic stretch.
10 minutes Cones Footballs	**Activity 1: Relays:** Divide the class into 3 groups. **Skipping:** Get the students to skip from cone 1 to cone 2 emphasising proper technique. **Skipping and Dribbling:** Skip from cone 1 to cone 2. Take the football from cone 2 and dribble to cone 3 and dribble back to cone 2. Leave the football at cone 2 and skip back into the group. Make sure to remind the students of proper technique. When dribbling, ensure the students keep the ball close using the instep/inside of the foot to control the football. 

	
10 minutes Cones Hurdles Poly-Spots Small Balls Beanbags	**Activity 2: Target Practice (Kicking Technique):** Use the same groups as activity 1. Prop the hula-hoops against the wall as a target. Have players aim for the hula-hoop using a short run up to kick the ball. 

10 minutes Cones Hurdles Poly-Spots Footballs	**Activity 3: Jumping and Kicking Obstacle Course:** Use the same groups as activity 1. Start by jumping over hurdles starting and landing on two feet. Horizontal jump from poly-spots, encouraging the students to jump as far as they can. Run up and kick the football towards the hula-hoops. Place the football back at the cone and return to the start.
5 minutes	**Cool Down:** Gentle jog and stretch.

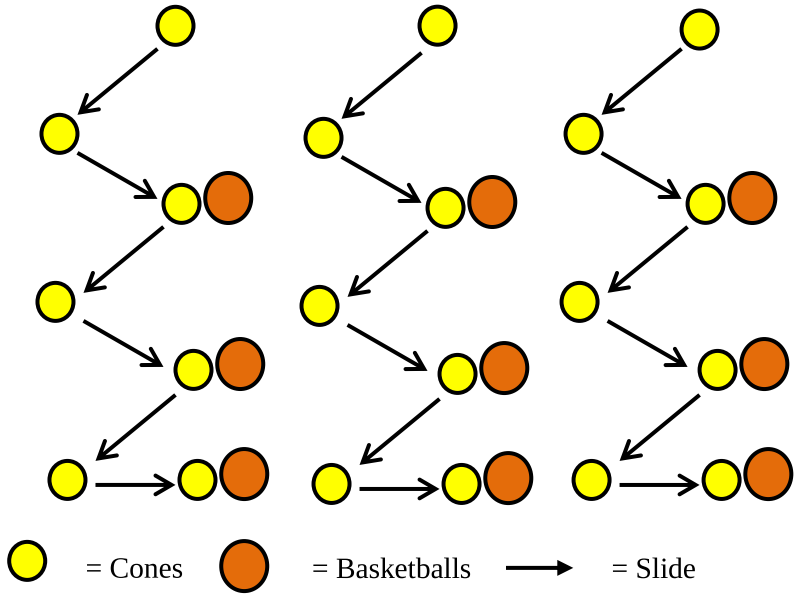
Session 11

Session 11: Horizontal Jump, Kick and Skip	
Time/Equipment	**Activity**
10 minutes Cones	**Warm Up: Traffic Lights:** Children run around in a circle marked out by cones. The instructor stands in the middle and has three cones (green, orange and red). Players must watch and react to the colour being held up. **Green Cone:** Run around. **Orange Cone:** Slow down. **Red Cone:** Stop and balance on one leg. Incorporate other locomotor skills (gallop, hop, skip and slide). Dynamic stretch.
10 minutes Cones Poly-Spots	**Activity 1: Relays:** **Skipping/Jumping Tag:** Set up poly spots around the school hall/gymnasium and get the taggers to wear bibs. Taggers skip/jump to tag other participants who are also skipping/jumping within the designated area. When a person is tagged, the tagger gives their bib to that person, who then becomes the tagger, while the previous tagger joins the rest of the group. Participants cannot be tagged if they are standing in a stork balance on one of the poly spots in the designated area. If a person is standing on a poly-spot they must perform vertical jumps as high as possible.
10 minutes Cones Poly-Spots Footballs Skittles	**Activity 2: Obstacle Course/Relays:** Divide the class into 3 groups. **Relay 1: Dribble and Kicking:** Dribble from the start as far as a poly-spot. Place the football on the poly-spot and aim to knock over the skittle. One point is given if the

	skittle is knocked. After aiming for the skittle, place the football back on the poly-spot.
10 minutes Cones Hurdles Poly-Spots Footballs Skittles	**Activity 3: Jumping and Kicking:** Use the same groups as activity 2. Practice horizontal jumping from one side of the hall to the next. The aim is to jump from one side of the hall to the next with as few jumps as possible. **Relay 2: Jumping and Kicking:** Jump as far as they can (x 2), jump over the mini hurdles (x 2), run up and kick the football at the skittle. One point is given if the skittle is knocked. After aiming for the skittle, place the football back on the poly-spot.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 12

Session 12: Slide, Dribble and Forehand Strike	
Time/Equipment	**Activity**
10 minutes Cones	**Warm Up:** **Animal Moves:** Participants move around the allocated area as a designated animal e.g. if asked to be a bunny the participants should hop. Other animals could be a seal, snake, kangaroo or crab. Allow participants to choose their own animal movements once they have come to terms with the game. When the whistle is blown, children freeze and balance in different positions. **Traffic Lights:** Children run around in a circle marked out by cones. The instructor stands in the middle and has three cones (green, orange and red). Players must watch and react to the colour being held up. **Green Cone:** Run around. **Orange Cone:** Slow down. **Red Cone:** Stop and balance on one leg. Incorporate other locomotor skills (gallop, hop, skip and slide). Dynamic stretch.
10 minutes Cones Rackets Tennis Balls Targets	**Activity 1: Forehand Strike:** Divide the class into 3 groups. Place targets on the wall at varying heights. Set up a starting point 3 metres from the wall. Grab the racket with one hand and the tennis ball with the other. Bounce the tennis ball, then forehand strike towards the wall aiming for the targets.
10 minutes Cones Basketballs	**Activity 2: Zig-Zag Dribble:** Use the same groups as activity 1.

<table>
<tr><td>Playground Balls</td><td>Place cones in a zig-zag formation. Get the students to slide from one cone to the next. At every second cone a basketball will be placed on the cone. Once the student reaches a cone with a basketball get them to bounce it 5 times before moving onto the next cone.

</td></tr>
<tr><td>10 minutes
Cones
Playground Balls
Rackets
Tennis Balls
Targets</td><td>Activity 3: Relay Races:
Use the same groups as activity 2.
The child will start by sliding from the start cone up to a playground ball, they will then pick the playground ball up and dribble it 5 times with their favourable hand, they will then slide to the next cone where they will pick up a tennis ball and a racket, striking towards targets placed on the wall.</td></tr>
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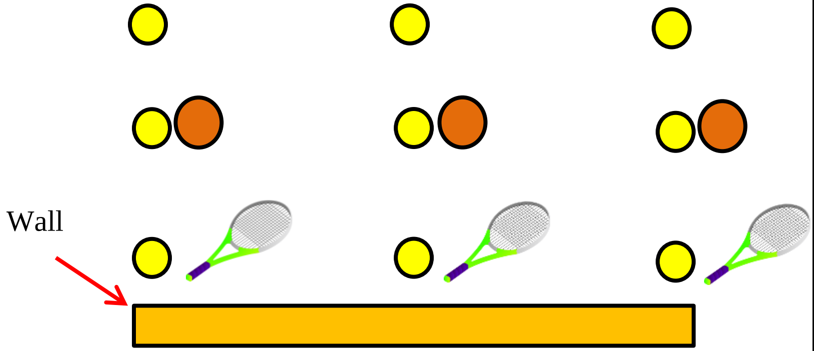
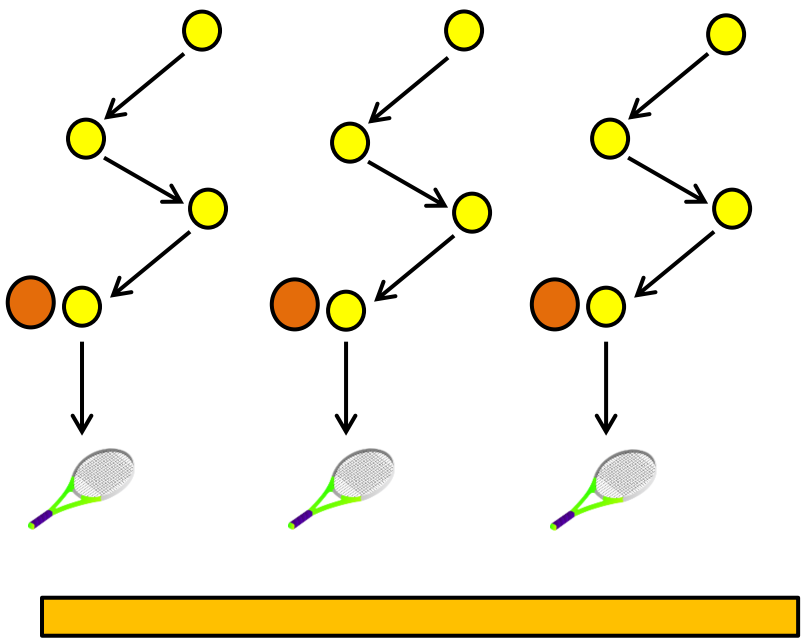
	
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 13

Session 13: Slide, Dribble and Forehand Strike	
Time/Equipment	**Activity**
10 minutes Bibs	**Warm-Up: Stuck in the Mud:** Assign three taggers and give them a bib for identification. If caught by a tagger, the child must stand with their arms and legs out wide. They can be freed when another child crawls under their legs or runs under their arms. Incorporate different locomotor skills e.g. run, gallop, hop, skip and slide. Dynamic stretch.
10 minutes Cones Basketballs Playground Balls	**Activity 1: Dribble and Slide:** Divide the class into 4 groups. The first person slides out to the second cone and picks up the basketball and dribbles it back into the group. The next person then dribbles out as far as the second cone and drops the basketball at the cone and slides back into the group. Repeat this a few times.
10 minutes Cones Rackets Tennis Balls Targets	**Activity 2:Forehand Strike:** Use the same groups as activity 1. Place targets on the wall at varying heights. Set up a starting point 3 metres from the wall. Grab the racket with one hand and the tennis ball with the other. Bounce the tennis ball, then forehand strike towards the wall aiming for the targets.
10 minutes Cones Playground Balls Rackets Tennis Balls Targets	**Activity 3: Relay Races:** Use the same groups as activity 2. The child will start by sliding from the start cone in a zig-zag pattern until they reach the poly-spot with the basketball. Once they reach the poly-spot they must bounce the basketball 5 times. They will then slide to the tennis racket and the tennis ball where they will forehand strike

	the tennis ball towards the targets on the wall. Once they hit the tennis ball towards the wall they must slide back to their group. 
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 14

Session 14: Two-Hand Strike, Hop and Balance	
Time/Equipment	**Activity**
10 minutes Bibs	**Warm-Up: Group Up:** Children run around the hall. Instructor blows the whistle and calls a number. Children form a group with the number the instructor calls and they stand on one leg. Go on the whistle again. Incorporate other locomotor skills (gallop, hop, skip and slide). Dynamic stretch.
10 minutes Cones	**Activity 1: Sideways Plank Relay:** Divide the class into 3 groups. Players must walk sideways with hands and feet on the ground. They must go around the cone and back to the next team member. If their knees touch the ground they must start again. First team with all their players back wins. This activity can be varied with bear crawls and crab crawls.
10 minutes Cones Beanbags Tennis Balls Buckets	**Activity 2: Hopping Challenge:** Use the same groups as activity 1. Place a bucket beside each team. Place a bucket of small balls and beanbags at the other end of the hall. Players hop from the start to the end zone where the balls are. They must count the number of hops they take and pick out that number of balls/beanbags. Players return the balls/beanbags to their team basket. The team with the least number of balls/beanbags wins.
10 minutes Cones Bats Batting Tee Tennis Balls Targets	**Activity 3: Hopping and Two-Hand Strike:** Use the same groups as activity 2. Players hop from the start to the batting tee. They must two-hand strike the tennis ball towards the targets on the wall. Players must collect the tennis ball and place it back on the batting tee. They must then hop back to their group.

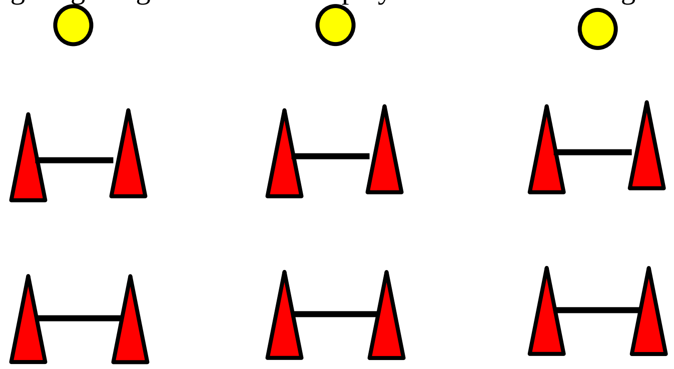
5 minutes	**Cool Down:** Gentle jog and stretch.

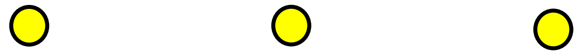
Session 15

Session 15: Two-Hand Strike, Hop and Balance	
Time/Equipment	**Activity**
10 minutes Cones	**Warm-Up: Traffic Lights:** Children run around in a circle marked out by cones. The instructor stands in the middle and has three cones (green, orange and red). Players must watch and react to the colour being held up. **Green Cone:** Run around. **Orange Cone:** Slow down. **Red Cone:** Stop and balance on one leg. Incorporate other locomotor skills (gallop, hop, skip and slide). Dynamic stretch.
10 minutes Cones Bats Batting Tee Tennis Balls Targets	**Activity 1: Two-Hand Strike:** Divide the class into 3 groups. Place targets on the wall at varying heights. Set up a starting point 3 metres from the wall and place the tennis ball on the batting tee. Strike the ball with two hands on the bat towards the wall aiming for the targets.
10 minutes Cones Rackets Tennis Balls Beanbags	**Activity 2: Balance Relay Race:** Use the same groups as activity 1. The first person in the group will place a tennis ball on a tennis racket and walk to the next cone whilst balancing the tennis ball. There they will place down the tennis ball and racket and place a beanbag on their head. They will walk with the beanbag on their head back to the first person in the group who will take the beanbag and walk towards the tennis ball and racket. If the child drops the tennis ball/beanbag they must return to the start.
10 minutes Cones	**Activity 3: Relay Races (Hop and Two-Hand Strike):** Use the same groups as activity 2.

Bats Batting Tee Tennis Balls Targets Ladders	The first child in each group will hop from the start cone to a number of poly-spots alternating their feet after they land on a poly-spot. After they land on the last poly-spot they will run to the next cone and pick up a bat and strike the tennis ball towards the wall aiming for a target. They will then run back to the start to allow the net person to go. Ladders can be used instead of the poly-spots for hopping.
5 minutes	**Cool Down:** Gentle jog and stretch.

Session 16

Session 16: Two-Hand Strike, Hop and Balance	
Time/Equipment	**Activity**
10 minutes Cones	**Warm Up: Cups and Saucers:** Divide the class into two teams. One team will be the cups and the other team will be the saucers. Randomly spread out cones with equal numbers turned upright (saucers) and upside down (cups). The cup team turn as many cones upside down as possible and the saucers team turn as many cones upright as possible. The team with the most cones turned their way wins. Dynamic stretch.
10 minutes Cones Hurdles Tennis Balls Beanbags Small Balls	**Activity 1: Galloping Relay with Hurdles:** Divide the class into 3 groups. Each team lines up behind their start cone. The first person gallops out over the hurdles and around the end cone and gallops back over the hurdles giving a high five to the net player to allow them to go. 

	
10 minutes Cones Hurdles Poly-Spots Small Balls	**Activity 2: Galloping Relay, Underhand Throw and Catch:** Use the same groups as activity 1. The setup is the same as activity 1 only this time there will be a poly-spot placed before the first hurdle. Each team has a soft ball. The first player gallops over the hurdles around the end cone and stops at the poly-spot on the way back. On the poly-spot, they underhand throw to the next team member who must catch it with two-hands. If they catch it the next person can go. If the ball is not caught, the ball must be thrown again until it is caught.
10 minutes Cones Poly-Spots Hurdles Hula-Hoops Tennis Balls	**Activity 3: Overhand Throw:** Use the same groups as activity 2. Players start by standing at a poly-spot and they must overhand throw a tennis ball towards the hula-hoop. Teams score a point for each tennis ball that bounces inside the hoop. After the tennis ball is throw players must gallop to collect their tennis ball and pass it to the next team member.
5 minutes	**Cool Down:** Gentle jog and stretch.