Investigation of physical activity and its correlates in adolescent youth: Evaluation of the Youth-Physical Activity Towards Health (Y-PATH) intervention.

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A thesis submitted for the award of Doctor of Philosophy (PhD)

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Authors Declaration

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

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Investigation of physical activity and its correlates in adolescent youth: Evaluation of the Youth-Physical Activity Towards Health (Y-PATH) intervention.

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Abstract

Introduction: Youth physical activity (PA) levels are extremely low with 80.3% of adolescents not meeting the 60 minutes/day PA guideline. Whilst participating in PA, one develops several fundamental movement skills (FMS) that are considered basic observable movement patterns. Today's generation of youth are not reaching FMS mastery by age 10 and are entering adolescence without the necessary basic skills proficiency. The Youth-Physical Activity Towards Health (Y-PATH) school-based programme aims to increase PA levels and FMS proficiency, whilst taking into account psychological and psychosocial correlates.

Methods: Participants (n = 534, 12 - 14 years) from 20 schools (intervention = 10) participated in the implementation and evaluation of Y-PATH. Measures collected at three time points include: height and weight, health-related fitness (HRF), 15 FMS, and objective PA. Psychological and psychosocial correlates were collected via questionnaire. Using baseline data the relationship between: PA, FMS and HRF, and between psychological and psychosocial correlates, PA, and FMS were analysed. Patterns of within day PA participation were also investigated. Analysis of longitudinal data was conducted to investigate the between-group differences for weekday PA.

Results: Results suggest i) a positive reciprocal relationship between PA and FMS, mediated by HRF, exists, ii) PA acts as a mediator between psychological and psychosocial correlates and FMS, iii) three distinct PA patterns during weekday and weekend days were found, and iv) multi-level modelling analyses indicates significant differences between-groups for weekday PA ($p<0.001$).

Conclusion: The results highlight i) the importance of increasing adolescents' fitness to enhance both PA participation and FMS development, ii) targeting PA levels is warranted as it mediates both psychosocial and psychological correlates, and FMS, iii) the need for interventions targeting specific time periods to increase PA, and iv) the Y-PATH school-based PA programme is effective in maintaining adolescent PA participation.

Chapter 1

Introduction to Thesis

1.1 Publications

Article in Press:

Where does the time go? Patterns of physical activity in adolescent youth. Belton, S., O'Brien, W., Issartel, J., McGrane, B., & **Powell, D.** (2016). *Journal of science and medicine in sport*, 1–5. doi:10.1016/j.jsams.2016.01.008

Physical self-confidence levels of adolescents: Scale reliability and validity. McGrane, B., Belton, S., **Powell, D**., Woods, C. B., & Issartel, J. (2015). *Journal of science and medicine in sport*, 1–5. doi:10.1016/j.jsams.2015.07.004

Article Under Review:

A cross-validation study of the TGMD-2: the case of an adolescent population. Issartel, J., McGrane, B., Fletcher, R., O'Brien, W., **Powell, D**., & Belton, S. (2016). *Journal of science and medicine in sport*.

The relationship between fundamental movement skill proficiency and physical self-confidence among adolescents. McGrane, B., Belton, S., **Powell, D**., & Issartel, J. (2016). *Journal of Sports Sciences.*

Poster Presentations:

Patterns of physical activity in adolescent youth as measured by acceleroemter. **Powell, D.,** Issartel, J., McGrane, B., O'Brien, W., & Belton., S. (2014). *Irish Postgraduate Conference,* Limerick (Ireland).

An analysis of adolescent sedentary behaviour using accelerometry and self-report. **Powell, D.,** Issartel, J., McGrane, B., O'Brien, W., & Belton., S. (2015). *PEPAYS Research Forum,* Limerick (Ireland).

The reliability and validity of a perceived motor competence scale among adolescents. McGrane, B., **Powell, D.,** Belton., S., Woods, C., & Issartel, J. (2015). *ISBNPA conference,* Edinburgh (Scotland).

Are Irish adolescents overestimating their actual motor skill abilities? McGrane, B., Belton., S., **Powell, D.,** & Issartel, J. (2015). *ISBNPA conference,* Edinburgh (Scotland).

Are low levels of physical activity confidence and high levels of perceived barriers to physical activity encouraging sedentary behaviour? **Powell, D.,** Issartel, J., McGrane, B., & Belton., S. (2015). *ISBNPA conference,* Edinburgh (Scotland).

Oral Presentations:

Are adolescents as good as they think? McGrane, B., Belton., S., **Powell, D.,** & Issartel, J. (2014). *Irish Postgraduate Conference,* Limerick (Ireland).

The "durability" of physical activity promotion amongst Irish adolescent youth: A structured pathway for ensuring sustainability. O'Brien, W., Belton, S., Woods, C., Meegan, S., McGrane, B., **Powell, D.,** & Issartel, J. (2014). *PEPAYS Research Forum,* Waterford (Ireland).

Discrepancy between perceived motor competence and fundamental movement skills proficiency. McGrane, B., Belton., S., **Powell, D.,** & Issartel, J. (2014). *ECSS conference,* Amsterdam (Netherlands).

Understanding adolescent sedentary behaviour using accelerometry and self-report. **Powell, D.,** Issartel, J., McGrane, B., O'Brien, W., & Belton., S. (2014). *ECSS conference,* Amsterdam (Netherlands).

Where does the time go? PA patterns of adolescent youth. Belton, S., O' Brien, W., McGrane, B., Issartel, J., & **Powell, D.** (2014). *ECSS conference,* Amsterdam (Netherlands).

Y-PATH, A new curriculum model for adolescent youth? Belton, S., O' Brien, W., McGrane, B., **Powell, D.,** Woods, C., & Issartel, J. (2014). *Global Summit on the Physical Activity of Children,* Toronto (Canada).

Evaluation of the Y-PATH intervention: results of a cluster randomised control trial. Belton, S., McGrane, B., **Powell, D.,** Woods, C., & Issartel, J. (2015). *ISBNPA conference,* Edinburgh (Scotland).

The association between objectively measured physical activity and physical activity barriers and confidence in adolescent youth. **Powell, D.,** Issartel, J., McGrane, B., & Belton., S. (2015). *PEPAYS Research Forum,* Limerick (Ireland).

Exploring the role of health-related fitness as a mediator in the reciprocal relationship between fundamental movement skills and physical activity. **Powell, D.,** Issartel, J., McGrane, B., & Belton., S. (September 2016). *PEPAYS Research Forum,* Kerry (Ireland).

Physically active, physically educated and physically literate: The Youth-Physical Activity Towards Health (Y-PATH) Intervention. O' Brien, W., Belton, S., **Powell, D.,** McGrane, B., Issartel, J. (September 2016). *HEPA Europe,* Belfast (Northern Ireland).

Similarities and differences between correlates of fundamental movement skills and physical activity in adolescents. **Powell, D.,** Issartel, J., McGrane, B., & Belton., S. (September 2016). *HEPA Europe*, Belfast (Northern Ireland).

1.2 Introduction

According to the World Health Organisation (WHO – World Health Organisation, 2010) chronic disease is the greatest health burden facing the world. Given the health benefits associated with participating in adequate physical activity (PA), it seems PA is one of the best placed preventative pills available to society. This thesis presents an evaluation of the efficacy of a school-based PA and fundamental movement skill (FMS) intervention in Irish adolescents. The rationale for the implementation and subsequent evaluation of an intervention of this nature is detailed briefly below.

1.2.1 Why Physical Activity in Irish Adolescents?

Physical activity has been defined, and is globally accepted, as any bodily movement which results in an increase in energy expenditure above resting levels (Caspersen & Christenson, 1985). Regular participation in PA is associated with lower incidence of non-communicable disease (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Individuals undertaking regular PA are likely to demonstrate higher levels of cardio-respiratory and muscular fitness, healthier body mass and composition, superior health, higher levels of functional health and better cognitive function (Warburton et al., 2010). Irrespective of the known benefits, global research suggests that approximately 80.3% of adolescents (13 - 15 years) are not achieving the recommended 60 minutes per day of moderate to vigorous PA (MVPA - Hallal, Andersen, Bull, Guthold, & Haskell, 2012). According to Woods and colleagues (2010) as part of the 'Children's Sport Participation and Physical Activity' (CSPPA) study, just 14% of 10 to 18 year old Irish young people met the national PA guideline of 60 minutes of MVPA per day. Considering the increasing prevalence of obesity in youth, with one in four unfit, overweight, obese and/or with high blood pressure (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010), targeting at risk populations is of urgent concern (Finucane et al., 2011). Equally worrying is the age related decline in PA observed by Woods and colleagues (2010), consistent with trends worldwide

(Hallal et al., 2012). The CSPPA study found that 13% of females aged 12 to 13 years, and 24% of males of the same age, self-reported meeting the PA guideline (Woods et al., 2010). This is in stark contrast to only 8% of females aged 14 to 15 years and 16% of males accumulating the recommended 60 minutes of MVPA per day (Woods et al., 2010). Considering that PA behaviour is understood to track across the age spectrum, from childhood into adolescence, and subsequently into adulthood (Telama et al., 2005), addressing the low activity levels in children and youth is essential.

Although it is known that habitual PA is low in adolescents, little is understood about the daily patterns of PA participation in youth. Some researchers have considered that differentially active children may exhibit different patterns of PA participation between weekdays and weekend days (Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2014), whilst others have considered different within-day patterns of PA (Mota, Santos, Guerra, Ribeiro, & Duarte, 2003; Trost, Pate, Freedson, Sallis, & Taylor, 2000). A combination of these methods, looking at the variation in these patterns according to the PA level of the individual had not been investigated prior to the work presented in this thesis. This work can provide valuable information on time periods during the day that targeted interventions should be aiming to affect.

Unsurprisingly, considering the high prevalence of inactivity in Irish children and youth, Woods and colleagues (2010) provided strategic advice for PA promotion which recommends the necessity for the provision of pathways for PA participation in youth. High on their list of priorities was the development of fundamental motor skills, independent of sports or specific activities, solely with the purpose of developing overall skills and abilities which form the basis of all sports and physical activities (Woods et al., 2010).

1.2.2 Why Fundamental Movement Skills in Irish Adolescents?

Through participation in sports and activities young people develop FMS (Gallahue & Ozmun, 2006). FMS are basic observable goal directed movement patterns traditionally divided into three composite groups; locomotor skills, object control and stability (Burton & Miller, 1998). They form the basis for many of the specialised skills required for participation in a variety of sports and activities (Gallahue & Ozmun, 2006). The development of FMS is expected to occur between the age of three and seven, during the fundamental movement phase, with mastery achieved by 10 years of age (Gallahue & Ozmun, 2006). 'Mastery' in terms of FMS is defined as displaying all components of a skill correctly, whereas 'near mastery' suggests all components but one are performed correctly (van Beurden, Barnett, & Dietrich, 2002). The development of these basic FMS such as running, skipping and jumping, is a prerequisite for the specialised movement phase, in which the child advances to more sports specific skills which allow lifelong PA participation (Gallahue & Ozmun, 2006; Hardy, King, Farrell, Macniven, & Howlett, 2010). A common misconception exists however, that these skills develop naturally as a result of maturation (Clark, 2007; Cools et al., 2009; Stodden et al., 2008); the role instruction and practice plays in the development of FMS must not be negated (Clark, 2007).

These basic FMS should be mastered by the age of 10, hence much research has investigated skill levels in children aged 10 and under. Research consistently reports low levels of FMS mastery in children (Hardy, Barnett, Espinel, & Okely, 2013; Hardy et al., 2010) which is concerning considering childhood proficiency is predictive of proficiency in adolescence, and later life (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010). Similar trends have been observed in adolescent populations (Booth et al., 1999; Hardy et al., 2013, 2010; Mitchell et al., 2013; O' Brien, Belton, & Issartel, 2015), which perhaps is more worrying considering the expectation that these FMS be fully mastered by this stage. In an

Irish context O’Brien and colleagues (2015) found that in a population of 12 year old adolescents, only 11% of children achieved advanced skill proficiency for the nine FMS tested. From a sample of 223 participants, only one participant was at complete mastery level across all nine movement skills (O’ Brien et al., 2015). Although proficiency levels differ from country to country, globally they are consistently low and certainly below the recommended age appropriate levels. The need to promote FMS mastery in both children and adolescents is therefore evident, in order to develop skilled individuals who can participate in lifelong recreation and competitive activities, and can use these skills in lifelong daily living situations.

The health benefits associated with FMS proficiency, which are emerging in recent research, provide further argument for the need to intervene and improve the low levels of mastery observed. A positive relationship between FMS and PA has emerged (Lubans, Morgan, Cliff, Barnett, & Okely, 2010), with higher levels of FMS proficiency associated with increased levels of PA participation. Limited research has investigated the direction of this relationship. Stodden and colleagues (2008) proposed that a reciprocal relationship exists between FMS and PA and demonstrates a ‘positive spiral of engagement’ i.e. children who are skilled participate in more PA giving them greater opportunities to develop their skills, a higher perceived skill competence and hence more impetus to be active. Barnett and colleagues (2011) found some evidence to support this hypothesis with positive cross-sectional associations found between object control and PA, in both directions. Evidence of this reciprocal relationship in the early stages of adolescence (12 years of age) has yet to be investigated, for overall FMS as well as its composite subtests (object control and locomotor). A greater understanding of this hypothesised relationship will help in the development of targeted interventions to increase both PA and FMS levels.

Further health benefits associated with the development of FMS include increased health-related fitness (HRF). According to the Stodden model (2008) HRF develops as a result of motor skill proficiency in early childhood. Stodden and colleagues (2008) proposed in middle and late childhood that HRF mediates the relationship between FMS and PA. Recent evidence suggests there is a direct relationship between the components of HRF and motor competency, with positive associations found between FMS and cardio-respiratory fitness, and musculoskeletal fitness (Cattuzzo et al., 2014; Lubans et al., 2010; Stodden, Langendorfer, & Roberton, 2009). Of most interest is the hypothesised mediating role HRF plays in the relationship between FMS and PA, considering the low PA levels and low FMS proficiency observed in youth, specifically in an Irish context. Hence, if the efficacy of this mediating pathway is identified, enhancing adolescent fitness could potentially serve to enhance both PA participation and skill development.

1.2.3 Correlates of Fundamental Movement Skills

The case for improving FMS proficiency is evident given the low levels consistently observed worldwide and the role motor proficiency plays in the initiation, maintenance, or decline of PA levels (Stodden et al., 2008). Extensive research has been conducted on the correlates of FMS. Biological and demographic variables such as age, weight status, gender, and socioeconomic status, are some of the most frequently examined correlates of FMS (Barnett et al., 2016). Behavioural attributes traditionally explored include PA and sports participation (Barnett et al., 2016). There is a notable absence of research considering psychological and psychosocial variables, which may go some way in explaining the complex nature of FMS proficiency (Barnett et al., 2016). Psychological and psychosocial variables believed to influence children’s PA behaviour include self-efficacy, attitudes and beliefs regarding PA, perceptions of own abilities, enjoyment, social support from parents, peers and teachers, and barriers and access to facilities (Welk, 1999). Considering the association between PA and FMS competency, it is possible that the psychological and psychosocial correlates that are associated with PA are not dissimilar for FMS. Hence in an attempt to fully understand the nature of FMS development, and how best to intervene, other potential unexplored correlates must be investigated.

1.2.4 Targeting Physical Activity and Fundamental Movement Skills

The evidence presented to date supports the need for the development, implementation and evaluation of interventions aimed at improving PA levels and FMS proficiency in adolescents. The WHO advocates for interventions which target PA amongst youth (Currie et al., 2012). Woods and colleagues (2010) suggest the development of FMS provides pathways for participation in PA, and hence should be included in interventions seeking to address the low levels of PA observed. Schools provide the ideal setting for the implementation of interventions of this nature, in view of the amount of waking hours adolescents spend in this environment (Haerens et al., 2006; O'Brien, Issartel, & Belton, 2013). Research suggests physical education (PE) is the best placed public health system through which improvements in PA levels can be made and teaching and learning of FMS can occur. The presence of mandatory PE provides the medium through which to affect change in PA behaviour (Heath et al., 2012). The availability of resources and equipment, PE curricula and lessons, and PE specialists, suggests the school and specifically PE class is best placed to implement effective PA and FMS interventions (Breslin, Murphy, McKee, Delaney, & Dempster, 2012).

The Youth-Physical Activity Towards Health (Y-PATH) intervention was developed and preliminarily trialled (Belton, O' Brien, Meegan, Woods, & Issartel, 2014) in response to the strategic advice provided by Woods and colleagues (2010). The Y-PATH intervention is a multi-component (parent/guardian, student, and teacher) school-based intervention aimed at improving PA levels and FMS proficiency in Irish youth (Belton et al., 2014). The purpose of the Y-PATH intervention is to target both locomotor and object control FMS proficiency, increase PA levels through the development of self-efficacy and a positive attitude towards PA, incorporate choice into PE lessons through a motivational climate so all students can participate, and to educate students on the health benefits associated with leading a physically active life (Belton et al., 2014). Some evidence for the efficacy of the Y-PATH intervention has been presented previously based on an exploratory trial involving two schools (O'Brien et al., 2013). In order to accurately assess the reproducibility of these results and the efficacy of the Y-PATH intervention, its implementation and evaluation must be assessed using a larger randomised controlled trial (RCT), in line with the Medical Research Council (MRC) framework (Campbell et al., 2000; O'Brien et al., 2013). Also of interest is the long-term effect of the Y-PATH intervention, considering the majority of interventions investigate only the short-term effect (Baranowski et al., 2011; Cliff et al., 2011). Increases in PA as a result of targeted interventions are encouraging, however from a public health perspective the sustainability of these results over a lifetime is of utmost importance. Short-term solutions to the global PA epidemic are not sufficient. An effective PA intervention which improves PA participation over a prolonged period of time is essential.

1.2.5 Summary and Significance of this Thesis

1.2.5.1 Understanding the Relationship between Physical Activity and Fundamental Movement Skills

- Globally adolescent PA levels are extremely low (Hallal et al., 2012). An age related decline in PA across transitional stages i.e. from childhood to adolescence, has been observed (Hallal et al., 2012; Woods et al., 2010). PA behaviour tracks from adolescence into adulthood (Telama et al., 2005), suggesting that interventions during these influential years are necessary. Understanding the relationship between PA and FMS is of paramount importance if interventions are to be effective. This thesis aims to identify whether a reciprocal relationship exists between PA and FMS, which is considered a significant gap in the literature (Robinson et al., 2015)..

- Stodden and colleagues (2008) proposed HRF mediates the relationship between PA and FMS. If the results support the efficacy of this mediating pathway, increasing adolescent fitness may serve to enhance both PA participation and skill development. This thesis seeks to investigate the role of HRF as a mediator in the hypothesised reciprocal relationship between PA and FMS, which will provide a substantial contribution to the literature (Robinson et al., 2015).

1.2.5.2 Developing Understanding of Physical Activity in Youth

- Potentially daily patterns of PA exist, which differentiate children who are as a whole 'more' active from those who are 'less' active children. This thesis seeks to determine whether daily patterns of PA differ across weekday/weekend, gender, and activity level; with an aim to address how this information could be used to guide future intervention strategies, as advocated by Hesketh et al. (2014).

1.2.5.3 Developing Understanding of Fundamental Movement Skills in Youth

- Understanding the correlates of FMS could assist in the development of targeted interventions seeking to improve current proficiency levels. Little research in the way of potential psychological and psychosocial correlates of FMS has been conducted (Barnett et al., 2016). Considering the consistent positive relationship between PA and FMS, traditional correlates of PA such as self-efficacy, social support and barriers to

PA may demonstrate a similar relationship with FMS, hence further developing our understanding of skill competence. This thesis will assess the relationship between several psychological and psychosocial correlates traditionally associated with PA (i.e. PA self-efficacy, barriers to PA, and PA social support), and FMS proficiency, hence addressing a considerable gap in the literature (Barnett et al., 2016).

1.2.5.4 Providing an Effective Intervention Strategy for Targeting Physical Activity and Fundamental Movement Skills in Youth

- The results from an exploratory trial of the Y-PATH intervention were positive, suggesting that Y-PATH has the ability to improve PA levels and FMS proficiency in youth (O'Brien et al., 2013). It is essential that the reproducibility of these results be tested on a larger scale, with an aim to addressing the long-term potential of Y-PATH to improve PA behaviour in Irish adolescents (O'Brien et al., 2013). This thesis aims to assess the efficacy of the long-term effect of the Y-PATH intervention on school day PA behaviour, and to determine whether differences in intervention effect by subgroup (gender, weight status, FMS level, VO_{2max} level) exist.

1.3 Aim and Objectives of the Study

Aim of Research:

The primary aim of this research was to implement, and evaluate the efficacy of the Y-PATH targeted school-based intervention designed to increase physical activity levels in Irish adolescents.

Primary Objective:

1. To assess the changes in school day physical activity behaviour (baseline, one year follow-up, and two year follow-up) of the experimental group (Y-PATH intervention) compared with the control group *(Chapter 6)*.

Secondary Objectives:

1. To explore the hypothesised reciprocal relationship between fundamental movement skills and physical activity *(Chapter 3)*.
2. To explore the role of health-related fitness as a mediator of the relationship between fundamental movement skills and physical activity *(Chapter 3)*.
3. To investigate whether the psychological and psychosocial correlates of physical activity also apply to fundamental movement skills *(Chapter 4)*.
4. To investigate the role of physical activity as a mediator between the psychological and psychosocial correlates of physical activity, and fundamental movement skills *(Chapter 4)*.

5. To explore the daily patterns of physical activity in early adolescent youth to determine whether specific time periods during the day pattern together, and identify whether patterns differed across varying activity levels *(Chapter 5)*.
6. To assess the efficacy of the Y-PATH intervention in improving PA levels in the intervention condition, in comparison to the control, during specific school day time periods as identified in Chapter 5 *(Chapter 6)*.
7. To assess any intervention effect on physical activity behaviour by gender, age, weight status, fundamental movement skill proficiency and VO_{2max} levels *(Chapter 6)*.

1.4 Research Questions

1. Does the Y-PATH intervention improve school day physical activity levels of adolescents, compared to adolescents in control schools, when assessed using a cluster randomised controlled trial *(Primary Objective 1)*?
2. Does a reciprocal relationship exist between physical activity and fundamental movement skills, and does health-related fitness play a role in mediating this relationship *(Secondary Objectives 1 & 2)*?
3. Do psychological and psychosocial correlates traditionally associated with physical activity correlate with fundamental movement skills and does physical activity mediate these relationships *(Secondary Objectives 3 & 4)*?
4. Do physical activity levels pattern during specific time periods during the day, and do these patterns differ across varying activity levels *(Secondary Objective 5)*?
5. Does a generic physical activity intervention aimed at improving overall physical activity levels improve physical activity during specific time periods during weekdays *(Secondary Objective 6)*?
6. Does the Y-PATH intervention effect on physical activity levels differ by subgroup (gender, weight status, fundamental movement skills level, or VO_{2max} level) *(Secondary Objective 7)?*

1.5 Thesis Structure

Following this introductory chapter, Chapter 2 will critically review and evaluate the literature on youth PA, FMS, the need to intervene, and appropriate and effective methods of intervention. Chapters 3 to 6 address the primary and secondary objectives of this thesis. Chapters 3 and 4 are cross-sectional studies exploring the baseline data prior to the intervention implementation, and examine the relationship between FMS proficiency and PA behaviours, as well as the correlates and mediators of this relationship. Chapter 5 presents a published study which the PhD researcher was last author on, investigating patterns of PA in adolescent youth using cross-sectional data. Chapter 6 assesses the efficacy of the Y-PATH intervention at improving school day PA levels of adolescents.

Chapter 2 - *Review of Literature.* The review of the literature examines existing research in the areas of youth PA, FMS, and interventions (specifically school-based), in an attempt to synthesise various ideas, results, and evidence which have informed the direction of this thesis.

Chapter 3 - *Exploring the role of health-related fitness as a mediator of the reciprocal relationship between fundamental movement skills and physical activity.* This chapter investigates the hypothesised reciprocal relationship between PA and FMS, including its composite groups (i.e. object control and locomotor skills). The mediating role of HRF in the reciprocal relationship between PA and FMS is also explored.

Chapter 4 - *Are the correlates of fundamental movement skill proficiency similar to the correlates of physical activity in adolescents?* This chapter seeks to identify whether psychological and psychosocial correlates traditionally associated with PA, act in a similar way with FMS given the relationship between PA and FMS. The correlates investigated include PA self-efficacy, barriers to PA, and social support. The role of PA in explaining these relationships is also assessed.

Chapter 5 - *Where does the time go? Patterns of physical activity in adolescent youth.* PA behaviour has been extensively researched with habitual PA participation in adolescents most frequently referred to in terms of total minutes of MVPA. This study, published in the Journal of Science and Medicine in Sport 2016, takes a novel approach to PA behaviour in youth, investigating the daily patterns of PA across weekdays and weekends, and across varying time periods within the day. The paper then seeks to identify whether PA differs across weekday/weekend, gender, and activity level.

Chapter 6 - *An evaluation of the randomised controlled trial of the Youth-Physical Activity Towards Health (Y-PATH) intervention - Can we improve physical activity levels in youth?* This chapter assesses the efficacy of the Y-PATH intervention in improving school day PA levels over a two year period. Data for this chapter was collected at three time points: baseline (September 2013), one year follow-up (September 2014), and two year follow-up (September 2015). Chapter 6 also evaluates the effect of the Y-PATH intervention at one and two year follow-up by subgroup (gender, age, weight status, FMS level, and VO_{2max}).

1.6 Definition of Terms

Accelerometer: Accelerometers are motion sensors which collect quantitative information about the vertical accelerations of the trunk and other body segments, at pre-determined time intervals (Trost, 2007). They provide information detailing physical activity intensity, frequency, pattern and duration.

Barriers to Physical Activity: Barriers to physical activity are perceived factors which prevent physical activity participation. Barriers to physical activity commonly include; cost, weather, pollution, lack of access, age, disability or injury, tiredness, lack of time, work and family commitments and other priorities (Salmon, Owen, Crawford, Bauman, & Sallis, 2003).

Body Mass Index: This is a measure of body composition derived from the formula weight (kg) divided by height (m^2). Gender-specific body mass index cut points are often then applied to define weight status into categories such as underweight, normal weight, overweight and obese.

Children and Young People: Persons aged five to 18 years. The term children denotes individuals aged five to 12 years and young people is used when referring to those aged 13 to 18 years (BHF National Centre Physical Activity and Health, 2013).

Fundamental Movement Skills: Fundamental movement skills are goal-directed movement patterns, traditionally divided into three subscales namely: locomotor (changing the location of the body relative to a fixed point in the environment), object control (imparting to, or alternatively receiving force from, an object), and stability skills (gaining and maintaining equilibrium relative to the force of gravity) (Burton & Miller, 1998). Examples of fundamental movement skills include running, hopping, skipping (locomotor), balancing (stability), throwing, catching and kicking (object control).

Health-Related Fitness: Physical fitness is the ability to perform everyday activities with vigour, and display a low risk of disease associated with inactivity (Pate, 1988). The components of fitness according to Pate (1988) comprise of; cardio-respiratory endurance, body composition, muscular strength/endurance, and flexibility.

Locomotor Skills: Locomotor skills such as running, skipping, and hopping, concern changing the location of the body relative to a fixed point in the environment (Gallahue & Ozmun, 2006).

Mastery/Near Mastery: Mastery in terms of fundamental movement skills suggests all components are performed correctly (van Beurden et al., 2002). Near mastery is defined as the correct performance of all components but one (van Beurden et al., 2002).

Mediator: A mediator variable accounts to some extent for the relationship between a predictor (independent variable) and criterion variable (dependent variable) (Baron & Kenny, 1986).

Moderate Physical Activity: Activities which leave an individual slightly out of breath and warm such as brisk walking (Cavill, Biddle, & Sallis, 2001).

Non-Communicable Disease: Non-communicable diseases are diseases which are neither contagious nor transferrable among people (BHF National Centre Physical Activity and Health, 2013).

Obesity: Obesity is defined as excess adiposity which is not conducive to health (Welk, Corbin, & Welk, 2006).

Object Control Skills: Object control skills such as catching, throwing and kicking, involve imparting to, or alternatively receiving force from, an object (Gallahue & Ozmun, 2006).

Patterns of Physical Activity: Patterns of physical activity refers to the clustering of physical activity during different periods of the day (Jago, Fox, Page, Brockman, & Thompson, 2010).

Perceived Competence: Perceived competence is defined as how a person perceives their ability to perform a skill or activity competently (Harter & Pike, 1984).

Physical Activity Intervention: Specific programmes developed in an attempt to increase exercise or physical activity behaviour, at an individual, group or population level, with the overriding purpose of resulting in positive health outcomes (Bouchard, Blair, & Haskell, 2012).

Physical Activity: Physical activity has been defined as any bodily movement produced by the skeletal muscles which results in an increase in energy expenditure above resting levels (Caspersen & Christenson, 1985).

Physical Education: Physical Education is a school subject which aims to provide learning opportunities and contribute to the overall development of children, through the medium of movement (Department of Education and Skills, 1999). The purpose of physical education is to enable young people to lead full, active and healthy lives (Department of Education and Skills, 1999).

Physical Inactivity: Physical inactivity is often defined in terms of not meeting the physical activity guideline deemed essential for health benefits. It comprises of doing little to no physical activity in daily living (work or home), for transport or during free time (Bouchard, Blair, & Haskell, 2012).

Post-Primary Education: The post-primary education sector consists of secondary, vocational, community and comprehensive schools. Post-primary education is divided into two cycles; the Junior Cycle (3 years) and Senior Cycle (2 - 3 years depending on an optional transition year). Students usually complete the Junior Cycle between the ages of 12 to 15. The Senior Cycle caters for students in the 15 to 18 year age group (Department of Education and Skills, 2004).

Psychological and Psychosocial: Psychological and psychosocial are often used interchangeably and refer to factors such as self-efficacy, perceived barriers to physical activity, and social support.

Reciprocal Relationship: A reciprocal relationship in terms of physical activity and fundamental movement skills means physical activity enhances skills competence, in addition to the reverse (Stodden et al., 2008).

Reliability: Reliability is the process of determining whether two administrations of an instrument produce a similar result (Thomas, Nelson, & Silverman, 2011).

Screen-Time: Mean hours per day spent on television, videos, and computers/computer games. Guidelines for screen-time suggest spending less than two hours per day in these behaviours (Anderson, Economos, & Must, 2008).

Sedentary Behaviour: Sedentary behaviours are defined as activities that do not result in substantial increases in energy expenditure above resting levels such as sleeping, sitting, lying, watching television and other screen-time pursuits (Pate, O'Neill, & Lobelo, 2008). Sedentary behaviours are distinguished from other seated activities which require more effort such as using a rowing machine, by the lower energy requirements of sedentary pursuits (BHF National Centre Physical Activity and Health, 2013).

Self-Confidence: A measure of the level of confidence someone has in their abilities.

Self-Efficacy: Self-efficacy refers to the cognitive processes which underpin belief in ones abilities to achieve goals and execute actions in given situations (Bandura, 1994).

Social Support: Encouragement, modelling, and support provided by parents, teachers, peers and coaches, to be physically active (Welk, 1999)

Test of Gross Motor Development-2: The Test of Gross Motor Development-2 is a gross movement performance measurement tool which provides criterion and norm-referenced data about the process of how children coordinate their trunk and limbs during the performance of fundamental movement skills (Ulrich, 2000).

Validity: The extent to which an instrument measures what it is supposed to (Thomas, Nelson, & Silverman, 2011).

Vigorous Physical Activity: Activities which cause an individual to feel out of breath and sweaty; usually the equivalent of at the very minimum light jogging (Cavill, Biddle, & Sallis, 2001).

1.7 List of Abbreviations

AHA study = Amherest Health and Activity study

BMI = Body Mass Index

BOT-2 = Bruininks-Oseretsky Test 2nd Edition

BOTMP = Bruininks-Oseretsky Test of Motor Proficiency

CARS = Children's Activity Rating Scale

CHD = Coronary Heart Disease

CI = Confidence Interval

CONSORT = Consolidated Standards of Reporting Trials

CPAF = Children's Physical Activity Form

CSPPA Study = Children’s Sport Participation and Physical Activity Study

CVD = Cardiovascular Disease

DCU = Dublin City University

DCUREC = Dublin City University Research Ethics Committee

DLW = Doubly labelled water

EE = Energy Expenditure

FMS = Fundamental Movement Skills

HBSC study = Health Behaviour in School-Aged Children study

HFF = Health-Related Fitness

HRA = Health-Related Activity

ICC = Intraclass Correlation

IPAN = Institute for Physical Activity and Nutrition

KTK = Körperkoordinationtest für Kinder

LEAP = Lifestyle Education for Activity Program

M-ABC = Movement Assessment Battery for Children

MIGI = Move It Groove it

MRC = Medical Research Council

M-SPAN = Middle School Physical Activity and Nutrition

MVPA = Moderate to Vigorous Physical Activity

NASPE = National Association for Sport and Physical Education

NCD = Non-Communicable Disease

NHANES = National Health and Nutritional Examination Survey

NW = Normal Weight

OSRAC-Preschool = Observational System for Recording Physical Activity in Children-Preschool

OWOB = Overweight and Obese

PA = Physical Activity

PAEE = Physical Activity Energy Expenditure

PAQ-C/PAQ-A = Physical Activity Questionnaire for Children/Adolescents

PASS = Physical Activity in Scottish Schoolchildren

PCA = Principal Components Analysis

PE = Physical Education

Q = Quartiles

RCT = Randomised Controlled Trial

SD = Standard Deviation

SE = Standard Error

SEQ = Self-Efficacy Questionnaire

SOCARP = System for Observing Children's Activity and Relationships during Play

SOFIT = System for Observing Fitness Instruction Time

SOPLAY = System for Observing Play and Leisure Activity in Youth

SPARK = Sports, Play, and Active Recreation for Kids

TGMD = Test of Gross Motor Development

TGMD-2 = Test of Gross Motor Development 2nd Edition

UK = United Kingdom

US = United States

VPA = Vigorous Physical Activity

WHO = World Health Organisation

YPAP = Youth Physical Activity Promotion

YPAQ = Youth Physical Activity Questionnaire

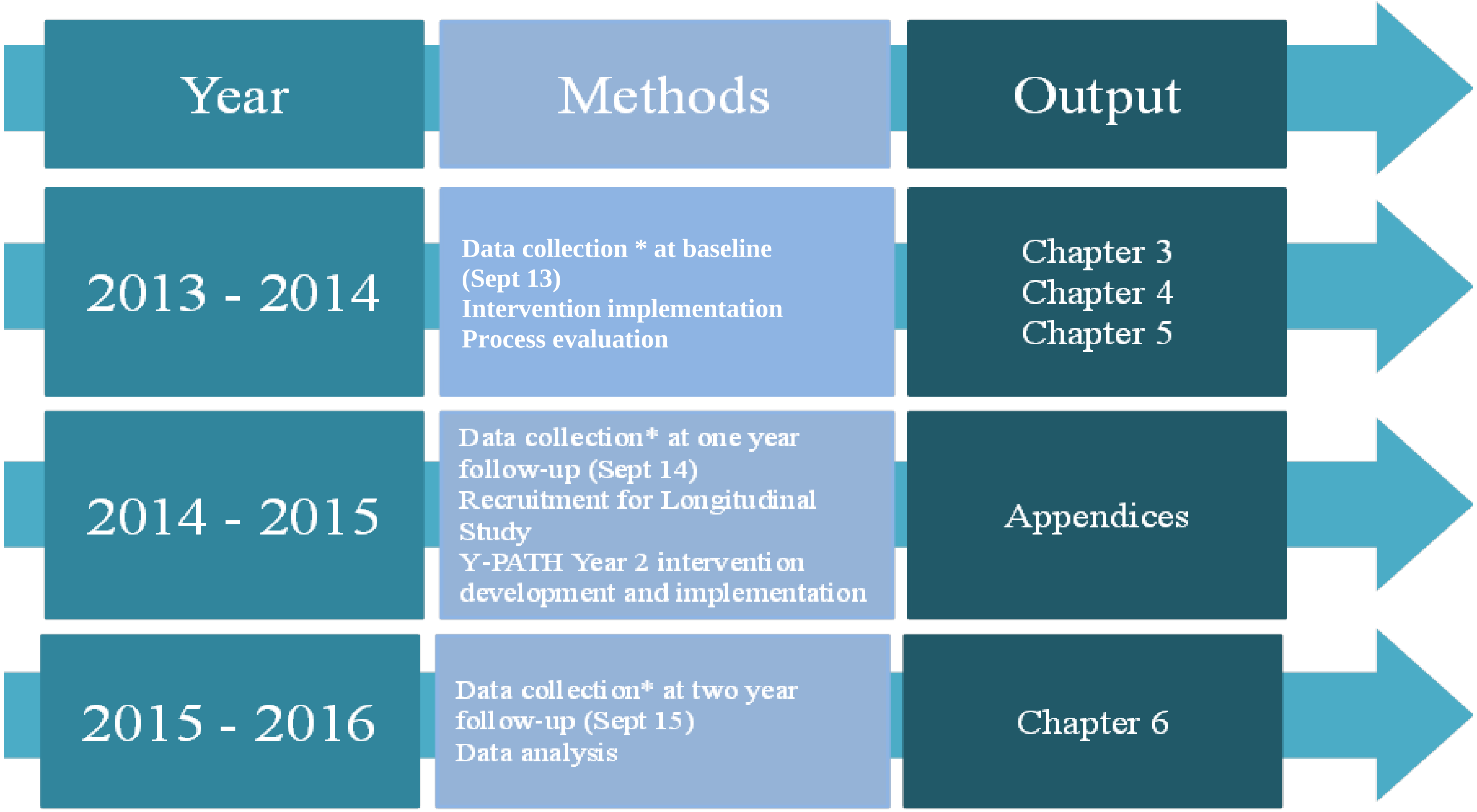
Y-PATH = Youth-Physical Activity Towards Health

YRBS = Youth Risk Behaviour Surveillance Survey

1.8 Delimitations

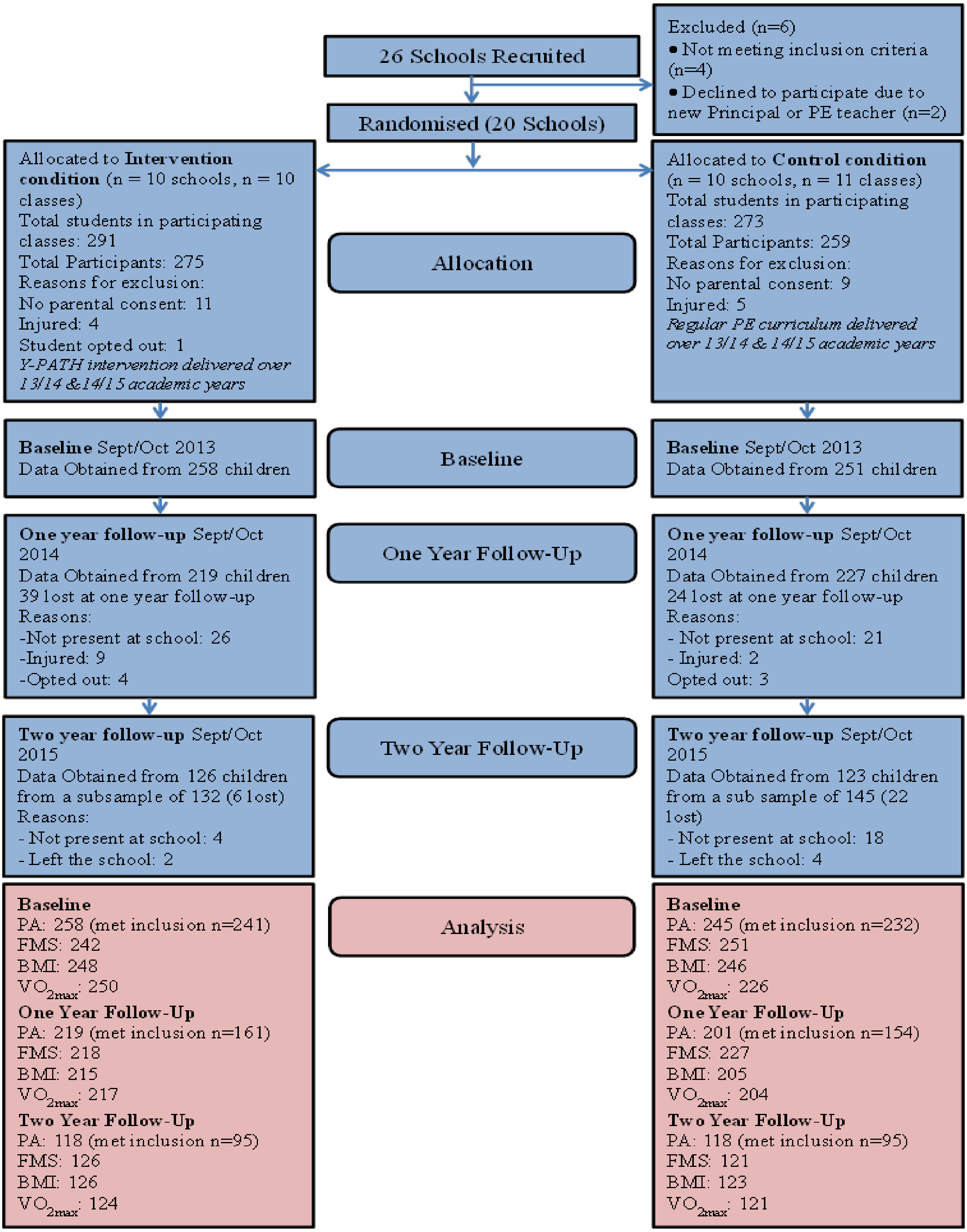
1. This study was delimited to first year post-primary youth at baseline, aged between 12 to 14 years.
2. The Y-PATH intervention was implemented in mixed-gender schools only in County Dublin (intervention n = 10).
3. The Y-PATH intervention lasted for one year in all intervention schools (n = 10) and two years in a subsample of intervention schools (n = 5). A third intervention year to coincide with all years of the Junior Cycle Physical Education curriculum has not been developed yet.
4. This study used accelerometers to measure physical activity behaviour which were restricted due to compliance issues.
5. This study assessed only gross fundamental movement skills and was delimited in that it did not measure fine motor skill proficiency.

1.9 Schematic Overview



Note. * = Data were collected as part of the Y-PATH programme on physical activity, body mass index, fitness levels, fundamental movement skills, and numerous psychological and psychosocial variables, however not all variables were the primary responsibility for this PhD.

1.10 Participant Overview



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Chapter 2

Literature Review

The purpose of this literature review is to summarise, synthesise and discuss the literature on physical activity, followed by fundamental movement skills and finally physical activity interventions (specifically school-based interventions).

2.1 Physical Activity

The purpose of this section is to review the literature regarding physical activity (PA) behaviour, participation and measurement in both children and adolescents. Firstly, the rationale for the importance of participating in PA will be explored, then the PA and sedentary guidelines, followed by the PA measurement tools and PA levels. Finally, the correlates of PA will be examined.

2.1.1 Physical Activity in the Modern Context

Prior to the industrial revolution people participated in much more labour intensive activities as part of their daily lives (Hallal, Andersen, Bull, Guthold, & Haskell, 2012). With an increase in the availability of new technological devices, PA has been gradually engineered out of our lives (Hallal et al., 2012). The introduction of steam, gas and electric engines, trains, and cars has all had an adverse effect on the worlds activity levels, activity which up this this point had been naturally embedded in daily living through active commuting and physically demanding jobs (Hallal et al., 2012). Much of the technology which has been introduced in the workplace and home in the last few decades has specifically aimed to reduce the physical demands on the body and increase worker productivity (Hallal et al., 2012). In recent years, more subtle advances in technology have significantly reduced activity levels (Hallal et al., 2012). The current generation of youth are extremely engaged with technology with the prevalence of screen-time ever increasing, namely through the use of technologies such as televisions, computers, internet, and other hand held devices (e.g.

mobile phones, iPads etc) (Bickham, Blood, Walls, Shrier, & Rich, 2013; Biddle, Pearson, Ross, & Braithwaite, 2010; Oliver, Duncan, Kuch, McPhee, & Schofield, 2012). Multiple sources have demonstrated that children and adolescents are spending the majority of their free time participating in these sedentary pursuits (Colley et al., 2011; Matthews et al., 2008; Whitt-Glover et al., 2009). Time spent in sedentary behaviour will be discussed in further detail later in the literature review, however it is important to note now that with an increasing prevalence of sedentary behaviour globally (Rey-López, Vicente-Rodríguez, Biosca, & Moreno, 2008), awareness of the importance and health benefits associated with leading a physically active lifestyle during both childhood and adulthood, needs to be created. PA has been defined as any bodily movement produced by the skeletal muscles which results in an increase in energy expenditure (EE) above resting levels (Caspersen & Christenson, 1985). Energy expenditure resulting from participation in PA can vary from low to high levels (Caspersen & Christenson, 1985). Intensities of PA can also be used to categorise PA i.e. light, moderate or vigorous (Caspersen & Christenson, 1985). This definition has been widely accepted amongst PA practitioners and researchers (Bouchard, Blair, Haskell, 2007; Caspersen & Christenson, 1985; Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010). In recent times, PA has been considered in terms of leisure time PA, exercise, sport, transportation, occupational work and chores (Bouchard el al., 2007). Leisure time PA can be considered in terms of sports, conditioning exercises, household chores and other activities (Caspersen & Christenson, 1985).

2.1.2 Health Benefits and Importance of Participating in Physical Activity

Strong evidence suggests that participation in PA is associated with lower rates of all-cause mortality, coronary heart disease (CHD), high blood pressure, stroke, metabolic syndrome, type II diabetes, breast cancer, colon cancer, depression, and falling (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Those who participate in regular PA are also likely to demonstrate higher levels of cardio-respiratory and muscular fitness, healthier body mass and composition, superior bone health, higher levels of functional health and better cognitive function (Warburton et al., 2010). Research conducted by the World Health Organisation (WHO - 2010), identified chronic disease as the greatest health burden the world faces. Low levels of PA behaviour have been associated with increases in health risk factors, which include the world's major non-communicable diseases (NCDs), namely CHD, type II diabetes, some cancers (breast and colon cancers), and all-cause mortality (Lee et al., 2012). Hence, increasing PA levels will aid in the reduction and cost to society of NCDs (Allender, Foster, Scarborough, & Rayner, 2007).

Independent of PA, sedentary behaviours are associated with increased cardio-metabolic disease, all-cause mortality and various physiological and psychological problems (Tremblay et al., 2011). A systematic review conducted by Proper and colleagues (2011) investigated the relationship between sedentary behaviours and health outcomes in adults. They identified a positive relationship between time spent sitting and the risk for type II diabetes (Proper, Singh, Van Mechelen, & Chinapaw, 2011). Furthermore, strong evidence of a relationship between all-cause and cardiovascular disease, was found in adults (Proper et al., 2011). Thorp and colleagues (2011) conducted a systematic review of longitudinal studies investigating sedentary behaviours and subsequent health outcomes. From self-report data, a consistent relationship of sedentary behaviour with mortality and weight gain was identified (Thorp, Owen, Neuhaus, & Dunstan, 2011). Using objectively measured sedentary time, one study from three, found markers of obesity predicted sedentary time in adults (Thorp et al., 2011). Sedentary time in youth is also associated with undesirable health outcomes. Tremblay and colleagues (2011) conducted a systematic review of sedentary behaviour and health indicators in school children. They found in a cohort of five to 17 year olds, that watching television for more than two hours per day was associated with unfavourable body composition, decreased fitness, lower self-esteem scores and decreased academic achievement (Tremblay et al., 2011). Decreasing sedentary behaviour was found to lower health risk factors in youth (Tremblay et al., 2011). Research suggests that daily television viewing of two hours or more is associated with reduced physical and psychosocial health, and that lowering sedentary time leads to reductions in body mass index (BMI - Tremblay et al., 2011).

On average 1% to 2.6% of total healthcare costs are due to physical inactivity (Pratt, Norris, Lobelo, Roux, & Wang, 2014). Oldridge (2008) identified the direct cost of cardiovascular disease (CVD) as a result of inactivity was between 1.5% and 3%. This is without considering the indirect costs associated with inactivity, such as premature death and disability, which tend to be more burdensome on society than the direct costs (Pratt et al., 2014). The burden of PA-related ill health in the UK in 2002 cost an estimated £1.06 billion to the National Health Service (Allender et al., 2007). Physical inactivity was directly responsible for 3% of years life lost due to disability (Allender et al., 2007). In Canada in 2001, the economic burden of physical inactivity was estimated to cost \$5.3 billion which equated to \$1.6 billion in direct costs and a further \$2.7 billion in indirect costs (almost double that of the direct costs) (Katzmarzyk & Janssen, 2004). The total economic costs of physical inactivity and obesity was 2.6% and 2.2%, respectively, of the total health care costs in Canada (Katzmarzyk & Janssen, 2004). It is estimated that 3.3 million people around the world die due to physical inactivity (World Health Organisation, 2009). Hence, physical inactivity is the fourth leading cause of death (World Health Organisation, 2009). More recent findings suggest that 5.3 of 57 million deaths worldwide were attributed to physical inactivity in 2008 (Lee et al., 2012). The financial cost associated with inactivity and its contribution to avoidable deaths worldwide can be prevented (World Health Organisation, 2010). It is approximated that 2,000 deaths annually are attributable to obesity in Ireland, with the cost of treating obesity estimated at €0.4 billion (The Report of the National Taskforce on Obesity, 2005).

Targeting at risk populations is of paramount importance. The prevalence of inactivity in youth (Eaton, Kann, & Kinchen, 2012; Jago, Anderson, Baranowski, & Watson, 2005; Riddoch et al., 2004; Troiano et al., 2008) and increased incidence of overweight and obesity amongst this cohort is at unprecedented levels. An estimated 170 million children globally were classified as either overweight or obese (Lobstein, Baur, & Uauy, 2004). Of those, approximately 22 million children, globally, under the age of five are overweight (Deckelbaum, Williams, & Christine, 2001). Given that childhood obesity often tracks into adulthood, obese children are at risk of becoming obese adults and suffer from the associated risk factors (Dietz & Gortmaker, 2001). Obese children experience the same comorbidities as obese adults (Dietz & Gortmaker, 2001), meaning exposure to these factors from as young as five years old, could see an individual living with a NCDs for several decades before reaching adulthood, which in turn will increase the impact of risk factors on adult diseases. The 'Children's Sport Participation and Physical Activity' study (CSPPA study) found that one in four children (from a sample of 1,215) aged 13.4 years, were deemed unfit, overweight or obese and had high blood pressure (Woods et al., 2010). An inverse relationship between BMI and PA has consistently been found in research (Andersen et al., 2006; Ekelund et al., 2012; Metcalf et al., 2011; Mitchell et al., 2013) suggesting the importance of PA in combating this obesity epidemic. Considering that PA behaviour tracks across the age spectrum, from childhood into adolescence, and subsequently into adulthood (Telama et al., 2005), addressing the role of PA as a contributor toward health outcomes, is urgent early in transitional stages. A collective voice from policy makers in terms of PA recommendations is necessary to address the current PA issues faced.

2.1.3 Physical Activity and Sedentary Guidelines

Physical inactivity and sedentary behaviour, have been recognised as predictors of chronic disease and illness amongst both youth and adults (Jago et al., 2005; Riddoch et al., 2004; Tremblay et al., 2011; Troiano et al., 2008). Simply understanding the health benefits associated with PA participation is not sufficient as it does not provide practical advice, which can be applied to individuals' daily lives to evoke change in behaviour. Extensive research has been conducted with a view to providing PA and sedentary behaviour guidelines (American College of Sports Medicine, 1988; Biddle, Cavill, & Sallis, 1998; Byers et al., 2002; NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1995; Sallis & Patrick; 1994; Tremblay, Warburton, et al., 2011).

Given the health benefits associated with regular PA participation, quantifying the amount and frequency of PA required has been of utmost importance over the past four decades. In 1988, the American College of Sports Medicine recommended that all children and youth obtain between 20 and 30 minutes of vigorous exercise each day (American College of Sports Medicine, 1988). The evolution of these recommendations has been ongoing. Sallis and Patrick (1994), in collaboration with the International Consensus Conference on Physical Activity Guidelines for Adolescents, reported that people aged 11 to 21 years should be physically active daily as part of an active lifestyle and engage in at least three sessions per week of moderate to vigorous activities lasting 20 minutes or more. In 1995, the NIH Consensus Development Panel on Physical Activity and Cardiovascular Health advised that all youth should accumulate 30 minutes of moderate PA on most or all days per week (NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1995). The UK Health Education Authority (Biddle et al., 1998) deemed this level of activity insufficient and recommended that children and youth participate in at least moderate intensity PA, for one hour per day. Supplementary to this, were suggestions that children and youth should also partake in strengthening exercises for the trunk and upper arm girdle on at least two or more days per week (Biddle et al., 1998). The Department of Health and Ageing in Australia (1999), in addition to recommending participation in at least 60 minutes of moderate to vigorous PA (MVPA) per day (5 - 18 year olds), also advocated for a reduction in screen-time to less than two hours per day. Development of these guidelines continued into the new century with the American Cancer Society (Byers et al., 2002) agreeing on the duration of PA suggested by the Department of Health and Ageing in Australia (1999), however the frequency differed in that they considered meeting these guidelines on five days per week, sufficient. In more recent times, accumulating at least 60 minutes of MVPA on most, or all days per week, is believed suitable levels of PA for children and youth (Strong et al., 2005; US Department of Health and Human Services and US Department of Agriculture, 2005). Recent research by Tremblay and colleagues (2011), led to the development of the new Canadian physical activity guidelines, which suggest that children and youth should be active daily through play, games, sports, transportation, recreation, physical education (PE), or planned exercise in order to accumulate PA through the course of daily living (Tremblay, Warburton, et al., 2011). It is recommended that children and youth accumulate at least 60 minutes of MVPA every day (Tremblay, Warburton, et al., 2011). The recommendations include participating in vigorous PA at least three times per week and muscular strengthening activities at least three times per week also (Tremblay, Warburton, et al., 2011). Meeting the PA guideline can improve cholesterol levels, blood pressure, body composition, bone density, cardio-respiratory and musculoskeletal fitness, and aspects of mental health in children and youth (Tremblay, Warburton, et al., 2011). The most recent and widely accepted PA guideline in the US and UK stipulate that youth should accumulate at least 60 minutes of MVPA on a daily basis in order to experience associated health and fitness benefits (BHF

National Centre for Physical Activity and Health, 2013; Physical Activity Guidelines Advisory Committee, 2012).

In an Irish context, the guideline is consistent with US and UK recommendations. The Department of Health and Children (2009), suggests Irish children and youth (aged 2 - 18 years), should be active for a least 60 minutes daily at moderate to vigorous intensity, incorporating muscle strengthening, flexibility and bone strengthening exercises, three times per week (Department of Health and Children, 2009). Updated UK guidelines in 2011 (Department of Health, Physical Activity, Health Improvement and Protection, 2011), only differed from current Irish recommendations in that they considered time spent on sedentary pursuits; suggesting the importance of children and young people minimising the amount of time spent sedentary for extended periods (Department of Health, Physical Activity, Health Improvement and Protection, 2011).

Canadian research has also sought to address the ever growing issue of sedentary pursuits in youth by developing sedentary behaviour guidelines for children (aged 5 - 11 years) and youth (aged 12 - 17 years) (Tremblay et al., 2011). Tremblay and colleagues (2011), recommend that children and youth should limit recreational screen-time (television, computer, video games etc), motorised transportation, time spent indoors, and time spent sitting within the context of the family, school and community. They suggest that recreational screen-time should be limited to no more than two hours per day (Tremblay et al., 2011). Adhering to the guideline can improve body composition, cardio-respiratory and musculoskeletal fitness, academic achievement, self-esteem, and social behaviours (Tremblay et al., 2011).

In summary, the most recent PA guideline for children and youth focus predominantly on; the requirement for a minimum of 60 minutes daily spent on PA behaviour, moderate to vigorous intensity, the inclusion of muscular strength, flexibility and bone strengthening exercises, and a reduction in time spent in sedentary pursuits namely television viewing. In order to measure adherence to the guideline and to fully understand current PA levels, accurate measurement tools which provide precise information on PA behaviour of children and youth are necessary (Trost, 2007).

2.1.4 Physical Activity Measurement

The previous section highlighted current PA and sedentary behaviour guidelines necessary for health worldwide amongst adolescents and youth. It has illustrated the national and international requirement for PA promotion. In order for clinicians and practitioners to correctly identify and monitor PA levels, practical tools which facilitate the measurement of PA levels amongst children and adolescents, are required. Previous research has identified various measurement tools, which help assess the complex nature of PA and sedentary behaviour. Two predominant measures have been identified namely self-report and objective measuring techniques. This section seeks to review the current methods for measuring PA in children and adolescent populations considering the multiple facets to PA: frequency, intensity, time and type, with particular focus on accelerometry.

2.1.4.1 Self-Report Physical Activity Measurement

Extensive means of gathering PA data through self-report exist including; self-administered recalls, interviewer-administered recalls, diaries, and proxy reports. There is great disparity between each of the measures with regard to the evaluation of type, duration, frequency and intensity of PA, depending on the intent of the specific study. Recall times also vary and can range anything from a day to a year. Some of the major benefits of using such measures to document PA levels include the low levels of cost associated, the ease at which they can be implemented to collect PA data, and the ability to not only record time spent in PA but also the type of PA contextualised. Self-report measures provide an alternative to objective measures where they would simply be impractical to utilise, such as during epidemiological research.

Although self-report is often considered a convenient measure, there are considerable drawbacks primarily the associated recall bias. It has also been found that self-report is not a suitable measure for use with a younger population due to the inability of children (under the age of 10) to accurately recall their participation and time spent in PA (Baranowski et al., 1984). In addition young people tend to have a lack of understanding of the term PA, sedentary behaviours and the different PA behaviours (light, moderate and vigorous) (Trost, Morgan, Saunders, Felton, & Ward, 2000). There are certain self-report measures, which try to overcome these limitations, such as the video-supported measure developed by Belton and Mac Donncha (2010) for the seven to nine year old age group. Due to conflicting reports regarding self-report with younger populations, exercising caution when using such tools with populations 10 years and younger is essential.

2.1.4.2 Objective Physical Activity Measurement

Objective measures of PA include direct observation, doubly labelled water (DLW), heart rate monitoring, pedometers, and accelerometers. A brief description of all methods will be discussed with acclerometery examined in further detail.

1. Direct Observation: Direct observation procedures vary depending on the study. Traditionally they entail observing the child in natural settings such as at home or in school for a period of time, and coding their PA behaviours during this period. Momentary time sampling, such as intervals of five or 10 seconds, up to a minute, are used to record activity patterns of PA. Direct observation has been found to be a valid and reliable tool for classifying and quantifying PA behaviour. Several direct observational systems exist and are used to quantify and classify PA behaviour as well as contextualise it. Systems frequently used include; the System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie, Marshall, Sallis, & Conway, 2000), Observational System for Recording Physical Activity in Children-Preschool (OSRAC-Preschool) (McKenzie, Cohen, Sehgal, Williamson, & Golinelli, 2006), Children's Activity Rating Scale (CARS), and the System for Observing Fitness Instruction Time (SOFIT) (McKenzie, Sallis, & Nader, 1991). McKenzie (2002) compared nine different protocols for direct observation use in children. Eight of the nine protocols demonstrated strong concurrent validity with heart rate monitoring, accelerometery, and EE (indirect calorimetry). Percentage agreement for interobserver reliability ranged from 84% to 99% (McKenzie, 2002). Notably the advantages of employing direct observation include its flexibility, and its ability to not only provide a duration for PA but also to record factors which influence and relate to PA behaviour such as availability of equipment, and support from parents and peers (Trost, 2007).

2. Doubly Labelled Water: DLW is considered one of the most accurate means of measuring EE under free living conditions (Plasqui & Westerterp, 2007). DLW is both an unobtrusive and non-invasive means of measuring EE in free living young children (Trost, 2007). According to Murphy (2009), DLW is regarded as the gold standard in EE measurement over time. Due to the low levels of researcher input required, this technique allows individuals to maintain relative normality within their daily lives. Subjects consume isotope enriched water (generally deuterium and 18O). A direct measure of carbon dioxide production is subsequently provided and an accurate estimate of EE during PA, calculated (Schoeller, 1999; Sirard & Pate, 2001; Trost, 2007). This technique has been validated in both adults and children against indirect calorimetry. It has been found to be accurate to within five to 10%. A major limitation of DLW is the cost of implementing the technique (Trost, 2007).

3. Heart Rate Monitoring: Heart rate monitoring is a measure of PA derived from the stress placed on the cardiopulmonary system during activity (Armstrong, 1998). Heart rate monitors collect and store objective information about the heart rates response to PA (Kohl et al., 2000). Heart rate monitors are a valid and reliable measure of PA (Trost, 2007). The multiple day storage capacity for minute-by-minute heart rates and relative inexpensiveness of heart rate monitors make their use in large PA scale studies feasible (Trost, 2007). The disadvantages however associated include; the discomfort to participants over longer wear-time periods, loss of data, and external factors to PA which influence the heart for example stress (Dale, Welk, & Mathews, 2002; Sirard & Pate, 2001; Trost, 2007).

4. Pedometers: Pedometers are simple devices that count the amount of times a specified acceleration threshold is exceeded. These counts are then used to indicate an overall number of steps taken (Corder, Ekelund, Steele, Wareham, & Brage, 2008). Hands and colleagues (2006) investigated the validity of pedometers compared to direct observation. A strong correlation of 0.90 was found, suggesting pedometers are a reliable and valid measurement tool that could be used in PA research to record youth PA. Pedometers are relatively inexpensive and the ease at which they can be used makes them a viable option for use on large-scale studies. Pedometers, however, not unlike accelerometers, are unable to record certain movements, and only work in the uniaxial plane, which is a considerable limitation (Trost, 2007).

<u>5. Accelerometers:</u> Accelerometers are motion sensor monitors which provide quantitative information regarding the vertical accelerations of the trunk and other body segments, at sampling time intervals specified by the researcher (Trost, 2007). They provide information detailing PA intensity, frequency, pattern and duration. Given their small size, robust design features, and relatively conservative price (when compared to DLW for example), accelerometers are an appealing measurement tool of PA in children and adolescents (Welk, Corbin, & Dale, 2000).

Comparison of Models: Actigraph accelerometers (formerly known as MTI and CSA 7164) are the most commonly used commercially available accelerometers in research (Trost, 2007). They have been extensively validated for use in children and adolescents (de Vries, Engels, & Garre, 2011; de Vries et al., 2006; Trost, 2007). Monitors are traditionally worn above the iliac crest of the right hip (Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2014; Puyau, Adolph, Vohra, & Butte, 2002; Trost, Way, & Okely, 2006) and should be as near to the body's centre of mass as is possible (Trost, McIver, & Pate, 2005). There are several models of Actigraph monitors available on the market (Sasaki, John, & Freedson, 2011; Trost, 2007; Vanhelst et al., 2012). Often multiple Actigraph models are used in the same study (Belton, O'Brien, Issartel, McGrane, & Powell, 2016; O'Brien, Issartel, & Belton, 2013). Models vary in the number of axes they record activity counts across; the GT1M originally was a uniaxial monitor recording activity counts in one (vertical) plane (John, Tyo, & Bassett, 2011), the dual plane was subsequently unlocked in the GT1M to allow biaxial activity counts (vertical and antero-posterior planes) (Sasaki et al., 2011), whereas the GT3X is a triaxial accelerometer recording movement in three planes (vertical, antero-posterior, and medio-lateral) (Sasaki et al., 2011). Extensive research has shown that the activity counts in the vertical plane from the Actigraph 7164 model used in the 1990s and early 2000s (Freedson, Melanson, & Sirad, 1998; Hendelman et al., 2000; Swartz et al., 2000), and the GT1M monitors, do not significantly differ (John et al., 2011; Kozey, Staudenmayer, Troiano, & Freedson, 2010). Following the release of the GT3X, Sassaki and colleagues (2011) examined if any differences existed between the counts obtained from the multiple axes of the GT1M and GT3X during treadmill walking/running (Sasaki et al., 2011). No significant inter-monitor differences were found in activity counts from the vertical plane, at any speed (Sasaki et al., 2011). High inter-monitor agreement was found for vertical activity counts suggesting when solely using the vertical plane, monitors are comparable (Sasaki et al., 2011). This suggests that both of these Actigraph models can be used side by side during field research.

Validity and Reliability of Accelerometers: To date several studies have investigated the validity of accelerometers in both laboratory-based and field settings (Trost, 2007). Many studies report strong positive correlations between EE and/or exercise intensity (Freedson, Pober, & Janz, 2005; Trost et al., 2005). Accelerometry provides an objective, practical, accurate and reliable means of quantifying the duration and intensity of habitual PA in children (de Vries et al., 2006; Rowlands, Pilgrim, & Eston, 2008; Ward et al., 2005). Validity studies have found Actigraph accelerometers to be a valid measure of PA in children and adolescents, comparing with heart rate monitoring (Ott, Pate, Trost, Ward, & Saunders, 2000), direct observation (Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005), indirect calorimetry (Trost, Ward, Moorehead, Watson, Riner, & Burke, 1998), whole-room calorimetry (Puyau et al., 2002), and DLW (Ekelund, Yngve, Brage, Westerterp, & Sjöström, 2004). Ott and colleagues (2000) investigated the validity of the CSA uniaxial accelerometer to measure free-play activities in nine to 11 year olds. The CSA uniaxial accelerometer was compared with heart rate monitoring and a significant correlation of 0.64 was found, suggesting the use of accelerometers in measuring children's free-play is appropriate (Ott et al., 2000). Actigraph accelerometers were validated for use with preschool children against direct observation (CARS) by Sirad and colleagues (2005). Correlations between observed and Actigraph intensity categorisations, ranged from 0.46 to 0.70 ($p< 0.001$). Validity of the CSA activity monitor as a measure of children's PA using EE (indirect calorimetry), as a criterion measure, was conducted (Trost et al., 1998). The CSA monitor was identified as a valid and reliable tool for quantifying treadmill walking and running in children ($r = 0.86$ and 0.87, $p<0.001$). Evenson and colleagues (2008) conducted a calibration study between accelerometers (Atigraph and Actical) using indirect calorimetry, to determine the threshold counts for classifying activity intensities in five to eight year olds. Results for the classification of moderate (0.85 and 0.86, respectively) and vigorous activity (0.83 and 0.86, respectively) by both the ActiGraph and Actical, were acceptable and the classification of sedentary behaviour was near perfect, suggesting both monitors are suitable at distinguishing PA intensities and sedentary behaviour amongst young children. Similarly, Kelly et al. (2004) investigated the validity of two accelerometers (CSA/MTI and Actiwatch) against direct observation of PA (CPAF - Children's Physical Activity Form) in three to four year olds. Minute-to-minute correlations, at the participant level (i.e. within child) were calculated between accelerometry and direct observations. CSA/MTI output was significantly correlated with CPAF ($r = 0.72$, $p < .001$) suggesting the accuracy of this monitor in measuring total engagement in PA. Scruggs and colleagues (2005) explored the relation agreement of tri-axial accelerometry (RT3 Tri-axial Research Tracker accelerometer) in measuring MVPA, compared with direct observation (SOFIT). A correlation of $r = 0.77$ ($p\leq.01$) was demonstrated.

Considering the high accelerometer validity and reliability obtained, the use of accelerometer counts to derive PA intensities has been widely accepted in PA research. It is however unclear what a count truly means, physically or physiologically (Chen & Bassett, 2005). Counts collected by accelerometers can be both positive and negative. Digital signal processing manages negative counts either converting them to positive counts or only taking the positive side (Chen & Bassett, 2005). A digital integration algorithm is then applied, which sums the 'raw counts' for a specified time frame (for example 10 seconds) resulting in PA counts to which cut points are applied to give PA intensities (Chen & Bassett, 2005). This method of processing accelerometer data is not without its advantages namely its simplicity for general understanding. There is however significant limitations associated with such processing techniques. The period over which accelerometer counts are averaged (epoch) can affect the interpretation of data leading to misclassification of PA intensities depending on whether a shorter or longer epoch length has been used (Chen & Bassett, 2005). The 'counts' based approach has prevented direct comparison of PA outcomes between studies due to the differences in algorithms used to collect, process, filter, and scale raw data (Chen & Bassett, 2005). For this reason there has been an emergence of devices and methods which allow researchers to process raw acceleration data. The GENEActiv is one such device. It is an inexpensive water-proof, wrist-worn monitor which offers an alternative consideration to Actigraph waist-worn monitors, as compliance is likely to be improved (Pavey, Gomersall, Clark, & Brown, 2015). The GENEActiv is a tri-axial acceleration sensor which due to a near body temperature is more sensitive at identifying non-wear from wear-time (Pavey et al., 2015). The GENEActiv allows access to the tri-axial raw, unfiltered acceleration data, which provides extremely rich data where the extraction of multiple time and frequency domain features is possible (Rowlands et al., 2014). As a result, there has been increased interest in pattern recognition techniques in an attempt to more accurately determine the quantification and classification of activities (Rowlands et al., 2014). The ActiGraph GT3X+ and GT9X also collect and record raw unfiltered accelerations (Fairclough, Noonan, Rowlands, van Hees, Knowles, & Boddy, 2015). PA data derived from raw accelerations improves comparability between studies using different monitors, and promotes transparency and consistency (Fairclough, Noonan, Rowlands, van Hees, Knowles, & Boddy, 2015). Although there are multiple benefits associated with using raw accelerations to derive PA outcomes, ‘counts’ based analysis is still prevalent due to its ease of use.

Processing and Inclusion Criteria: Standardising the decision making process, when using accelerometers to measure youth PA in free living situations, is top priority (Esliger, Copeland, Barnes, & Tremblay, 2005). The screening process of objectively measured accelerometer PA data has received much consideration. It is now deemed appropriate practice to omit the first and last day of accelerometer data due to subject reactivity (Esliger et al., 2005). Counts below zero and ≥15,000 are considered non-wear due to biological plausibility (Esliger et al., 2005). The length of the monitoring period has also been examined due to its potential impact on compliance levels, study costs and subsequent habitual PA behaviour (Trost, 2007). According to Trost and colleagues (2005), the number of monitoring days needed to achieve a reliability of 0.80 ranges from four to nine days (Trost et al., 2005). Variations in the number of valid days considered appropriate across studies have been observed with some studies using two or three valid days (Bäcklund, Sundelin, & Larsson, 2011; Goran, Reynolds, Michael, & Reynolds, 2005; Kriemler et al., 2010), and others including three weekdays and one weekend day (Gorely, Nevill, Morris, Stensel, & Nevill, 2009; Klesges et al., 2010; Maddison et al., 2011; Salmon, Ball, Hume, Booth, & Crawford, 2008). The use of a seven-day monitoring protocol has become widely accepted as suitable for use with adolescents (Sirard, Kubik, Fulkerson, & Arcan, 2008; Sutherland et al., 2013; Troiano et al., 2008; Trost, 2007). This also accounts for the difference in weekend and weekday PA behaviour (Jago et al., 2005), by sampling on both types of day within the seven-day protocol.

To accurately quantify habitual PA behaviour the minimum minutes of recorded wear-time for a given day must be considered. The inclusion criteria used varies greatly from study to study. Some studies use a minimum of 800 minutes per day (Baranowski et al., 2011; Jago et al., 2006; Kriemler et al., 2010), 600 minutes per day (Bäcklund et al., 2011; Cliff et al., 2011; Maddison et al., 2011; Patrick et al., 2006; Salmon et al., 2008), 540 minutes per day (Gorely et al., 2009), 480 minutes per day (Fitzgibbon et al., 2011) or as little as 300 minutes per day (Goran et al., 2005; Puder et al., 2011). The variations observed in hours of wear-time and number of valid days' wear required for analysis, may be due to difficulties in dealing with compliance and hence less stringent inclusion criteria may be necessary. In a continued effort to increase compliance levels, studies utilise multiple compliance strategies including; SMS reminder texts in the morning and afternoon during the wear-time period (Belton, O' Brien, Wickel, & Issartel, 2013), the use of record cards to detail any periods of non-wear (Sirard & Slater, 2010), and monetary incentives such as being entered into a draw for a voucher (Belton et al., 2013, 2016; Lounsbery, McKenzie, Morrow, Monnat, & Holt, 2013).

Accelerometer Cut Points: Accelerometer use is widespread in PA research however; treatment of accelerometer data is inconsistent across studies. The categorisation of PA counts to PA intensities remained a contentious issue until recently (Trost et al., 2011). The existence of at least five different youth peer reviewed cut points has created extensive issues for researchers seeking to measure, understand and subsequently intervene on youth PA (Trost et al., 2011). The option for researchers to select from a battery of youth PA cut points namely Evenson, Freedson, Mattacks, Puyau and Treuth (Evenson et al., 2008; Freedson et al., 2005; Mattocks et al., 2007; Puyau et al., 2002; Treuth et al., 2004) results in minutes spent in MVPA and PA varying depending on the cut points selected (Trost et al., 2011). Trost and colleagues recently published a much-needed study, which sought to compare the classification accuracy of the five previously published youth cut points using EE, via indirect calorimetry. Trost et al. (2011) found across all four intensities (sedentary, light, moderate, and vigorous), the Evenson and Freedson cut points exhibited significantly better agreement than the Mattocks, Puyau, and Treuth cut points. Only the Evenson cut points provided acceptable classification accuracy for all four PA intensities and performed well among children of all ages (Trost et al., 2011). Hence, Trost and colleagues concluded that the Evenson Actigraph cut points are the most suitable at estimating time spent in sedentary, light, moderate, and vigorous PA, in both children and adolescents (Trost et al., 2011).

2.1.4.3 Physical Activity Measurement Summary

This section has identified the key features of the most commonly used PA measurement tools namely self-report methods, direct observation, DLW, heart rate monitoring, pedometers and accelerometers. Each method is not without its value or limitations. However, each serves its purpose in a given population and research design. Objective measures of PA such as accelerometers, provide valuable and reliable information on the quantification of PA behaviour and intensity (de Vries et al., 2011; de Vries et al., 2006; Trost, 2007). The use of a combination of both self-report PA measures such as the Y-PAQ questionnaire (Corder et al., 2009) and objective accelerometry, provides much richer, accurate data on youth PA behaviour. As a result of the vast battery of PA assessment techniques available, much research has been conducted in the measurement and quantification of PA levels in children, adolescents and adults, globally. The next section will seek to synthesise this information providing an overview of current PA levels.

2.1.5 Physical Activity Levels

As previously demonstrated, the evidence highlights the importance of regular PA in children and adolescents to promote lifelong health and fitness (Allender et al., 2007; Whitt-Glover et al., 2009). This generation of youth are one of the first to develop risk factors of chronic diseases and illnesses due to leading predominantly inactive and sedentary lifestyles (Jago et al., 2005; Riddoch et al., 2004; Tremblay et al., 2011; Troiano et al., 2008). Recent research worldwide from both self-report and objectively measured PA suggests that the majority of youth are not meeting the recommended 60 minute daily MVPA guideline (Aibar, Bois, Generelo, Zaragoza Casterad, & Paillard, 2013; Belton, O' Brien, Meegan, Woods, & Issartel, 2014; Colley et al., 2011; Eaton et al., 2012; Ekelund et al., 2012; Riddoch et al., 2004; Troiano et al., 2008; Woods et al., 2010). Given that PA levels track from childhood into adulthood, ensuring adolescents are meeting the PA guideline is of utmost importance as active children are more likely to be active in adulthood (Telama et al., 2005). Understanding the extent of the problem and trends of inactivity is therefore essential in order to create targeted interventions.

The prevalence low PA levels worldwide is worrying. According to research conducted by Hallal and colleagues (2012), 80.3% of adolescents (13 - 15 years), globally, self-report not meeting the recommended PA guideline (Hallal et al., 2012) and females are less active than males. Troiano and colleagues (2008) measured the PA levels of the US population using accelerometry, using a representative sample of children (6 - 11 years), and adolescents (12 - 19 years). The data was collected as part of the National Health and Nutritional Examination Survey (NHANES) 2003 - 2004 (Troiano et al., 2008). The results are from a total of 6,329 participants who supplied one day of accelerometer data and 4,867 participants that provided four or more days of data (Troiano et al., 2008). For youth aged six to 17 years, the age-specific Freedson (2005) cut points were applied to give time spent in moderate (500 to 3999 counts per minute) and vigorous (4000 to 7599 counts per minute) PA (Troiano et al., 2008). Across both age groups, mean activity counts per minute were consistently higher for males than females (Troiano et al., 2008). On average, children (aged 6 - 11 years) accumulated between 10 and 16 minutes of vigorous activity per day (Troiano et al., 2008). Children (both genders) accumulated more than one hour per day of PA equal to moderate intensity or above (Troiano et al., 2008). There was a considerable drop in PA levels as age increased with 16 to 19 year olds only achieving 33 minutes of PA for males and 20 minutes of PA for females (Troiano et al., 2008). This provides evidence for the age related decline in PA behaviour. From the sample, only 42% of children met the recommended PA guideline (which was defined in this study as accumulating 60 or more minutes of MVPA on five or more days). Gender differences were observed in the youngest cohort with 48% of males compared to 35% of females, meeting the PA recommendations (Troiano et al., 2008). As the population aged, adherence to the guideline reduced with only six to 8% of adolescents meeting the guideline (Troiano et al., 2008). These low levels of adherence to the PA guideline are worrying and suggest that across all age groups, activity levels are insufficient to result in health benefits.

Research conducted by Colley et al. (2011), on a Canadian population, further affirm the inactivity epidemic observed in children and youth. Data were collected using Actical accelerometers with time spent at various movement intensities derived from the following cut points; sedentary: less than 100 counts per minute, light: 100 to less than 1,500 counts per minute, moderate: 1,500 to less than 6,500 counts per minute, and vigorous: 6,500 or more counts per minute (Colley et al., 2011). Results suggest that as little as 7% of Canadian children and youth (9% of males and 4% of females), meet the 60 minute MVPA guideline on at least six days per week (Colley et al., 2011). Less than 2% of children obtain at least 90 minutes of MVPA on a daily basis (Colley et al., 2011). Adherence rates do however increase significantly when aiming to meet the MVPA guideline on three days per week, with more than half of males (53%) and a third of females (35%), achieving said levels of activity (Colley et al., 2011). Also of concern is the magnitude of time spent on sedentary pursuits. On average Canadian children and youth spent 8.6 hours (or 62% of waking hours), in sedentary behaviour (Colley et al., 2011). Time spent on sedentary pursuits was higher for females, compared to males (Colley et al., 2011). The PA cut points used in this study were more stringent and thus differed from those used by Troiano et al. (2008). This may partly explain the lower adherence to the PA guidelines observed in the Canadian population (Colley et al., 2011). It is important to note however that PA levels of Canadian children and youth, not unlike US, are extremely low.

Globally, these trends are being observed irrespective of the known benefits and necessity of PA, for healthy living. Riddoch et al. (2007), sampled 5,595 children (aged 11.6 - 11.9 years), in the southwest of England with the aim of measuring their PA levels and patterns using accelerometry (Riddoch et al., 2007). Of concern, is the exceptionally low level figure of just 2.5% of children (5.1% of boys and 0.4% of females) meeting the 60 minute MVPA per day PA recommendations (Riddoch et al., 2007). In this research, participants were spending on average just 20 minutes per day in MVPA (Riddoch et al., 2007): 25 minutes per day for males and 16 minutes per day for females (Riddoch et al., 2007). These PA levels are considerably lower than those reported for European children (Riddoch et al., 2004). Riddoch and colleagues (2004) sampled the activity levels of 2,185 European children (Denmark, Portugal, Estonia, and Norway) aged nine and 15 years. Three interesting findings are of note from this study. Males were more active than females at both nine and 15 years of age (21% more active and 26% more active respectively) (Riddoch et al., 2004). Overall nine year olds were more active than 15 year olds (27% more active in males, 32% more active in females) (Riddoch et al., 2004). In contrast to the UK findings (Riddoch et al., 2007), the vast majority of both nine year old males and females met the PA guideline (97.4% and 97.6% respectively) (Riddoch et al., 2004). Although fewer children achieved the recommended PA levels at age 15 with a marked gender difference observed (81.9% of males and 62% females) (Riddoch et al., 2004), these levels were still much higher than those obtained in the UK sample (Riddoch et al., 2007). This could in part could be due to the different cut points applied which differed by more than 2000 counts per minute (1000 and 1500 counts/min, and 3600 counts/min respectively) (Riddoch et al., 2004, 2007).

In an Irish context, the trends witnessed, are not unlike those observed globally (Hallal et al., 2012; Reilly et al., 2004). The Irish Health Behaviour in School-Aged Children (HBSC) study 2010, found 25% of Irish children self-reported meeting the PA guideline with gender differences observed (31% of males meeting PA guideline versus 18% of females) (Kelly, Gavin, Molcho, & Nic Gabhainn, 2012). Younger children were more likely to report obtaining adequate PA on seven days per week, compared to older children (Kelly, Gavin, Molcho, & Nic Gabhainn, 2012). The low levels of PA, the associated age related decline in PA, and the gender differences observed in an Irish cohort as reported by the HBSC study, was consistent with almost all countries surveyed in the Currie et al. (2012) study. The CSPPA study collected nationally representative data on PA engagement in a sample of 5,397 primary and post-primary children (aged 13.8 ± 2 years) (Woods et al., 2010). Findings highlighted the alarming levels of inactivity in Ireland. Woods et al. (2010) found that only 19% of primary and 12% of post-primary school children self-reportedly met the minimum PA recommendations, with females considered less likely to meet the PA guideline than males. Woods and colleagues (2010), found further evidence of the age related decline in PA participation, reporting the likelihood of meeting the PA guideline decreased with increase in age (Woods et al., 2010). Important to note is the use of self-report PA measures in the HBSC study and CSPPA study, compared to objective measures in the previously discussed international studies. Research conducted by Belton et al. (2016) on the Youth-Physical Activity Towards Health (Y-PATH) project, provides objectively measure PA data from an Irish cohort. The Evenson et al. (2008) cut points were applied (moderate: 2296 – 4011 counts per minute, and vigorous: ≥4012 counts per minute). Findings suggest 32.4% of Irish adolescents (aged 11.8 - 14.4 years) met the 60 minute MVPA per day guideline (Belton et al., 2016). A significantly greater proportion of males (41.4%) compared to females (22.7%) met the guideline (Belton et al., 2016). These low levels of PA in Irish youth are consistent with findings by Woods et al. (2010) and Kelly et al. (2012), although slightly higher.

Notably, gender differences in PA engagement have frequently been observed with males obtaining higher levels of PA than their female counterparts (Kelly et al., 2012; Troiano et al., 2008; Woods et al., 2010). Understanding why females participate in less PA than males is of keen importance, and specifically targeting these factors to improve PA levels in females is necessary. Given that the gap between actual PA levels and the PA guideline widens with age (Kelly et al., 2012; Riddoch et al., 2004; Woods et al., 2010), and the age related decline in PA behaviour, stemming this problem at the critical transitional stage from primary school to second level education demands urgent attention.

2.1.6 Physical Activity Correlates and Determinants

Understanding why children and adolescents are physically active or inactive is essential as it contributes to evidence-based planning of interventions which will effectively target factors known to cause inactivity (Bauman et al., 2012). Determinants of PA are factors that affect, or are thought to affect, participation in PA (Encyclopaedia of Exercise Medicine in Health and Disease, 2012). The term correlates is not used in the literature, as it is now acknowledged that many factors discussed in relation to PA are not, or may not be, true determinants as causality cannot be determined (Bauman, Sallis, Dzewaltowski, & Owen, 2002). The two terms will be used interchangeably in this section according to the term used in the individual study being discussed.

According to the adapted ecological model presented by Bauman and colleagues (2012) individual (psychological and biological) and interpersonal factors (social support and cultural norms) in early life and childhood are correlates and determinants of PA participation. In adolescence the ecological model suggests environmental factors begin to play a role in determining PA behaviour (Bauman et al., 2012). The Youth Physical Activity Promotion (YPAP) model (see Figure 2.1), which adopts a social-ecological framework, also conceptualises that PA engagement can be attributed to four factors; predisposing, reinforcing, enabling and demographic factors (Welk, 1999). Considering this framework for exploring the correlates and determinants of PA participation, predisposing factors commonly investigated in PA research include psychosocial variables (perceived competence, self-efficacy, attitude, perceived behavioural control, value of health and status). Reinforcing factors consider social and cultural variables (perceived parental role model, parental activity, and social support for physical activity from parents, family, peers and coaches or teachers). Biological variables such as fitness and skills ability form the basis of enabling factors. Demographic variables frequently investigated in relation to PA participation include gender, age, ethnicity, parental marriage status and BMI. Welk's (1999) classification of determinants of PA behaviour i.e. predisposing, reinforcing, enabling and demographic factors will act as the framework for investigating the existing body of literature on the correlates and determinants of PA participation.

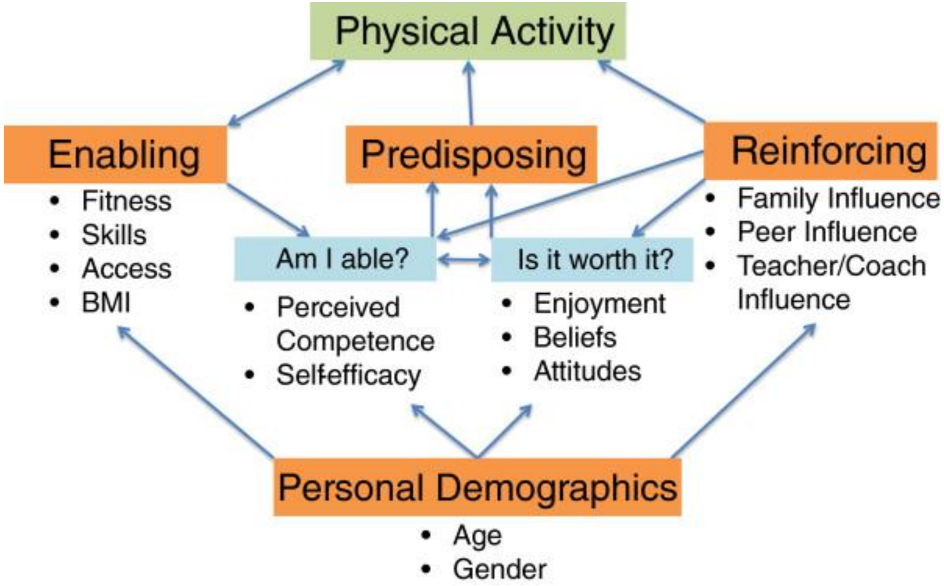

Figure 2.1. A conceptual diagram of the Youth Physical Activity Promotion Model (Welk, 1999), taken from Belton et al. (2014)

2.1.6.1 Predisposing Factors for PA participation as defined by the YPAP Model

Predisposing factors as defined by Welk (1999) include variables which increase the likelihood of an individual participating in regular PA (Welk, 1999). Predisposing factors can be categorised by the decision making processes and have their foundations in two prominent questions; *'Is it worth it?'* and *'Am I able?'* (Welk, 1999). The first question considers the benefits and cost of participating in PA, whereas the second considers a person's beliefs in their physical abilities and competence (Welk, 1999). Although an individual may recognise the importance of being physically active, if they do not feel they have the necessary skills they will be unlikely to engage in continued PA participation (Welk, 1999), hence the importance of understanding both mechanisms in young people. Predisposing factors include both cognitive and affective variables namely: attitudes, perceived benefits, and beliefs about PA, enjoyment of PA and interest in PA (Welk, 1999). Predisposing factors which facilitate ability include; perceived competence, self-efficacy and physical self-worth (Welk, 1999). In the context of PA and skills ability, perceived competence is defined as how a person perceives their ability to perform a skill or activity competently (Harter & Pike, 1984). Self-efficacy refers to the cognitive processes which underpin belief in one's abilities to achieve goals and execute actions in given situations (Bandura, 1994). A review by Van Der Horst et al., (2007) examined the correlates of PA from studies published between January 1999 and January 2005 (Van Der Horst, Paw, Twisk, & Van Mechelen, 2007). Van Der Horst and colleagues (2007) identified self-efficacy as a correlate of PA in both children and adolescents. The role of attitude in PA was more prevalent in the older adolescent cohort compared to with children, where no relationship was found (Van Der Horst et al., 2007). No association was found between PA and perceived benefits, self-perception, fun/enjoyment and depression. Evidence linking PA and intention, perceived barriers and competence was also found to be inconclusive (Van Der Horst et al., 2007). There is a plethora of research which has investigated the relationship between self-efficacy, and adolescent PA behaviour (Anderson, Wojcik, Winett, & Williams, 2006; Dishman et al., 2004; Lee et al., 2012; Van Der Horst et al., 2007). The Dishman et al. (2004) study advocates for the role of self-efficacy in increasing PA among black and white adolescent females. Hence, the use of self-efficacy as a targeted predisposing factor for PA participation in intervention designs may be warranted (Sallis, Prochaska, & Taylor, 2000; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007).

2.1.6.2 Reinforcing Factors for PA participation as defined by the YPAP Model

Reinforcing factors are defined by Welk (1999) as factors which support the child's PA behaviour (Welk, 1999). Most commonly this element of social support for PA comes from parents, teachers, peers and coaches in the form of encouragement, modelling and support (Welk, 1999). Much research has investigated the relationship between parental and peer support, and levels of PA participation. Extensive research suggests that parental and peer support have a positive influence on youth PA behaviour (Bauman et al., 2012; Duncan,

Duncan, & Strycker, 2005; Mcguire, Hannan, Neumark-Sztainer, Cossrow, & Story, 2002; Neumark-sztainer, Story, Hannan, Tharp, & Rex, 2003). Feeling supported by family and friends may provide adolescents with the sense of belief that they can attempt to participate in activities, which ultimately results in higher PA levels. Social support is believed to be positively associated with PA behaviour in adolescents and hence has been targeted in several interventions (Fitzgibbon et al., 2011; Haerens et al., 2006). In a systematic review of the correlates of PA of children and adolescents, Sallis and colleagues (2000) found parental PA levels were most frequently investigated as a measure of social support for PA behaviour in children and youth. However, no association was found between parental PA level and adolescent PA behaviour (Sallis, Prochaska, & Taylor, 2000). Parental PA levels were positively associated with child PA behaviour in 38% of studies measuring parental influence on activity levels. Measures of parental support, direct help from parents, and support from "significant others" were consistently related to adolescent PA behaviour (Sallis et al., 2000). Family influences and peer support were found to be positively associated with PA in the Van Der Horst el al. (2007) review. Craggs et al. (2011) also found higher scores on social support measures to be consistently associated with smaller declines in adolescent PA levels (self-report). This further suggest the importance of social support in promoting and maintaining youth engagement in PA behaviour (Craggs, Corder, Van Sluijs, & Griffin, 2011).

2.1.6.3 Enabling Factors for PA participation as defined by the YPAP Model

Enabling factors as defined by Welk (1999) are factors which allow youth to participate in PA, specifically biological and environmental variables (Welk, 1999). Actual ability as a result of biological factors for example fitness, skill levels, and body composition, all have the ability to affect if youth will seek out PA opportunities and persist with participation (Welk, 1999). The built environment such as access to parks, readily available sports equipment, and sports clubs/programmes, can also have a massive influence on PA participation in youth (Welk, 1999). According to the YPAP model, biological factors such as skills and fitness are predictive of, and influence, youth PA participation (Welk, 1999). Skills according to Gallahue and Ozmun (2006) first develop as basic skills known as fundamental movement skills (FMS), before progressing to more sports specific skills, which promote PA participation according to Welk's YPAP model (1999). It is suggested that mastery of FMS (such as running, skipping and jumping) should be developed by the age of 10 to 11 years old (Department of Education Victoria 1996; Gallahue and Ozmun 2006). In order for children to continue to lead active lives into adolescence, it is therefore imperative that these basic skills are mastered in youth. Lubans and colleagues (2010) conducted a review of the associated health benefits of FMS in children and adolescents (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). They found 21 studies which assessed eight potential benefits of FMS (Lubans et al., 2010). Strong evidence for the positive association between FMS and PA was found in both children and adolescents (Lubans et al., 2010). Interestingly, Lubans et al. (2010) also found another biological variable namely cardio-respiratory fitness, was positively associated with FMS competency. It is believed that activities that develop FMS, also place high demand on respiratory fitness and hence influence fitness levels (Stodden et al., 2008). This will be discussed further, later in the literature review.

2.1.6.4 Demographic Factors for PA participation as defined by the YPAP Model

Demographic factors including gender, age, ethnicity and social economic status, will have a direct influence on the individual and how they adapt to all other influences (predisposing, reinforcing and enabling factors) (Welk, 1999). Sallis and colleagues (2000) conducted a systematic review of published literature between 1970 and 1998, investigating the correlates of PA in children (3 - 12 years) and adolescents (13 - 18 years). The review identified 11 demographic and biological variables, of which seven were studied further. In children, gender was most often investigated, with 81% of comparisons suggesting males were more active than females (Sallis et al., 2000). Amongst adolescents, from 28 studies which investigated the relationship between gender and PA, 27 found that males were more active than females (Sallis et al., 2000). A more recent systematic review which considered studies published between 1999 and 2005, identified a positive association between gender (male) and PA levels (Van Der Horst et al., 2007). This finding supports the work of Sallis and colleagues (2000). In children aged nine years and younger, Craggs and colleagues (2011), also found that gender was consistently associated with changes in PA. Females exhibited a larger decline in PA behaviour, than males (Craggs et al., 2011), suggesting that gender plays a significant role in determining PA participation (Craggs et al., 2011; Sallis et al., 2000; Van Der Horst et al., 2007). Given that females are consistently less active than males, targeting females specifically appears imperative.

Given the complex nature of PA participation in children and adolescents, our understanding of the factors which influence participation is still relatively unclear (Van Der Horst et al., 2007). According to Bauman et al. (2012) future research needs to move beyond investigating associations between PA and potential correlates, and focus on data modelling to assess casual determinants. Our understanding of environmental correlates (social environment, built environment, and natural environment) of PA (transport and leisure time) in low and middle income countries is still relatively poorly understood (Bauman et al., 2012). Other innovative correlates of PA exist beyond the ecological model and require examination such as genetic determinants, societal factors and the role of brain function in determining PA participation (Bauman et al., 2012). Furthermore, the development of skills according to the YPAP model are enabling factors which allow participation in PA (Welk, 1999). As alluded to previously, in recent decades, the role of FMS in adolescent PA behaviour has been one such innovative correlate, which has been given increasing importance. The nature of the relationship between FMS and PA is complex, which is not surprising considering the intricacy of FMS development. Further understanding of the relationship between FMS and PA participation in youth is necessary, given that FMS are considered a prerequisite for PA participation (Okeley, Booth, & Patterson, 2001). The next section of the literature review will seek to debunk existing knowledge and literature on FMS in an attempt to identify the role skills development has in increasing PA participation.

2.2 Fundamental Movement Skills

The purpose of this section is to review the relevant literature concerning FMS proficiency in children and adolescents. Firstly, our understanding of the term FMS will be explored and described, the school setting as a means of teaching and improving FMS, FMS measurement tools and the current levels of FMS. Finally, the correlates of FMS will be examined in detail.

2.2.1 Description of Fundamental Movement Skills

As previously stated, FMS are defined as basic observable movement patterns (Gallahue & Ozmun, 2006). FMS are goal-directed movement patterns, traditionally divided into three subscales namely: locomotor (changing the location of the body relative to a fixed point in the environment), object control (imparting to, or alternatively receiving force from, an object), and stability skills (gaining and maintaining equilibrium relative to the force of gravity) (Burton & Miller, 1998). These basic skills form the foundation for many specialised skills required in numerous sports and leisure activities (Gallahue & Ozmun, 2006). In a child's early years, the development of fine and gross motor skills is necessary (Cools et al., 2009). Fine motor skills require control of small muscles to achieve the skill outcome, typically demanding a high degree of hand and finger precision as well as hand-eye coordination (Magill & Anderson, 2007). Gross motor skills require the manipulation of large musculature to achieve the skill outcome (Magill & Anderson, 2007). In early childhood gross motor skill development is required for stability and body control whilst exploring the environment (Cools et al., 2009). Fine motor skills are required for the development of basic self-help skills (Cools et al., 2009). The process of FMS development is controlled by the requirements of the task, the biology of the individual and the condition of the learning environment (Newell, 1986). Gallahue and Ozmun (2006) created an hourglass model (see Figure 2.2), which depicts the stages of development from infancy into adulthood.

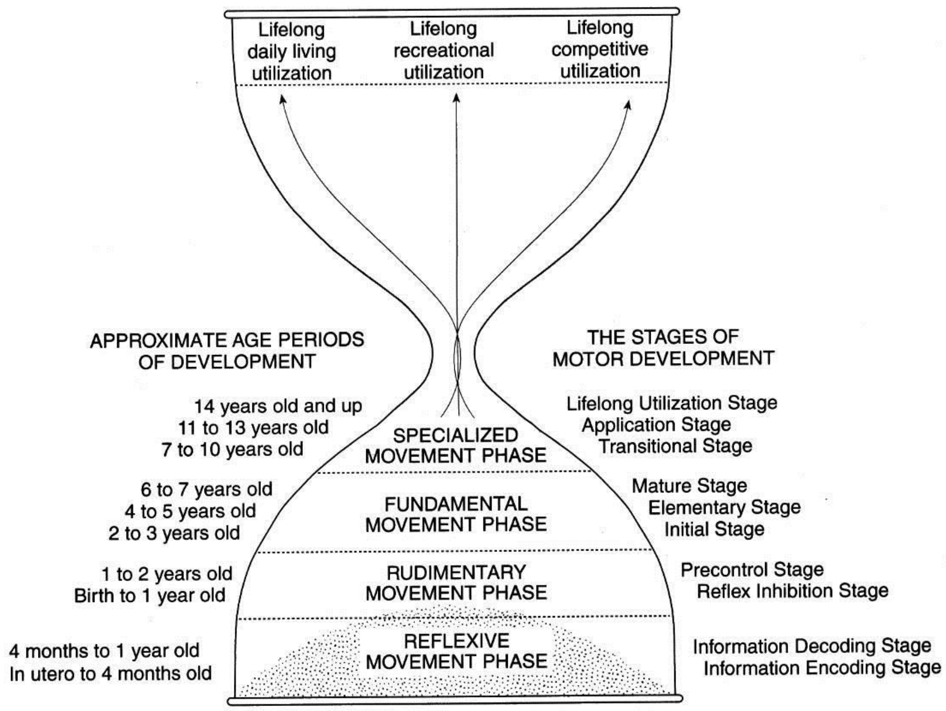

Figure 2.2. Hourglass model of the stages of development (Gallahue & Ozmun, 2006)

This model was developed in an attempt to outline the key stages of motor development from birth into adulthood (Gallahue & Ozmun, 2006). Children's overall motor development includes the development of FMS during the fundamental movement phase (Gallahue & Ozmun, 2006). The reflexive and rudimentary movement phases occur in infancy, developing skills, which form the oundation for the fundamental movement phase (Gallahue & Ozmun, 2006). During the fundamental movement phase children gain increased control of their fine and gross motor skills (Gallahue & Ozmun, 2006). The development of FMS is a prerequisite for the specialised movement phase which results in skills for daily living, and recreational and competitive use (Gallahue & Ozmun, 2006). Each stage of motor development as per Gallahue and Ozmuns hourglass model (2006) will be discussed in further detail.

Infants begin their development with the reflexive and rudimentary movement phases (Gallahue & Ozmun, 2006). The reflexive stage spans from birth to a year old. During this phase the infants' body responds with involuntary reflexes (primitive and postural reflexes) to various stimuli. The rudimentary movement phase progresses from reflexive movements in the reflexive phase, with the first forms of voluntary movement observed during this phase. In the early stages of the rudimentary phase, movements of the head, neck and trunk are observed. As the infant proceeds into the latter stages of this phase (up to two years of age) more deliberate movements develop such as reaching, grasping and releasing, as well as locomotor skills specifically creeping, crawling and walking (Gallahue & Ozmun, 2006). Infants progress to the fundamental movement phase, where they continue to develop on these previously established skills from three years of age to seven. During this stage the child begins to learn to control his actions to a variety of external and internal stimuli. In the early stages of this phase (age three) the first attempts at performing fundamental movement patterns are made, with greater control and rhythmical coordination developed throughout this phase (Gallahue & Ozmun, 2006). Children gain increased control of their fine and gross motor skills which are involved in the development of basic FMS (such as running, skipping, kicking, jumping, throwing and catching). As the child ages, the development and control of each FMS progresses from the initial stages to mastery. Individual skills are merged with other skills to form coordinated movement. The development of these basic FMS is a prerequisite for the specialised movement phase, in which the child advances to more sports specific skills (Gallahue & Ozmun, 2006; Hardy, King, Farrell, Macniven, & Howlett, 2010). During the latter stages of the specialised movement phase, the adolescent develops cognitive sophistication through personal experiences and begins to combine and apply basic FMS to the performance of sports related skills in activities of their choice and preference (Gallahue & Ozmun, 2006). Research conducted by O'Keefe and colleagues (2007) investigated this concept of transferability of basic FMS to more sports related skills. Specifically, the investigation confirmed that learning the overhand throw was positively related with the sport specific skills of both badminton (overhand clear) and the javelin (throw) (O'Keefe, Harrison, & Smith, 2007). This suggests the importance of developing these basic skills at a young age to enable sports participation later in life and lifelong PA engagement. Several factors influence development at this stage in an individual's life. Maturational qualitative functional changes such as the maturing of the brain influence development as a child's higher order cognitive abilities change (Watson & Lowery, 1967). Structural growth changes which occur as result of ageing influence development such as increase in physical size, neuro-muscular changes and adaptation, hormonal changes and differing body fat by gender (Watson & Lowery, 1967). The lifelong utilisation stage is determined largely by decisions, interests and competencies established in the previous stage (Gallahue & Ozmun, 2006). Skills are refined further and applied to a lifetime of daily living, recreational, and sports-related activities (Gallahue & Ozmun, 2006). Other factors affect this stage such as availability of time and money, equipment and facilities, and physical and mental limitations (Gallahue & Ozmun, 2006). Innate ability and talent, opportunities, physical condition and personal motivation will also dictate a person's participation in PA (Gallahue & Ozmun, 2006). The hourglass model of motor development proposed by Gallahue and Ozmun (2006), in its entirety, is influenced by hereditary and lifestyle factors. Hereditary factors are predisposing factors which influence an individual's rate of development and overall ability. Very little can be done in the way of influencing the genetic makeup of a person (Gallahue & Ozmun, 2006). Lifestyle factors, are largely environmentally based, and are determined by factors such as physical fitness, nutritional status, diet, exercise, the ability to handle stress, and social and spiritual well-being (Gallahue & Ozmun, 2006).

Gallahue and Ozmun (2006) highlight that children have the potential to master FMS by six years of age, and that all children should have these basic skills fully developed by the age of 10 (Gallahue & Ozmun, 2006). A common misconception exists however, that these skills develop naturally through maturation (Clark, 2007; Cools et al., 2009; Stodden et al., 2008). This negates the role of instruction and practice of FMS, which according to Clark (2007), is negligent. The development of motor skills does not solely depend on biological, hereditary or environmental aspects, but instead is an interactive process of the previously mentioned constraints (Clark, 2007). FMS must be nurtured, promoted, and practiced (Booth et al., 1999; Okely & Booth, 2004). Their development takes years and requires specific experiences and teaching to reach mastery (Booth et al., 1999; Clark, 2007; Mitchell et al., 2013; Okely & Booth, 2004). According to Booth et al. (1999), it takes approximately 10 hours of instruction for a child to master one FMS. The importance, therefore of providing at least one hour per week of FMS focused teaching, during the early years of childhood, is essential to enable children to master most FMS. A meta-analysis investigating the effectiveness of motor skill interventions, found a significant positive effect on improvements of FMS in children, which further strengthens the argument for FMS centred lessons and curriculum (Logan, Robinson, Wilson, & Lucas, 2011). Logan and colleagues recommend that early childhood education centres should implement 'planned' movement programmes as a strategy to promote motor skill development in children (Logan et al., 2011). McKenzie and Lounsbery (2009) advocate for PE as a medium through which these programs, aimed at teaching youths generalisable movements, can be implemented.

2.2.2 Fundamental Movement Skills in the School Setting

The school setting provides an ideal environment for the nurturing, teaching and practising of FMS to occur. PE is the best placed public health delivery system through which children and adolescents can be accessed (Clark, 2007). Strong and colleagues (2005) suggest that only 40% of the emphasis of PA in adolescents (aged 12), is placed on motor skill development (Strong et al., 2005). They recommend to aid in the development of FMS guided instruction and supervised practice, by qualified teachers, coaches, and others who work with children, are necessary (Strong et al., 2005). Okely and Booth (2004) identified the need for a focus on the development of FMS in primary schools, recommending adequate curriculum time, resources and professional development be devoted to FMS.

In Irish primary schools this message has been translated to the PE curriculum. One of the aims of PE as stated in the curriculum document is *"to help in the acquisition of an appropriate range of movement skills in a variety of contexts"* (Department of Education and Skills, 1999, p. 10). Although, these recommendations have been made, their implementation may be limited as children progress from primary school (4 - 12 years) into secondary school (12 - 18 years) without being adequately skilled for their age (Breslin, Murphy, McKee, Delaney, & Dempster, 2012; O' Brien et al., 2015). A lack of curricular cohesiveness is also observed with no recommendations made by the Irish Junior Cycle PE curriculum regarding the teaching and learning of basic fundamental skills (National Council for Curriculum and Assessment, 2003). Perhaps, not unlike other research, the National Council for Curriculum and Assessment, believe these skills should naturally be mastered by secondary school age (Cools et al., 2009), hence the lack of inclusion of FMS in second level curriculum (National Council for Curriculum and Assessment, 2003). In recent times, there is a growing body of evidence that youths display low levels of FMS proficiency (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Breslin et al., 2012; Hardy et al., 2013). Woods and colleagues (2010), advocate for more emphasis to be put on the development of FMS in Irish adolescents (Woods et al., 2010). O'Brien et al. (2015), support this recommendation, with their recent findings suggesting Irish adolescents are entering post-primary education insufficiently skilled and significantly below mastery levels (O' Brien et al., 2015). It is therefore imperative that changes at policy level in post-primary PE be addressed, with specific efforts aimed at targeting low FMS levels required.

The role of PE in promoting and developing FMS, has been long since identified in other countries around the world. In the US the development of motor skills is at the forefront of both primary (elementary) and secondary (high) school PE curriculums (McKenzie & Lounsbery, 2009; McKenzie, Sallis, & Rosengard, 2009; Sallis & McKenzie, 1991). The National Association for Sport and Physical Education (NASPE), determine that a physically educated person is an individual who displays competency in a variety of movements forms for the development of motor skills (NASPE, 1995). It was recommended, by the American Heart Association, that PE is a medium through which to promote lifelong PA. As such, PE should provide youths with the opportunity to learn generalisable motor skills (Pate, Davis, Robinson, Stone, & McKenzie, 2006). Pate et al. (2006), made several policy and practice recommendations: one of which suggested the need for evidence based health-related PE programs which encourage substantial amounts of MVPA (50% of the lesson) and teach movement skills which allow lifelong engagmement in PA. A number of multidisciplinary interventions which include a PE component, have been developed in response to these recommendations. The Sports, Play, and Active Recreation for Kids (SPARK) is one such evidence based PE programme (Dowda et al., 2005; McKenzie et al., 2009; Sallis et al., 1997), which was originally developed to target low PA and fitness levels. In recent years, it has evolved to also include a focus on the development of a variety of basic movement skills during PE units through prescription of skills associated with specific sports (McKenzie et al., 2009). The 'Get Skilled: Get Active' teaching aid was developed in Australia and was aimed specifically at improving basic skill competency amongst children and adolescents (NSW Department of Education and Training, 2000). This resource was originally developed for use by primary school PE teachers. It provides assistance in assessing FMS with skills description and breakdown supplied and subsequently how to incorporate the development of FMS in lessons (NSW Department of Education and Training, 2000). In recent years, an Irish PE intervenetion called the Y-PATH programme was developed to target low PA and FMS levels simultaneously in adolescent youth (Belton et al., 2014). The efficacy of this interevention was established on a small scale (n = 174), non-randomised controlled trial (O'Brien et al., 2013). It was recommended by the authors that a larger scale evaluation of the Y-PATH intervention is warranted (O'Brien et al., 2013). Given that a positive effect for the Y-PATH intervention has been observed on PA and FMS levels, it seems justified that its efficacy be established for a larger sample, in a randomised controlled trial.

In each of the school-based FMS interventions discussed, various FMS measurement tools and methods were utilised. Different FMS measurement tools are best suited to different populations and contexts (Cools et al., 2009). The next section will provide an overview of the leading FMS measures available for use at a population level.

2.2.3 Measurement of Fundamental Movement Skills

The effectiveness of interventions and programs aimed at improving FMS is largely centred on the ability of practitioners and researchers to collect accurate information about the skill level of participants (Hands, 2002). Several different tools to assess motor skill proficiency in children are available. Each tool is aimed at a specific target group, whether that be based on age range, testing for motor deficiencies or focusing specifically on fine motor skills, gross motor skills or both, hence the content included varies to cater to that group (Cools et al., 2009). Assessment tools used to test FMS can either be quantitative or qualitative in nature. Quantitative measurement tools are traditionally product-oriented and norm-referenced (Cools et al., 2009; Hands, 2002). The score from a quantitative measurement tool is normally a number such as the time in seconds it takes to run 100 metres, the distance of a throw or jump, or the number of successful catching attempts in 20 seconds (Burton & Miller, 1998). This result is then often compared to the performance of one's peers of similar age and gender; implying similar developmental and maturational stage should be observed (Hands, 2002). In a PE context, this form of movement assessment is often undertaken as it is relatively easy for the teacher to perform on observation. It is however extremely limited as it does not provide sufficient information on the movement process, failing to identify specific gross motor skill strengths and weaknesses which should subsequently determine how the teacher designs instruction for those that are experiencing developmental delays and sets annual goals to encourage development. Focusing on product as opposed to process, fails to consider the variability in movement patterns, thus it does not identify specific components of the movement process that require improvement (Hands, 2002; Ulrich, 2000). Qualitative measures provide an alternative to this by focusing on the actual performance of the movement, namely the form or technique (Hands, 2002). Qualitative FMS measurement tools are criterion-referenced in that each skill performed is compared to a list of predetermined criteria or components (Cools et al., 2009). Qualitative results provide much more meaningful rich data which informs practitioners and researchers of specific components requiring practice, development and intervention (Hands, 2002). They also assist in identifying motor development delays or areas of weakness in motor skill proficiency (Ulrich, 2000). There are numerous FMS assessment tools, aimed at specific target groups, each with their own advantages and delimitations. The following section provides a detailed account of five such tools.

2.2.4 Assessment Tools

The Movement Assessment Battery for Children (M-ABC) and subsequent revision the M-ABC-2 are tests which establish developmental status of FMS (Henderson and Sugden, 1992; Henderson, Sugden, & Barnett, 2007). Their focus is on specifically identifying developmental delay or deficiency in a child’s movement skill. The M-ABC is suitable for use with children between the ages of four and 12 years old. It consists of 32 items which are subdivided according to four age bands. Each age band consists of eight items which test children’s skills in the following three categories; manual dexterity, ball skills and balance skills. The test duration is between 20 to 30 minutes per child. The revised version, the M-ABC-2 (Henderson et al., 2007), is suitable for a slightly extended and older age range (3 - 16 years). This measure focuses on identifying how a child negotiates everyday tasks which would be encountered in both the home and school environment. Qualitative observations have been included as part of this revision. The M-ABC-2 operates across three age bands, with some individual item changes to increase correspondence, sensitivity and consistency between items and across age bands (Henderson et al., 2007). According to Burton and Miller (1998), this test is a suitable measure to assess motor abilities, early milestone, FMS and specialised movement. Research has demonstrated high inter-rater reliability for the M-ABC (ICC = 0.94 - 1.0) (Henderson and Sugden, 1992). A study of seven tasks of the M-ABC-2 Age Band 3 demonstrated excellent inter-rater reliability (ICC = 0.92 - 1.0) (Henderson et al., 2007). A small study of all age bands demonstrated good reliability for component scores (r = 0.73 - 0.84) and total test scores (r = 0.80) (Henderson et al., 2007). The strengths of this measure include cross-cultural validity. The test can be used in several European countries (Petermann, Bös, & Kastner, 2011). This measure, however, is limited in its use in that the original M-ABC test is product-oriented and largely norm-referenced only revealing that a child cannot perform and hence a more qualitative interpretation of the score is recommended (Henderson & Sugden, 1992). It fails to identify a child's strengths and weaknesses over a large range of skills given the limitations of being confined to the skills in a specific age band (Henderson and Sugden, 1992; Henderson, Sugden, & Barnett, 2007). The small range of skills assessed in each specific age band may also lead to a false negative in terms of identifying a child with low motor skill proficiency.

A second measurement tool of FMS proficiency is the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) and its revised format, the Bruininks-Oseretsky Test 2nd Edition (BOT-2 - Bruininks & Bruininks, 2005). This tool assesses fine and gross motor development in an attempt to identify mild to moderate coordination deficiencies in four to 21 year olds. The BOT-2 consists of 53 items which are divided into eight subtests namely; fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper limb coordination and strength. The testing time for one individual is exceptionally long ranging from 45 to 60 minutes, although a short form screening tool has been developed which takes 15 to 20 minutes to administer (Cools et al., 2009). Other limitations include the difficulty in obtaining the assessment battery, the complex scoring sheet, and the duration of the test being deemed inappropriately long for use with younger children in one session (Peerlings, 2007). The low number of specific FMS assessed also poses a considerable limitation, particularly for studies attempting to assess a variety of sports specific FMS.

The Körperkoordinationtest für Kinder (KTK) is another skills measurement tool used in children aged five to 14 years to assess typical developmental patterns, as well as being used in children with brain damage, behavioural problem and learning difficulties (Kiphard and Shilling, 1974; Kiphard and Schilling, 2007). The test is predominantly based on dynamic balance skills with a focus on gross body control and coordination. The test has been reduced from six original items, to a shortened four items. Administering the test to one child takes 20 minutes. The KTK is considered a thoroughly standardised and reliable tool. The

KTK is limited in its use given that it is centred on one element of gross movement namely balance, and does not consider locomotor or object control skills (Cools et al., 2009). Also scores on the KTK are product-oriented and subsequently compared to norms, meaning the process of the skill performance is not considered (Cools et al., 2009).

The Get Skilled Get Active tool is an Australian resource which is used to assess motor skills (New South Wales Department of Education and Training, 2000). This process oriented tool was developed as a teaching resource and assessment tool for teachers. A unique strength of this measurement tool is its inclusion of all categories of FMS (locomotor, object control, and stability) (Gallahue & Ozmun, 2006; Haywood & Getchell, 2009). It underwent rigorous review by a consultancy team of 52 experts, who decided 11 skills (catch, overhand throw, kick, forehand strike, two-handed sidearm strike, ball bounce, punt, sprint run, leap, dodge, vertical jump), were important for overall motor skill development of elementary school-age children (Department of Education Victoria, 1996). Test-retest reliability was reported for 42 primary school-aged children over a cycle of seven days. An updated resource consisted of 12 skills (New South Wales Department of Education and Training, 2000), eight of the original 11 skills (catch, overhand throw, kick, forehand strike, sprint run, leap, dodge, vertical jump), taken from the original resource (Department of Education Victoria, 1996), and four additional new skills (hop, side gallop, skip and static balance) (New South Wales Department of Education and Training, 2000). The broadening of this resource was done in an attempt to address the gender bias towards males and to reflect more accurately the skills applicable to a wide range of sports (Okely & Booth, 2004). The Get Skilled Get Active resource also has the ability to explore sociodemographic distribution of FMS proficiency in this school-age population (Okely & Booth, 2004). Each skill is broken down into observable and behavioural components, that are scored to give an estimation of the level of skills proficiency of the performer (Okely & Booth, 2004).

Teachers receive a checklist which is used to analyse the skills performance of the students (New South Wales Department of Education and Training, 2000). According to Okely and Booth (2000), reliability and validity of the skills and their components has been established. Barnett and colleagues (2010), do however question the validity of the measure in its ability to measure performer skill proficiency compared to that specified in the current literature (Barnett et al., 2010).

Finally, the Test of Gross Motor Development 2nd Edition (TGMD-2), measures gross movement performance using qualitative criteria (Ulrich 1985; Ulrich, 2000). According to Logan and colleagues (2011), results from a meta-analysis of the effectiveness of motor skill interventions in children, found that only studies using the first and second edition of the Test of Gross Motor Development (TGMD), met all inclusion criteria (Logan et al., 2011). Both the TGMD and the TGMD-2 are norm-referenced, process-oriented measures for use in children between the ages of three to 10 years. The TGMD-2 (a revision of the original TGMD), can be used to; identify children whose skills are developmentally behind their peers, plan specific intervention programs to improve skill level in those children displaying signs of developmental delay and assess changes in skills proficiency as a result of maturation, experience and instruction (Cools et al., 2009). Both editions of the measure (TGMD and TGMD-2), include a composite measure for object control (strike, dribble, catch, kick and throw) and locomotor skills (run, gallop, hop, leap, jump, skip and slide) (Ulrich 1985). The revised version (TGMD-2) removed skipping from the locomotor composite and added the underhand roll to the object control composite (Ulrich, 2000). Each skill is assessed by a child's ability to demonstrate between three and five performance criteria (Ulrich 1985; Ulrich, 2000). The child gets two attempts at each skill with a point given when a component is present, and a zero when it is not (Ulrich 1985; Ulrich, 2000). Locomotor and object control composites can be calculated, as well as overall FMS score and age equivalents can be derived (Cools et al., 2009). The test is relatively quick to administer, taking just 15 to 20 minutes, with little equipment required (Cools et al., 2009). Due to the high validity and reliability, the TGMD and TGMD-2 have been widely used in research seeking to measure FMS in children and adolescents (Breslin & Rudisill, 2011; Cliff, Wilson, Okely, Mickle, & Steele, 2007; Goodway, Crowe, & Ward, 2003; Hardy et al., 2010; O' Brien et al., 2015; Valentini & Rudisill, 2004). Given that Logan and colleagues (2011) highly recommend the use of both the TGMD and TGMD-2, and the fact that it has been validated and translated for use in different countries (Evaggelinou, Tsigilis, & Papa, 2002; Houwen, Hartman, Jonker, & Visscher, 2010; Wong & Yin Cheung, 2010), it seems justified to select these measurement tools over other alternatives. The TGMD and TGMD-2 however are somewhat limited as they do not include a measure of stability (Gallahue & Ozmun, 2006), and despite use in adolescent populations, it has not yet been validated in this cohort (O' Brien et al., 2015). In an Irish sporting context, the skip, vertical jump and balance are also deemed important (O' Brien et al., 2015), however the TGMD-2 does not include these skills. A combination measurement tool which incorporates the 12 skills assessed by the TGMD-2, and the additional three skills mentioned (skip, vertical jump, and balance), would be best suited to testing the skill levels of an Irish population. Given the exceptionally low FMS levels in childhood (Hardy et al., 2013), assessment and development of these FMS, both in primary school (age 4 - 11 years) and secondary school (age 12 - 18 years) is essential. This suggests that a valid and reliable measurement tool for FMS is necessary for use in adolescents in order to track FMS proficiency levels from childhood.

2.2.5 Levels of Fundamental Movement Skills

Until recent times, little research had been conducted on fundamental movement in an adolescent population. Acknowledgement of the importance of developing FMS has led to increased interest and research in this area. A body of data now exists which outlines the current levels of FMS proficiency in children and youth.

Okely and Booth (2004) provided some of the first evidence of the prevalence of FMS mastery among young Australian children. They sampled six basic FMS in 1,288 children (aged 6.2 - 8.2 years) in New South Wales (Okely & Booth, 2004). Results from this study found in both females and males across all years, the proportion of participants, who displayed mastery for any skill, did not exceed 35%. These results suggest that FMS levels in this cohort are low to moderate. These findings are slightly lower than similar research conducted, which found 40% of participants (aged 9.3 - 15.3 years) achieved mastery for five out of six skills (Booth et al., 1999). Given the differences in age, higher levels of mastery would be expected in the older adolescent population sampled by Booth and colleagues (1999). This highlights the extremely low levels of FMS attainment in this cohort, Hardy and colleagues (2010), examined the FMS levels in a slightly younger cohort (aged 4 - 5 years), given that previous research suggested that intervention at this level was necessary due to the low proficiency levels in primary school-aged children (Okely & Booth, 2004). Eight skills were assessed and results indicated that almost 75% of children demonstrated mastery of the run, while the proportion of children who possessed mastery was lower for all other skills ranging from 9% to 44% (kick; 35%, gallop; 31%, hop; 25%, jump; 22%, catch; 20%, throw; 16% and strike; 14%) (Hardy et al., 2010). While the previous evidence highlights discrepancies in FMS competency in children, more recent research in Australian youths and adolescents (9 - 15 year olds), suggest they are not meeting their developmental expectancy with low FMS competency (below 50%) observed (Hardy et al., 2013). Increases between 1997 and 2004 were observed across all children in the sprint, vertical jump and catch, and in the catch between 2004 and 2010. Given that increases in FMS ability were observed over time, it would suggest that FMS competency can be improved beyond the reported levels (Hardy et al., 2013).

These low levels of FMS proficiency are not confined to Australia alone. Globally, low prevalence of FMS competency are observed (Mitchell et al., 2013; O' Brien et al., 2015; O'Brien et al., 2013). Cliff and colleagues (2012) compared the mastery of 12 FMS (run, gallop, leap, horizontal jump, slide, hop, bounce, catch, kick, overhand throw, strike, and roll) between an overweight/obese sample and a reference sample from the US. Irrespective of the differences in FMS mastery observed between the reference sample and overweight/obese sample, proficiency levels were low in normally developing individuals specifically in locomotor skills with only 44% to 55% of participants aged eight to 10 years mastering the horizontal jump, leap or gallop (Cliff et al., 2012). Considering an Irish context, O'Keefe and colleagues (2007), conducted a PE study which identified that the fundamental skill of throwing namely the over arm throw, was inadequately developed in adolescent youth (15 - 16 years). More extensive research in an Irish population was conducted by O'Brien and colleagues (2015), who examined nine FMS in 12 to 13 year olds (O' Brien et al., 2015). A sample of 242 participants were assessed on the run, skip, horizontal jump, vertical jump, kick, catch, overhand throw, strike and stationary dribble. Only 11% of participants scored either near mastery or mastery for all skills suggesting that overall skill execution is low amongst adolescent youth and below developmentally appropriate levels (O' Brien et al., 2015). The concept of mastery and near mastery in FMS, suggests that although children are performing below the expected skills proficiency levels, some components are consistently absent, however not all components are. O'Brien and colleagues (2015) determined advanced skill proficiency was weak due to consistent failure across skills of similar components namely an inability to; crouch with the knees bent and arms behind the body, forcefully raise the arms upwards, move the arms in opposition to legs, and land on the balls of the feet. The low FMS levels observed are in line with previous research (Okely & Booth, 2004). Adolescents therefore may experience difficulty in transitioning to specialised sports specific skills, given that they do not have the basic skills mastered by age 13. While FMS proficiency levels vary from country to country, they are unanimously low across the spectrum with mastery levels falling below 50% in children and adolescents. Evidently, there is a need to address and correct these worrying trends in FMS (Hardy et al., 2013, 2010; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; O' Brien et al., 2015; Stodden et al., 2008).

2.2.6 Gender Differences in Fundamental Movement Skills

Differences in FMS ability according to gender have been widely observed with controversial outcomes. Research has found that males are generally more proficient than females in performing object control skills such as throwing, catching or kicking (Ehl, Roberton, & Langendorfer, 2005; Raudsepp & Paasuke, 1995; Runion, Roberton, & Langendorfer, 2003; van Beurden, Barnett, & Dietrich, 2002). Gender differences in locomotor skills are somewhat inconclusive, with some studies reporting no gender differences exist (Hume et al., 2008; Raudsepp & Paasuke, 1995; van Beurden et al., 2002), whilst others suggest males or females are more proficient. Understanding differences in motor skill performance across males and females is important, as it can help determine how to intervene to improve motor skill proficiency.

Okely and Booth (2004), found significant gender differences in the prevalence of mastery and near mastery, in half of the skills they assessed. Males performed significantly better than their female counterparts in all object control skills (catch, kick, throw, and strike), which could largely be due to environmental factors where males receive more encouragement, instruction and practice of these skills through participation in specific sports and activities (Ehl et al., 2005; Okely & Booth, 2004; Raudsepp & Paasuke, 1995; Runion et al., 2003; van Beurden et al., 2002). No gender differences were observed in five locomotor skills (hop, side gallop, dodge, vertical jump, and leap) and one body control skill (balance). Females however, were more proficient in skipping than males. This gender difference could be due to gender specific cultural expectations, with females more likely to participate in activities that develop skipping such as dance and gymnastics (Okely & Booth, 2004).

Van Beurden and colleagues (2002), observed similar results in a cohort of children aged eight to 11 years (n = 1045). Only 21.3% achieved mastery in less than half the FMS, with males displaying greater proficiency in object control skills, namely throw and kick, compared to females who rated poorest in these skills (van Beurden et al., 2002). This difference could in part be attributed to biological factors as males at this age have lower triceps skinfold thickness, larger arm joint diameter and greater estimated amount of arm muscle mass, than their female counterparts, which facilitates greater performance in object control skills (van Beurden et al., 2002). Environmental factors also play a role, in that males may be more likely to be encouraged, instructed and more practiced in these skills through sports participation (van Beurden et al., 2002). In line with previous research, females scored higher in locomotor skills (hop and side gallop) than their male counterparts (Okely & Booth, 2004; van Beurden et al., 2002). Haywood and Getchell (2009), propose that maturational factors such as changes in growth and sex hormones, may be contributing to the gender differences in skills ability during the adolescent years. Barnett and colleagues (2010), consider both biological and environmental factors such as opportunities to be active, encouraged and practised in skills, as contributing factors to the gender inequities in skills performance (Barnett et al., 2010).

Gender differences pose concern especially given their potential to track from childhood into adolescence. A longitudinal study, tracking gender differences in FMS proficiency from childhood into adolescence, was conducted by Barnett and colleagues

(Barnett et al., 2010). Participants were assessed in 2000, on three object control and three locomotor skills, aged 10 years, with a follow up in 2006/07. Barnett et al. (2010), in line with previous research (Hume et al., 2008), found males were outperforming females in object control skills, with gender differences observed in the kick, catch and throw. These gender differences subsequently tracked into adolescence. Potential reasons for these observations include the hypothesis that males participate in activities which involve greater object control skills and hence they receive encouragement, positive reinforcement, and prompting to develop these skills (Barnett et al., 2010) In contrast to the differences observed in object control skills, no gender differences were found in locomotor skills (Barnett et al., 2010).

Irish research demonstrates similar trends of gender differences in FMS proficiency, as those observed globally. Breslin et al. (2012), conducted research on FMS proficiency in children (aged 7 - 8 years) in Northern Ireland (Breslin et al., 2012). Findings confirm that children in an Irish context are displaying similar skills abilities as those observed globally, with males performing better than females on all but one locomotor skill (the log roll), where females outperformed them (Breslin et al., 2012). More recent research by O'Brien and colleagues (2015) suggest that skill levels remain relatively underdeveloped in Irish adolescents. Nine FMS were assessed (run, skip, horizontal jump, vertical jump, kick, catch, overhand throw, strike and stationary dribble) in 12 to 13 years olds (n = 242). Overall, only 11% of participants scored mastery or near mastery for all nine skills. Interestingly it seems gender differences continue to persist in Irish adolescents, with males scoring higher in overall composite FMS score, than females (O' Brien et al., 2015). Gender differences were also found in overall object control score, with males obtaining higher scores than females, however no gender differences were found for overall locomotor mean score performance (O' Brien et al., 2015)

Based on the existing literature, it seems evident that males demonstrate greater mastery and proficiency of object control skills, compared to their female counterparts (Barnett et al., 2010; Breslin et al., 2012; O' Brien et al., 2015; Okely & Booth, 2004; van Beurden et al., 2002). A gender divide in locomotor skills is not as apparent (Hume et al., 2008; Raudsepp & Paasuke, 1995; van Beurden et al., 2002). Given that gender differences in levels of FMS have been observed across all age groups (Barnett et al., 2010; Breslin et al., 2012; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006), developing targeted interventions which focus on particular components of FMS and are gender specific, are warranted. Research suggests that both biological and environmental factors may be contributing to the gender differences witnessed (Barnett et al., 2010; Haywood & Getchell, 2009). Irrespective of the causes of these gender differences in FMS proficiency, is the urgent need to address them through evidence based PE interventions which specifically target and facilitate females to develop proficiency in object control skills (Lounsbery et al., 2013).

2.2.7 Correlates of Fundamental Movement Skills

Worldwide, proficiency levels in FMS remain consistently low from childhood through to adolescence. Interventions targeting overall FMS proficiency are therefore warranted. Efforts to improve FMS must consider targeting specific areas which are poor, for example females, given their lower levels of mastery observed when compared to males. Successful interventions must also consider the complex nature of FMS proficiency and exploit the correlates of FMS, in order to see improvements in FMS mastery. Given the lower mastery levels of FMS in females, this may contribute to their lower PA levels (Hardy et al., 2013). This in one example of a correlate of FMS, however according to research several correlates exist which potentially affect FMS proficiency levels. Stodden and colleagues

(2008) proposed a conceptual model which hypothesises the potential correlates of FMS. This will be discussed in further detail in this section.

Stodden and colleagues (2008), acknowledge that although extensive research has been conducted on promoting the importance of PA, it is still unknown how to ensure sustained lifelong PA participation (Stodden et al., 2008). Researchers believe this in part could be due to failing to recognise the role of motor skill proficiency in the initiation, maintenance, or decline of PA levels (Stodden et al., 2008). A conceptual model was developed hypothesising the relationships among motor skill competency, PA, perceived skill competency, health-related physical fitness (HRF), and risk of obesity resulting in either healthy weight or unhealthy weight (Stodden et al., 2008). As a result, the direct relationships between these variables and motor skills proficiency have been explored at length; however few studies have investigated the mediating pathways or the model as a whole. This section of the literature review will seek to provide an overview of the associated benefits and correlates of FMS namely discussing PA, HRF, perceived competence, and BMI.

2.2.7.1 Role of Physical Activity

With recent research, a much clearer picture has emerged of the relationship between PA and FMS in children and adolescents (Holfelder & Schott, 2014; Lubans et al., 2010; Robinson et al., 2015; Stodden et al., 2008). Lubans et al. (2010) identified 13 studies which looked at the relationship between FMS and PA participation. A mixture of PA measures was used (self-report, objective measures, and a combination of the two). From both cross-sectional and longitudinal data, FMS was found to be associated with at least one component of PA (non-organised activity, organised activity, pedometer step counts) in 12 studies (Lubans et al., 2010). Hence, a plethora of research now exists, which suggests that FMS proficiency is positively associated with habitual PA in both children and adolescents

(Barnett et al., 2009; Lubans et al., 2010; Okely, Booth, & Patterson, 2001; Wrotniak et al., 2006). Research conducted by Barnett and colleagues (2011) has also considered the direction of this relationship suggesting that a reciprocal relationship exists between FMS and PA i.e. participation in PA enhances FMS development rather than or potentially in addition to, the reverse. In a cohort of adolescents (aged 16.4 years), Barnett et al. (2011) found a reciprocal relationship between object control and MVPA and a one-way relationship from MVPA to locomotor skill (Barnett et al., 2011). This provides rationale for targeting FMS and PA simultaneously in interventions. Similarly, Barnett et al. (2009), identified that childhood object control proficiency was positively associated with adolescent PA levels and accounted for between 12.7% and 18.2% of time spent in MVPA and organised activity, respectively (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009). Object control proficient children, are therefore more likely to become active adolescents, suggesting the importance of targeting FMS and specifically object control skills in childhood, to promote long-term PA. Lopes et al. (2011) also recognised the importance of motor skill proficiency as a predictor of change in childhood PA. They found that children with low initial motor control levels demonstrated the greatest decline in PA behaviour over time (Lopes, Rodrigues, Maia, & Malina, 2011). They concluded that motor control is an important predictor of PA behaviour in children (Lopes et al., 2011). Further longitudinal evidence of this relationship between FMS proficiency and PA, can only strengthen the argument, from a public health perspective, for improvements in FMS teaching and practice. In an Irish context Woods and colleagues (2010), provides support for the advocacy of FMS, and subsequent increases in PA behaviours which has largely been supported in the literature.

2.2.7.2 Role of Health-Related Fitness

The relationship between FMS and the components of HRF is extremely complex (Pate, Oria, & Pillsbury, 2012). Our understanding firstly of physical fitness (and subsequently HRF) has had a storied past (Pate, 1988), with definitions relying solely on movement capacities both too narrow and too broad. Pate (1988) determines that the use of three terms is acceptable, namely; motor performance, physical fitness and health-related physical fitness. HRF as defined by Pate (1988) encompasses cardio-respiratory fitness, muscular strength, muscular endurance, flexibility and body composition. According to the Stodden model (2008), HRF develops as a result of motor skill proficiency, in early childhood (Stodden et al., 2008). Subsequently, in middle and late childhood, Stodden and colleagues (2008) suggest HRF acts as a mediator of the relationship between PA and FMS proficiency, as increased fitness enables continued PA participation (Stodden et al., 2008). Although efficacy of the mediating pathway has yet to be undertaken, recent evidence for the direct relationship between FMS and HRF has been found (Cattuzzo et al., 2014). From a potential 44 studies, 16 investigated HRF independently or using a composite HRF measure, with all studies finding a positive association with FMS (Cattuzzo et al., 2014). Positive associations were found specifically between FMS and cardio-respiratory fitness, and musculoskeletal fitness. This builds on the findings of Lubans et al. (2010), who found a positive relationship between FMS competency and a component of HRF; cardio-respiratory fitness. In addition, Stodden et al. (2009) found in young adults (aged 18 - 25), that 79% of the variance in overall fitness was predicted by the jumping, kicking and throwing (Stodden, Langendorfer, & Roberton, 2009). This provides some of the strongest evidence, suggesting FMS and HRF are highly related (Stodden et al., 2009). More longitudinal data exploring the changes in FMS and HRF over time, are required to fully understand these casual relationships (Lubans et al., 2010).

2.2.7.3 Role of Perceived Competence and Self-Confidence

Perceived competence and self-confidence have in recent times been investigated in relation to FMS. Both terms are often used interchangeably however there is a notable difference. Perceived competence has been central to the formulation of social learning theory (Badura, 1977) and is defined as one's awareness of their ability to perform a specific activity, whereas self-confidence refers to one's self-assuredness in their ability or judgement. The role of both as correlates of FMS will be discussed in detail.

Perceived competence is also highlighted in Stodden's model (2008) as a mediating factor between FMS and PA. Perceived competence is a person's individual perception of their own actual movement abilities (Harter, 1999). According to Harter's proposed model (1999) aimed at explaining the relationship between perceived motor competence and FMS; actual FMS competence, leads to perceived competence, whilst perceived competence plays a leading role in motivation which subsequently results in PA participation, compared to FMS level. Perceived competence is linked with mastery attempts and persistence in early childhood (Nicholls & Miller, 1983). A child may have low FMS proficiency, however, perceive themselves as highly competent. In adolescence, it is expected due to greater cognitive function, that children will be able to more accurately approximate their actual skills in relation to their peers (Harter, 1999). Thus children, who perceive their skills as low, will see tasks as more challenging and be less likely to participate and miss opportunities to develop their skills (Stodden et al., 2008). It is during this transition from early childhood to middle childhood, that stronger relationships between perceived FMS competency and actual FMS ability, are expected (Stodden et al., 2008). Babic and colleagues (2014), found out of all aspects of self-concept, perceived competence had the strongest relationship with PA. Barnett et al. (2015) investigated the associations between young children's (aged 4 - 8 years) perceived and actual ball skill competence. Results found that females had lower perceived and actual object control skill, than their male counterparts (Barnett, Ridgers, & Salmon, 2015). Actual competence in object control skills, was positively associated with perceived object control competence, in both genders (Barnett et al., 2015). This finding is in line with findings from similar research conducted with young children (LeGear et al., 2012; Robinson, 2011). Youth with higher levels of perceived competence therefore appear to demonstrate relative skill competence (Barnett et al., 2015; LeGear et al., 2012; Robinson, 2011). Perceived competence therefore plays an important role in motivating young people to be active and hence develop skills competency. Other studies have looked at the complex relationship between FMS proficiency, perceived FMS competence and PA as proposed in Stodden's model (Stodden et al., 2008), investigating the role of perceived competence as a mediator (Barnett et al., 2011; Khodaverdi, Bahram, Stodden, & Kazemnejad, 2015). Barnett et al. (2011), found perceived sports competence partially mediated the reciprocal relationship between object control proficiency and PA (Barnett et al., 2011). Given that perception of skill proficiency appears important for the relationship between PA and actual object control skill, Barnett and colleagues (2011), suggest the need to focus on increasing perceived competence to affect change in PA levels and FMS proficiency. Khodaverdi et al. (2015), more recently examined the mediating role of perceived motor competence, on the relationship between actual motor skill and PA levels in children (Khodaverdi et al., 2015). Interestingly, they found significant associations between perceived motor competence, gross motor quotient and locomotor skills, albeit the correlations were generally low to moderate (Khodaverdi et al., 2015). Khodaverdi and colleagues (2015) found perceived competence mediated the relationship between actual motor competence and PA ($b = .16$, 95% CI = [.12, .32]), suggesting the importance of perceived competence. McGrane and colleagues (2015) developed a physical self-confidence scale for use in adolescents, which aimed to assess the physical self-confidence of adolescents across genders at performing specific FMS. Results highlighted a significant gender difference in overall physical self-confidence with males scoring significantly higher than females (McGrane, Belton, Powell, Woods, & Issartel, 2015). Similar gender differences were observed for both overall locomotor physical self-confidence score and overall object control physical self-confidence score (McGrane et al., 2015). Given the gender differences in physical self-confidence (McGrane et al., 2015), and the association of higher perceived competence with higher actual competence (Barnett et al., 2015; LeGear et al., 2012; Robinson, 2011), strategies targeting FMS acquisition and/or PA levels, therefore must consider promoting children's self-perception, particularly in females.

2.2.7.4 Role of Weight Status

Finally, Stodden at al. (2008) proposed a dynamic and reciprocal relationship between weight status and the aforementioned factors (FMS, PA, HRF and perceived motor competence) exists. This was best described as a "positive spiral of engagement", implying that FMS proficiency, higher perceptions of FMS competence, greater PA, and higher levels of HRF results in a healthy weight status (Stodden et al., 2008).

Extensive research has investigated the direct relationship between motor skill and weight status, specifically BMI. D'Hondt et al. (2009), investigated gross and fine motor skills in overweight and obese children compared with normal-weight individuals (D'Hondt, Deforche, De Bourdeaudhuij, & Lenoir, 2009). Scores in both balance and ball skills, were significantly lower in obese children compared to their normal weight counterparts. Similarly, manual dexterity was greater in the normal-weight sample, suggesting that general motor skill level is lower in obese children than in normal-weight and overweight individuals (D'Hondt et al., 2009). This lower skills ability observed in obese children is likely to impede participation in physical activities, particularly given that obese individuals recorded lower results in tasks requiring the movement of more body segments i.e. more body mass.

D'Hondt and colleagues (2011) more recently explored gross motor coordination in relation to weight status in a sample of five to 12 year olds (D'Hondt et al., 2011). Higher weight status was associated with poorer results in the KTK assessment (D'Hondt et al., 2011). In line with previous research (D'Hondt et al., 2009), the effect of increased BMI was most prevalent on items requiring dynamic body coordination. Older overweight and obese children (10 - 12 year olds) demonstrated significantly poorer motor skills compared to their younger corresponding peers which suggests the need for early development of FMS in children (D'Hondt et al., 2011). Lubans et al. (2010) reported in their recent systematic review that weight status is the most commonly assessed physiological benefit of FMS proficiency (Lubans et al., 2010). From nine studies which investigated weight status and its relationship with FMS, six found an inverse relationship between FMS proficiency and weight status meaning normal weight individuals demonstrate greater skill acquisition compared to their overweight and obese counterparts (Lubans et al., 2010). This presents a vicious circle, in which overweight and obese children are less likely to be active as a result of excess mass and hence demonstrate lower skill levels which further impedes their ability to participate (Cairney, Hay, Wade, Faught, & Flouris, 2006). A plethora of research suggests FMS proficiency is associated with healthy weight, which subsequently strengthens the argument and urgency for increased focus on teaching, developing and practising of FMS.

2.2.7.5 Potential Correlates

As previously discussed, much research has investigated the correlates of FMS. A recent systematic review by Barnett and colleagues (2016), found the most examined correlates of FMS were biological and demographic variables such as age, weight status, gender and socioeconomic status (Barnett et al., 2016). Behavioural attributes traditionally explored include PA and sport participation (Barnett et al., 2016). Notably there is an absence of research which considers psychological and psychosocial variables which may help explain the complex nature of FMS proficiency (Barnett et al., 2016). Given FMS levels continue to remain low, future research should seek to further examine and explain the potential correlates and mediators which may help us understand how to increase FMS proficiency in youths.

In conclusion, the justification for promoting improvements in FMS proficiency is largely due to the associated benefits of FMS (Lubans et al., 2010) namely the consistent positive associations identified between FMS proficiency with PA levels and HRF (Cattuzzo et al., 2014; Lubans et al., 2010). Similarly, the inverse relationship between weight status and FMS proficiency would suggest the need to implement effective FMS interventions to combat undesirable weight status (D'Hondt et al., 2009; Lubans et al., 2010). Acknowledging the central role self-confidence and perceived competence appears to play in FMS ability is also important in prospective FMS interventions, as those that perceive themselves as competent in skills are more likely to demonstrate the desired proficiency (Barnett et al., 2015; LeGear et al., 2012; Robinson, 2011). Although extensive research has gone some way in identifying the correlates of FMS, other elements such as psychological and psychosocial variables have yet to be investigated in relation to FMS proficiency (Barnett et al., 2016), and may aid further in our understating of FMS proficiency and how best to intervene in order to reap the associated benefits.

Given the low levels of FMS proficiency observed in adolescents worldwide, and the current benefits associated with the acquisition of FMS proficiency, the need to intervene is evident and urgent. Utilising the PE curriculum has proven successful in other countries (Dowda et al., 2005; McKenzie et al., 2009; Sallis et al., 1997), and perhaps is the best placed public health delivery system through which we can access children and adolescents (Clark, 2007).

2.3 Physical Activity Interventions

The literature review thus far has identified low PA and FMS levels. Given the health benefits associated with both it therefore seems apparent that efforts to address and rectify these low levels observed globally, must be made. This section of the literature review will make a case for the need to intervene and considerations in the implementation of PA and FMS interventions.

2.3.1 How to Intervene

As previously discussed, PA levels are extremely low across the age spectrum (Hallal et al., 2012). Of particular interest are the low levels of PA in children and adolescents (Currie et al., 2012; Eaton et al., 2012; Troiano et al., 2008; Woods et al., 2010). Given that PA behaviour tracks from childhood into adulthood (Telama et al., 2005), failing to address the worrying PA trends in adolescence would appear senseless. Participation in the recommended amount of PA is associated with several major health benefits including lower rates of; stroke, CHD, metabolic syndrome, type II diabetes, and all-cause mortality (Warburton et al., 2010). Due care must be taken of our young people, with efforts to improve PA both warranted and urgent. It is evident from existing research, that monitoring of PA levels alone is not sufficient. Physical activity is positively associated with many demographic, biological, and social and cultural variables (Dishman et al., 2004; Lee et al., 2012; Van Der Horst et al., 2007). Improvements in PA levels will more than likely cause a positive contamination effect and result in increased self-efficacy levels, perceived competence and social support, HRF, BMI, as well as FMS proficiency (Craggs et al., 2011; Dishman et al., 2004; Lubans et al., 2010; Van Der Horst et al., 2007). Considering the literature, the positive association consistently observed between PA and FMS proficiency would suggest targeting both simultaneously in interventions may prove fruitful (Lubans et al., 2010). Low levels of PA and FMS over prolonged periods can lead to undesirable weight status which ultimately results in low perceived and actual sports ability further preventing participation in sport and activities (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Gallahue & Ozmun, 2006). According to Stodden et al. (2008), a reciprocal relationship exists between PA levels and FMS proficiency meaning increased participation in PA is likely to provide the opportunities to develop skills proficiency, in addition to the reverse; individuals with greater skills proficiency are more likely to participate in PA (Stodden et al., 2008). Given that FMS form the building blocks for more sports specific skills, their development is necessary for lifelong PA participation (Gallahue & Ozmun, 2006). Despite the known benefits of PA participation, and the importance of FMS development, in Ireland both PA levels and FMS proficiency remain below the expected and required levels (O' Brien et al., 2015; Woods et al., 2010). Addressing these low levels is a public health priority particularly given the high incidence of childhood obesity (Wang & Lobstein, 2006), which tracks from childhood into adulthood (Dietz & Gortmaker, 2001).

Considering the evidence, it is evident that an effective intervention which targets adolescent PA and FMS levels simultaneously is necessary in addressing youth health concerns. Multiple interventions have been implemented and evaluated, targeting PA levels and/or FMS proficiency (McKenzie et al., 2004; Pate et al., 2005; Sallis et al., 1997; Salmon, Ball, Hume, Booth, & Crawford, 2008; van Beurden et al., 2003). Interventions targeting PA alone are hence limited given the previously discussed need to target PA and FMS simultaneously. Notably, interventions of this nature are often conducted in children, however given the noticeable dropout and decline in PA during adolescence (Hallal et al., 2012; Kimm et al., 2000; O'Donovan et al., 2010), and the lack of FMS proficiency in this cohort (O' Brien et al., 2015), targeting the adolescent population specifically is necessary. In this period of transition from childhood into adolescence, and subsequently into adulthood, maintaining interest in PA pursuits is essential, to ensure that individuals have the skills and habits which enable them to continue leading healthy, physically active lifestyles.

Given that young people are failing to meet the PA guideline and are participating in increased levels of sedentary pursuits (Currie et al., 2012; Eaton et al., 2012; O'Brien et al., 2013; Troiano et al., 2008; Woods et al., 2010), recommendations by the WHO for the introduction of successful PA interventions, seem justified (Currie et al., 2012). Varied and diverse efforts have been made to improve PA levels across different age groups including; campaigns and informational approaches, behavioural and social approaches, and environmental and policy approaches (Heath et al., 2012). School-based interventions aimed at improving PA levels in school-aged children have been widely recommended, given that it is in school where this population spend the majority of their waking hours (Haerens et al., 2006; O'Brien et al., 2013). School-based interventions have great potential to affect change in PA behaviour, particularly given the availability of mandatory PE in many countries (Heath et al., 2012). Physical activity interventions which target the PE lesson specifically have been proven to be effective in increasing youth PA levels (McKenzie, Sallis, & Nader, 1991; McKenzie & Lounsbery, 2009; Strong et al., 2005). Schools provide the ideal setting for PA interventions not solely due to the access they provide to the adolescent population, but also as a result of readily available resources and equipment, PE curricula and lessons, and trained PE specialists (Breslin et al., 2012). Kriemler and colleagues (2011) conducted a review of recent reviews of PA and fitness interventions (Kriemler et al., 2011). They identified the school-based application of multi-component intervention strategies as the most consistent and promising intervention strategy, with improvements in both in-school PA and out-of-school PA levels observed (Kriemler et al., 2011). Multi-component interventions fall under the umbrella of the ecological model as they consider the many different factors which ultimately influence health-related behaviours (Murillo Pardo et al., 2013). According to

Murillo Pardo et al. (2013) ecological models have been proven to be appropriate conceptual models to design interventions aimed at improving PA levels. Multi-component interventions consider social and environmental elements often incorporating three core components namely; developing students' knowledge and skills, providing social support and creating environmental conditions and opportunities which are conducive to healthy living (Murillo Pardo et al., 2013). There is much evidence supporting the efficacy of multi-component interventions aimed at increasing PA levels and FMS proficiency in children and adolescents (Dobbins, Husson, DeCorby, & LaRocca, 2013; Van Sluijs, McMinn, & Griffin, 2008). Multi-component school-based interventions are mainly developed either through curricular or non-curricular channels (Murillo Pardo et al., 2013). According to Timperio and colleagues (2004) strategies to promote PA among children, adolescents and young adults that incorporate whole-school approaches including curriculum, policy and environmental strategies appear to be more effective than those that incorporate curriculum-only approaches. In agreement with Timperio et al. (2004), Perry and colleagues (2012) suggest that PA interventions must target ecological domains beyond the individual to be successful, namely; social networks, socio-cultural and community aspects, environment and policy. Potential strategies include; providing additional opportunities for PA and non-traditional PE classes in the environmental domain, and incorporating elements of role modelling and social support (family, peer, teacher) in the social networks domain (Perry et al., 2012). Future interventions therefore seeking to improve PA and FMS levels simultaneously should place the participant at the centre of the intervention whilst also considering the environmental and social elements which are likely to influence engagement. In school age children, providing a conducive whole-school approach towards PA is essential given the quantity of time spent in the school environment. Also incorporating a parent element is warranted as at this stage in maturation, parental support is deemed essential in terms of providing the encouragement and means to participate in PA be it monetary, transport, or otherwise.

2.3.2 Components of Interventions

The school setting has long been defined as the ideal setting for PA interventions given that young people spend the majority of their waking hours in the school setting (Kriemler et al., 2011; Timperio et al., 2004; Van Sluijs et al., 2008). It is possible to globally reach the population of interest with ease rather than relying on family involvement. School-based interventions are considered the most universally appropriate means of intervening in low PA and fitness levels in youth (Kriemler et al., 2011). Reviews of school-based interventions provide in-depth information on specific components of effective interventions (Kriemler et al., 2011; Timperio et al., 2004; Van Sluijs et al., 2008). Several specific promising intervention strategies have been identified. Timperio and colleagues (2004), stress for the inclusion of whole-school approaches to interventions, which incorporate curriculum, policy and environmental strategies as opposed to curriculum-only approaches. In addition, interventions which include a familial element generally appear more effective (Timperio et al., 2004). According to Salmon et al. (2007), interventions that are most effective in the school setting include a focus on PE, activity breaks and family strategies (Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007). Kriemler et al. (2011) reviewed current systematic reviews on the effect of school-based interventions on PA and fitness in children and adolescents (aged 6 - 18 years). In agreement with Timperio and colleagues (2004), Kriemler et al. (2011) suggests that multi-component approaches in children showed the highest level of evidence for increasing overall PA (Kriemler et al., 2011). They also advocated for the inclusion of a family component (Kriemler et al., 2011). Furthermore, Murillo Padro et al. (2013) recognises the importance of including computer-tailored interventions, and acknowledges the necessity for female specific strategies which consider their interests and needs (Murillo Pardo et al., 2013). Perry et al. (2012) suggests the importance of targeting ecological domains beyond the individual when developing PA interventions for adolescents (Perry et al., 2012). Potential components include; social networks (family, peer, and teachers), socio-cultural and community (cultural awareness, community member and organisations), environment (schools, parks, and neighbourhood safety), and policy (Perry et al., 2012).

Research has found that multi-component school-based interventions have the ability to increase both in-school PA and out of-school-PA levels (Kriemler et al., 2011; Salmon et al., 2007). School-based interventions with transferable benefits outside of the school setting are essential for life long PA participation. Evidence suggests that a whole-school approach to PA is conducive to increases in PA levels (Belton et al., 2014; de Meij et al., 2011; Murillo Pardo et al., 2013). Moving beyond the PE lesson and PE teacher as the sole provider of PA opportunities in the school setting is essential, with the inclusion of other staff members as PA role models necessary. It is also recommended that inclusion of a community element in adolescent PA interventions may prove effective (McKenzie & Lounsbery, 2009; McKenzie, Sallis, & Rosengard, 2009; Pate et al., 2005). As previously stated, PE is our best placed health system through which to implement PA and specifically FMS interventions, despite the discrepancies in PE time observed. PE provides the opportunity to develop generalisable movements and basic FMS which are the building blocks of future sports participation. Using PE to specifically focus on the teaching and practising of these basic skills appears sensible. Several interventions exist which use the medium of PE and health-related activity to both develop FMS proficiency and increase PA levels, namely the “Move it Groove it” intervention (van Beurden et al., 2003), and the Y-PATH intervention (Belton et al., 2014; O’ Brien et al., 2015).

Research has found that effective PA interventions include a family or community element (Van Sluijs et al., 2008). Children and adolescents are strongly influenced by the people and social context in their lives, therefore inclusion of parental or familial components whether educational or supportive for PA participation, has proven worthwhile (de Meij et al., 2011; Haerens et al., 2006; O'Brien et al., 2013; van Beurden et al., 2003). The JUMP-in primary school-based community intervention aimed at improving PA in a Dutch population, included a parental information services element (de Meij et al., 2011). This involved the delivery of information meetings, courses and sports activities for parents (de Meij et al., 2011). Reaching parents poses considerable difficulties, hence the use of pre-existing structures by the JUMP-in intervention such as language courses or coffee morning to maximise attendance (de Meij et al., 2011). In an Irish context when seeking to make contact with parents through primary and secondary school interventions, using existing structures such as parent teacher meetings and school induction meetings at the start of the academic year particularly in secondary schools may prove beneficial. Haerens and colleagues (2006) used a similar technique when involving a parental element in their PA and healthy eating intervention in middle school children. Parents were invited through their child's school to attend an interactive meeting on healthy food, PA and the relationship with undesirable weight status (Haerens et al., 2006). The school newsletter was also used as a medium to incorporate parents in the intervention, as well as a home adult version of the computer-tailored intervention and regular updates through an information folder on their child's participation in the computer-tailored programme (Haerens et al., 2006). This suggests that giving parents access to the intervention material may assist in their engagement with the intervention and encouragement of their child. Intervention materials can be provided in the form of leaflets, CDs or through online access through specially designed websites. General consultation with parents when implementing whole-school approach interventions appears justified (van Beurden et al., 2003).

In summary, it is fair to acknowledge that conflicting evidence exists on the recommended best practices when developing and implementing youth PA interventions. From the literature there is a strong rationale for multi-component school-based interventions when targeting PA levels in youth (Kriemler et al., 2011; Timperio et al., 2004; Van Sluijs et al., 2008). Using PE as the medium through which the teaching, learning and practicing of motor skills is incorporated, as well as providing substantial opportunities to gain minutes of MVPA, appears effective (Breslin et al., 2012; McKenzie, Sallis, & Nader, 1991; McKenzie & Lounsbery, 2009; Strong et al., 2005). The inclusion of a whole-school approach with a parental element seems justified (de Meij et al., 2011; Haerens et al., 2006; van Beurden et al., 2003). Using pre-existing structures such as parent-teacher meetings or introductory parent talks at the start of the academic year seem the best placed mechanisms through which to reach parents and maximise attendance (de Meij et al., 2011). Making intervention materials available to parents is one such strategy for encouraging parental support (Haerens et al., 2006). In addition, providing information sessions and leaflets which educate the parents on the content and purpose of the intervention appear to assist the parent in supporting and encouraging their child in leading a more physically active lifestyle (de Meij et al., 2011; Haerens et al., 2006). Decisions regarding the best practice and procedures when designing and implementing interventions must be made with the target population in mind. It therefore seems justified to review existing PA and FMS interventions which have been conducted in the child and adolescent populations, to identify appropriate elements for consideration. Some caution must be taken when reviewing established interventions, as each is restricted to a degree and the limitations must be addressed with a need for future interventions to consider them during their design phase.

2.3.3 Examples of Interventions

There is an ever growing number of school-based intervention programmes seeking to improve child and adolescent PA participation, FMS proficiency, and HRF, whilst also educating on the principles of health and fitness. These interventions have been evaluated rigorously and can inform future efforts to increase PA behaviour in this population. This section seeks to provide an overview of the implementation and evaluation of evidence-based PA interventions.

Multi-component interventions which use a health-related PE programme have been implemented and evaluated in both children (9 years) and adolescents (13 years). The SPARK intervention conducted in the US recruited 955 fourth graders from seven schools (Sallis et al., 1997). The primary objective of the health-related PE programme was to increase PA levels during PE class and in hours outside of school time. The outcome measures included PA (self-report and objectively measured, by accelerometer), fitness (mile run, sit-ups, pull ups, and sit and reach test), skin folds and direct observation of activity levels during PE classes. A quasi-experimental design was employed where schools were assigned to one of three conditions; specialist led (PE was led by a trained PE teacher), teacher led (the teacher was responsible for delivering the PE intervention), and control condition where traditional PE was delivered by the classroom teacher. SPARK PE was delivered three times per week with a focus on teaching basic skills and encouraging high levels of PA. Participants were also taught self-management which entailed educating students on how to transfer lessons learnt in PE to their time outside school in order to increase PA behaviour in everyday life. PE homework sought to encourage parent engagement and an element of social support for the participant. Results found that students in the intervention conditions were exposed to more PE than those in the control condition and they also spent significantly more time in PA behaviour during school hours. On follow up, females in the intervention classes exhibited significantly greater fitness ability (abdominal strength and endurance, and cardio-respiratory endurance) than females in the control group. No significant differences were found between groups in activity levels outside of school hours. This intervention is limited in that its attempts to increase PA outside of school failed. In addition, increases in fitness levels were only observed in females. Future interventions should seek to increase overall PA, during both in-school and out-of-school time, in order to see marked changes in youth MVPA for health benefits. Also targeting male fitness levels is warranted irrespective of the fact that they demonstrate higher baseline fitness levels, as overall fitness and PA is below recommended levels. The Lifestyle Education for Activity Program (LEAP), a two-year intervention, not dissimilar to the SPARK intervention, was assessed in an older cohort (13.6 years) of females using a group-randomised controlled field trial (Pate et al., 2005). The intervention sought to change the school environment and instructional practices in order to improve the support and encouragement of females to be physically active, increase their enjoyment of PA and improve MVPA levels during PE lessons (≤ 50% of lesson time). The multi-component intervention consisted of the following six elements; PE, health education, school environment, school health services, faculty/staff health promotion, and a social support element, namely family/community involvement. Results confirmed that the incidence of vigorous PA (VPA) was greater in intervention schools than control schools. From the LEAP intervention cohort, 45% of females reported on average one or more block of 30 minutes of VPA per day during the recall period, compared to 36% of females in the control condition. The LEAP programme therefore has the ability to increase participation in VPA. Important to note however is the sample used consisted solely of females. Whether these findings would be observed in a male sample is not known. Findings from the SPARK and LEAP interventions suggest the introduction of a specialised PE curriculum focusing on health-related activity and skills, has the ability to improve PA levels during PE class, when compared to traditional elementary school PE. The percentage of adolescents that can benefit from such interventions is extremely high given that the majority of this cohort is readily accessible through the elementary PE class. Their efficacy however needs to be established in an adolescent mixed-gender cohort as SPARK was only trialled with children and the LEAP intervention solely targeted females, yet the prevalence of inactivity is high in adolescents of both genders.

Interventions including a teacher-training element have been vigorously tested. Providing professional development for PE specialists and using existing adapted curriculum through which to intervene has proven popular and effective in both PA and FMS interventions. Both the Move It Groove it (MIGI) intervention and the Middle School Physical Activity and Nutrition (M-SPAN) place the teacher at the centre of the intervention, providing teacher-training in-service workshops in an attempt to alter the way PE is delivered with the aim of increasing PA and FMS levels. The MIGI intervention implementation and evaluation was conducted in New South Wales, Australia, on 1,045 year three and year four children aged between seven and 10 years, from nine intervention and nine control schools (van Beurden et al., 2003). It aimed to improve children's FMS proficiency and increase PA participation, simultaneously. Using a quasi-experimental design, a whole-school approach was adopted which included the development of school project teams (including principals, teachers and parents), and the introduction of a teacher 'buddy' system web site (providing strategies, resources and knowledge from expert educators). Four teacher-training workshops were also delivered. Grants to enable the purchasing of necessary equipment were made available. Primary outcome measures included; mastery or near mastery of eight FMS (static balance, sprint run, vertical jump, kick, hop, catch, overhand throw, and side gallop), and time spent in MVPA and VPA during PE was analysed (using SOFIT PE observational tool). Positive results were found with significant improvements in FMS made by both males and females (ranging from 7.2% to 25.7%). A significant increase of 3% in VPA was identified. This finding suggests that it is possible to improve children FMS proficiency through specialised PE lessons, without sacrificing time spent in MVPA and VPA. Similarly, the M-SPAN intervention, was developed and implemented with the aim of improving PA levels during middle school PE class time (McKenzie et al., 2004). A randomised control trial was conducted in 24 middle schools (intervention n = 12, control n = 12) in Southern California with a sample size of approximately 25,000 children. Intervention schools engaged in a two-year intervention programme. Intervention PE teachers received professional development in the form of five three-hour in-service training sessions. The aim of these sessions was to educate and assist teachers in; understanding the importance of health-related PE lessons, developing PE curriculum centred on activity, improving class management style and instruction in order to optimise PA time in lessons, and providing a supportive environment in order to encourage and promote change. Control schools continued with usual practice. The primary outcome measure was the use of SOFIT observation tool during lessons on 11 randomly selected days, to categorise activity levels of students, the lesson context and teacher behaviour. Significant increases in MVPA in PE lessons were observed (equating to approximately three minutes per lesson). An 18% increase in MVPA was identified by year two in intervention schools. The effect of the intervention was greater for males when compared to their female counterparts. Findings from M-SPAN highlight that it is possible to increase minutes of MVPA during PE lessons without increasing the frequency of lessons, simply by utilising a standardised programme centred on PA participation. Given that the effect size varied according to gender, more specific strategies may be required when targeting female PA levels. Although both interventions were successful, the level of teacher training in both was quite high, labour intensive and possibly quite costly. Future cost and time efficient interventions seeking to increase PA and FMS levels, should attempt to identify if lower levels of researcher involvement can demonstrate similar levels of efficacy.

Existing interventions have evaluated their efficacy in specific social groupings namely disadvantaged socioeconomic status groups. The Switch-Play intervention is one such intervention which was conducted on a low socioeconomic cohort aged 10 years in Melbourne, Australia (Salmon et al., 2008). The aim of the intervention was to prevent weight gain, reduce time spent in sedentary pursuits namely screen-time, encourage PA engagement and enjoyment, and develop FMS. Three hundred and eleven children participated in the group-randomised trial where they were assigned to one of four conditions; behavioural modification condition, FMS condition, a combination of the two conditions, and the control condition. Children in the behavioural modification condition received 19 lessons lasting a duration of 40 to 50 minutes each, which focused on educating children on the amount of time being spent on PA and screen-time pursuits with an aim to eventually encourage participants to switch screen-time behaviour for PA alternatives. The FMS group received the same duration and quantity of lessons (19 lessons, lasting 40 to 50 minutes each); however the focus of these lessons was on the mastery of six FMS through participation in games. The combination condition received all lessons from both the behaviour modification condition and the FMS condition. The control condition continued with their normal curriculum. The primary outcome measures included; BMI, PA (accelerometry), self-reported screen-time behaviour, self-reported PA enjoyment, and six FMS (overhand throw, two-handed strike, kick, dodge, sprint, and vertical jump). Body image and food intake were also assessed. Results found that BMI was significantly lower in the combined condition when compared to the control group. In addition, participants in the combined condition were significantly less likely to become overweight/obese, than control participants. Compared to control children, FMS participants recorded more time in, and greater enjoyment of, PA behaviours. When compared to all other conditions, behaviour modification children recorder higher levels of PA behaviour and time spent on screen-time behaviour, specifically television viewing, across all four time points. The efficacy of the Switch-Play intervention in seeking to prevent excess weight gain, and promote PA participation and enjoyment, in children, is evident from these findings. These findings are limited as they are specific to children from lower socioeconomic status. Future interventions should aim to prove effective across the population, in both advantaged and disadvantaged individuals. Interventions which demonstrate this ability will be best placed to improve PA and FMS levels universally, prove cost and time efficient, and can be implemented with ease in areas where socially advantaged and disadvantaged individuals co-exist.

The Y-PATH intervention is a multi-component school-based intervention (Belton et al., 2014). Its development and design has been guided by the attributes and limitations of previously discussed PA and FMS interventions. It aims to; target both locomotor and object control FMS proficiency, increase PA levels through the development of self-efficacy and a positive attitude towards PA, incorporate choice into PE lessons so all students can participate with a focus on moving away from traditionally competitive games based activities, and to educate students on the health benefits associated with leading a physically active life. There are three key components of the Y-PATH intervention. 1) Student component: participate in specialised Y-PATH PE, which focuses on health-related activity and development of FMS through the current PE curriculum, delivered by a specialist PE teacher. 2) Parent or guardian component: information sessions and leaflets provided to parents/guardians prior to the beginning of the intervention, in an attempt to educate them on the importance and health benefits of PA. 3) Teacher component: all school staff attend two workshops with an aim to create a whole school approach to PA and positive role modelling for students (Belton et al., 2014). A one week “Teacher Pedometer Challenge” was integrated mid-course during the Y-PATH intervention in an attempt to further engage teachers in student PA promotion. The Y-PATH intervention requires relatively low levels of researcher involvement and hence is cost and time efficient. The efficacy of the Y-PATH intervention was established through a non-randomised controlled trial (O'Brien et al., 2013). Two mixed-gender schools in a rural town in Ireland participated in the study (intervention n = 1, control n = 1), with a total of 174 participants aged between 12 and 14 years old. The school with the larger sample size was randomly allocated to the intervention arm. The intervention school received specialist PE teacher training and a Y-PATH intervention folder with six HRA lessons and subsequent integration suggestions for use across all PE strands. Supplementary resources such as student activity journals and Y-PATH posters were also provided. The intervention was implemented by the specialist PE teacher in the individual school, during the weekly PE class. The primary outcome measure was PA (self-report and accelerometry), with BMI and 15 FMS (run, skip, gallop, slide, leap, hop, horizontal jump, vertical jump, kick, catch, overhand throw, strike, underhand roll, dribble, and balance), collected as secondary outcome measures. Intervention and control participants both demonstrated increases in daily PA levels and FMS proficiency over time. A significantly greater increase in PA levels and FMS proficiency was however observed in intervention participants suggesting that the Y-PATH intervention has the potential to increase PA and FMS levels in adolescents. It is important to note that although positive results were found for both males and females, it is based on an exploratory trial. In order to fully establish the efficacy of the Y-PATH intervention, its implementation and evaluation involving a randomised controlled trial (RCT) and larger sample size is necessary (O'Brien et al., 2013). Further research should seek to trial the Y-PATH intervention as part of a RCT in a socially diverse sample, including both advantaged and disadvantaged areas to identify the universal efficacy of Y-PATH.

2.3.4 Evaluation of Interventions

When designing and implementing a complex intervention with multiple components, there are several distinct phases which must be considered in the development and evaluation process (Campbell et al., 2000). A variety of study designs can be employed depending on the nature of the research question (Craig et al., 2008). According to O'Brien et al. (2013) in order to fully evaluate the efficacy of the Y-PATH intervention, a RCT must be conducted in order to identify if the positive findings observed in the exploratory trial are reproducible when adequately controlled, with appropriate statistical power. Randomised controlled trials are widely accepted as the most reliable method of determining the effectiveness of an intervention (Campbell et al., 2000). When conducting an intervention there are several key components which must be addressed namely; developing the intervention, assessing the feasibility and evaluating the effectiveness both of the implementation and cost (Campbell et al., 2000). Other methodological issues for definitive RCTs include sample size, inclusion and exclusion criteria, and methods of randomisation, and challenges of complex interventions (Campbell et al., 2000)

The Medical Research Council (MRC) developed a framework (see Figure 2.3) which aims to help researchers and research investors to adopt appropriate methods when developing randomised controlled trials of complex interventions (Campbell et al., 2000).

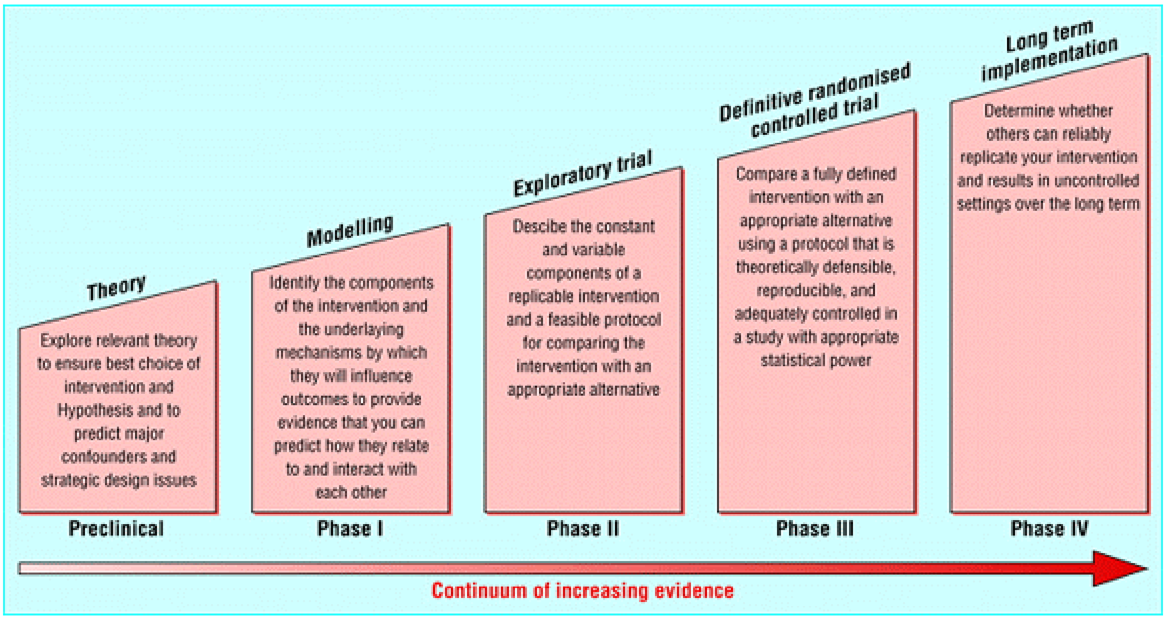

Figure 2.3. MRC Framework for complex interventions (Campbell et al., 2000)

It therefore would appear appropriate to follow the framework outline when attempting to progress from an exploratory trial, and move toward the evaluation of a definitive RCT to assess the ability of the Y-PATH intervention to improve PA levels and FMS ability on a large scale.

2.4 Discussion

In this literature review the importance of PA participation and FMS proficiency have been explored at length. Globally, extremely low PA levels have been observed (Hallal et al., 2012), and children's FMS levels are below those expected (Hardy et al., 2013, 2010; O' Brien et al., 2015). Given the health benefits of regular PA participation (Warburton et al., 2010), increasing PA levels is a huge public health issue. Physical activity behaviour has been found to track from childhood into adulthood (Telama et al., 2005), hence the urgent need to foster good PA habits in childhood and adolescence. FMS proficiency is similarly low in children and adolescents (O' Brien et al., 2015). If youth do not develop these skills their ability to participate in sports and other physical activities is compromised (Gallahue &

Ozmun, 2006). It is therefore justified and appropriate that interventions targeting PA and FMS be implemented.

From reviewing the literature, it is clear that numerous PA interventions exist operating in a variety of settings such as school-based, community, and family based (Perry et al., 2012; Salmon et al., 2007; Van Sluijs et al., 2008). Unsurprisingly, the school setting provides the opportune location for youth and adolescent PA interventions, considering the ease of access to the population and the substantial amount of waking hours this cohort spend in school (Kriemler et al., 2011). Multi-component school-based PA and FMS interventions appear most appropriate given the unquestionable evidence suggesting their efficacy (Kriemler et al., 2011; Perry et al., 2012; Salmon et al., 2007; Timperio et al., 2004). PE lessons provide a central forum for targeting PA and FMS levels, with pre-existing curriculum, specialist teachers and equipment readily available (Breslin et al., 2012; Heath et al., 2012). PE provides the opportunity to develop generalisable movement skills (Gallahue & Ozmun, 2006). Hence, incorporating specific focus on the teaching and practising of FMS in PE lessons appears worthwhile. Furthermore, adapted PE lessons can increase PA levels both in-school and out-of-school time (McKenzie & Lounsbery, 2009). In addition, a whole school approach to PA is effective, with a community or familial element also associated with higher efficacy levels (Belton et al., 2014; Timperio et al., 2004; Van Sluijs et al., 2008). Multi-component interventions such as; SPARK, M-SPAN, LEAP. Move it Grove it, and Switch have been stringently evaluated. The Y-PATH intervention has been developed to increase PA and FMS levels simultaneously in Irish adolescents (Belton et al., 2014; O'Brien et al., 2013). Y-PATH has been guided by the attributes and limitations identified in previously evaluated PA and FMS interventions. Preliminary findings support the simultaneous integration of health-related activity and FMS in PE class, with a parent and teacher involvement, in an attempt to increase adolescent PA levels (O'Brien et al., 2013). These findings however are based solely on an exploratory trial, hence the efficacy of the Y-PATH intervention needs to be established using a RCT in line with the MRC framework, to identify if the positive findings observed are reproducible when adequately controlled, with appropriate statistical power (Campbell et al., 2000).

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Chapter 3

Exploring the role of health-related fitness as a mediator of the reciprocal relationship between fundamental movement skills and physical activity.

Manuscript to be submitted as: Exploring the role of health-related fitness as a mediator of the reciprocal relationship between fundamental movement skills and physical activity.
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3.1 Abstract

Objectives: To explore the hypothesised reciprocal relationship between fundamental movement skill (FMS) competence and physical activity (PA) behaviour and investigate the role of health-related fitness (HRF) as a mediator of this association.

Design: Cross-sectional.

Methods: Adolescents aged 12.80 years (SD±.45 years) were recruited from 20 schools (n = 222, 50% male). FMS (TGMD, TGMD-2, Victorian Skills Manual), moderate-to-vigorous physical activity (MVPA) per day (Actigraph accelerometers for a 7-day period), and HRF (3 minute Queens College step test used to calculate a predicted VO_{2max} value) were assessed. Descriptive statistics and frequencies were calculated. Preacher and Hayes (2004), bootstrap method was used to assess the hypothesised reciprocal relationship between FMS and PA and the potential mediating effect of VO_{2max} on the reciprocal relationship between PA and FMS. Mediation was determined using the logic of Baron and Kenny (1986).

Results: A reciprocal relationship was found between PA and FMS ($\tau' = 0.22$, $p<0.01$ in both directions). VO_{2max} mediated 17% and 19% of these relationships, respectively. **Conclusion:** Analyses suggest a reciprocal relationship between PA and FMS exists in youth. VO_{2max} explained part of this relationship, in both directions, suggesting that increasing adolescent fitness will serve to enhance both PA participation and skill development. The unexplained variance in the reciprocal relationship between PA and FMS must be explored further in an attempt to understand and target this relationship, better.

Key words: adolescent, fundamental movement skills, physical activity, health-related fitness, mediation reciprocal

3.2 Introduction

Fundamental movement skills (FMS) such as running, throwing and catching, are the building blocks of movement and form the foundation for more complex sports specific skills necessary for lifelong physical activity (PA) participation (Haywood & Getchell, 2014). There is now convincing evidence of an association in childhood between FMS competence and levels of PA (Lloyd, Saunders, Bremer, & Tremblay, 2014; Logan, Robinson, Wilson, & Lucas, 2011; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). However, the extent to which FMS, particularly different types of FMS, influence PA during adolescence, a time when levels of inactivity are particularly high (Hallal, Andersen, Bull, Guthold, & Haskell, 2012), is poorly understood. Longitudinal research (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009) has shown, for example, that object control skills (i.e. the manipulation and propulsion of objects) in childhood were predictive of adolescent PA behaviour, and the proficiency of these skills was also found to track into adolescence. However, locomotor skills did not predict future PA and did not track well over time. Further studies exploring the relationship between different types of FMS (i.e. locomotor and object control skills) and PA during adolescence are needed.

A recent systematic review has identified one of the key gaps in research in the area of FMS is the suggested reciprocal relationship between FMS and PA and the mediators of this relationship (Robinson et al., 2015). Higher levels of PA may lead to greater FMS competence, or alternatively greater FMS competence may be associated with higher levels of PA participation. Stodden et al. (2008) proposed a conceptual framework of mechanisms that may influence and mediate PA levels. The relationship between FMS and PA, according to this model, is reciprocal and demonstrates a 'positive spiral of engagement' i.e. children who are skilled participate in more PA giving them greater opportunities to develop their skills, a higher perceived skill competence and hence more impetus to be active (Stodden et al., 2008). Barnett et al. (2011) provided some evidence to support this hypothesis, with positive cross-sectional associations found between object control and PA, as well as PA and object control during adolescence (Barnett, Morgan, Van Beurden, Ball, & Lubans, 2011). Barnett et al. (2011) found these relationships in 16 year olds; whether similar relationships exist in the early stages of adolescence (12 years) for overall FMS as well as its composite subtests (i.e. object control and locomotor) remains to be identified.

In Stodden's Model (2008), health-related fitness - HRF (i.e. muscular strength/endurance, cardio-respiratory fitness, and body composition as defined by Pate, 1988), is situated as a mediating variable between FMS competence and PA behaviour (Stodden et al., 2008). HRF is recognised as a predictor of chronic disease and health outcomes across all ages (Brill, Macera, Davis, Blair, & Gordon, 2000; Ortega, Ruiz, Castillo, & Sjöström, 2008) with the benefits of HRF considered as important as those associated with PA (Blair & Jackson, 2001; Rizzo, Ruiz, Hurtig-Wennlöf, Ortega, & Sjöström, 2007). Studies have consistently found positive associations between components of HRF (cardio-respiratory fitness), and FMS competence (Cattuzzo et al., 2014). The role of HRF as a mediator in the relationship between PA and FMS, as proposed by Stodden et al. (2008), could therefore potentially be very important, particularly in an adolescent population. Hypothetically, youth who have higher levels of HRF have greater aerobic capacity to participate in prolonged periods of PA, and hence have greater opportunity to become proficient in FMS. The reverse may also be true.

Khodaverdi, Bahram, Stodden, and Kazemnejad (2015) examined the mediating effect of HRF on actual FMS and PA in children, and found that aerobic fitness was the only measure of HRF that mediated the relationship between actual FMS (locomotor composite) and PA behaviour. Whether a similar relationship exists for adolescents has yet to be determined. The purpose of this paper is thus to: 1) explore the reciprocal relationship between FMS competence and PA behaviour; 2) investigate the role of HRF as a mediator of this association and 3) assess the reciprocal relationship between FMS composite subtests (i.e. object control and locomotor) and PA.

3.3 Methods

3.3.1 Overview

Cross-sectional data were collected as part of baseline data collection for a cluster randomised controlled trial evaluating the effectiveness of a multi-component school-based PA intervention entitled the 'Youth-Physical Activity Towards Health' (Y-PATH) programme' (Belton, O' Brien, Meegan, Woods, & Issartel, 2014; O'Brien, Issartel, & Belton, 2013). All mixed-gender second level schools in the greater Dublin area were invited to participate in the study. Twenty-six schools showed interest in the project and were recruited. Of those, four schools did not meet the inclusion criteria. Twenty-two schools consented to participate. Two schools had to withdraw from the study prior to testing (due to a change in physical education [PE] teacher and principal). Participants (n = 534) were sampled from the included 20 schools. Inclusion criteria specified that participants must be a first year student (12 – 13 years). Participants and their parents were given project information and consent forms. Principal and parental consent was sought, as well as student assent. All participants were free to withdraw from the research at any stage. Ethical approval was obtained from the University Research Ethics Committee.

3.3.2 Measures

FMS: Fifteen FMS were assessed during a regular PE class. The Test of Gross Motor Development-2nd Edition (TGMD-2) was used to asses 12 skills; six locomotor: run, hop, gallop, slide, leap and horizontal jump, and six object control: catch, kick, throw, dribble, slide and roll (Ulrich, 2000). The skip (Test of Gross Motor Development: TGMD - Ulrich, 1985), vertical jump, and balance (Victorian Fundamental Movement Skills Manual - Victoria, Department of Education, 1996) were included as they were considered relevant in an Irish sporting context (O' Brien, Belton, & Issartel, 2015).

A team of 12 researchers (final year of a PE teacher education programme) were trained prior to testing, by four experts, on correct demonstration of each FMS and testing protocol. Participants were given three attempts at each skill; one familiarisation and two trials with no feedback given at any stage. All skills were recorded and analysed at a later date by the research team. Two trained researchers (expert scorers) assessed a sample within each of the selected skills to ensure a correlational index of agreement reaching a minimum of 99% reliability. The two expert scorers trained six of the field researchers in the scoring protocols. Prior to processing, a minimum of 95% inter-rater agreement for each of the 15 skills on a pre-coded dataset was achieved between the two expert scorers and the six field researchers. The trained researchers alongside the expert scorer were required to reach a minimum of 95% inter-scorer agreement per component for each selected skill on a pre-coded data set. As per the TGMD-2 protocol a "0" was given where a component was not observed and a "1" where a component was observed. The two assessments were summed to give a raw score per skill. All skills were subsequently summed to give a raw FMS score per participant. A locomotor skill score and object control skill score were also calculated separately for each participant.

Accelerometry: Participants wore an Actigrah accelerometer (models GT1M, GT3X or GT3X+; Actigraph LLC, Pensacola, FL) on an adjustable elasticated belt above the iliac crest of the right hip (as per Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2015). Participants were asked to wear the accelerometer during all waking hours with the exception of water-based activities such as showering and swimming and contact sports deemed unsafe for accelerometer wear (e.g. rugby). Accelerometers were set to record using a 10 second epoch (Cain, Sallis, Conway, Dyck, & Calhoon, 2013). A number of strategies were employed to ensure compliance (Belton, O' Brien, Wickel, & Issartel, 2013): students were met in the morning of each school day to ascertain compliance with the wear instructions; an optional twice daily SMS reminder text was sent before school and in the afternoon; teachers in each school checked whether or not participants were wearing their monitors each school day; students were advised to place reminders to wear monitors, in noticeable areas in their homes; a record card was provided for recording periods of non-wear; and students who were compliant with the wear-time inclusion criteria, entered a class draw for a €20 sports voucher (per class).

The minimum number of valid days required for inclusion in analysis was three weekdays and one weekend day (Cain et al., 2013; O'Brien et al., 2013). In line with other studies, a day was deemed valid (and therefore included in analysis) if there was a minimum of 10 hours recorded wear-time per day (Cain et al., 2013; O'Brien et al., 2013). Monitor non-wear was defined as ≥20 consecutive minutes of zero counts (Cain et al., 2013; O'Brien et al., 2013). Counts below zero and above 15,000 were excluded due to biological plausibility (Esliger, Copeland, Barnes, & Tremblay, 2005; O'Brien et al., 2013). The mean daily minutes spent in MVPA was estimated using the validated cut points derived by Evenson, Catellier, Gill, Ondrak, and McMurray (2008), for adolescents in this age group: MVPA ≥2296 counts/min.

HRF: The Queens College three-minute step test was administered to calculate an estimate of VO_{2max}. A protocol as per McArdle, Katch, Pechar, Jacobson, and Ruck (1971) was followed. After a 20 second familiarisation period and once all participants were comfortable with the process, the three-minute trial began whereby each participant continuously stepped for three minutes up and down a pre-set height of 41cm (bench/steps) to a metronome.

Cadence was set at 22 steps per minute for females and at 24 steps per minute for males. Post-trial, a trained researcher was given five seconds to find the pulse in the participants' right wrist. Once researchers had the pulse, it was counted for a 15 second period post-exercise. This was converted to beats per minute (bpm) and subsequently used to calculate VO_{2max} using the following gender specific formulae: male VO_{2max} (ml/kg/min) = 111.33 - (0.42 x heart rate (bpm)); female VO_{2max} (ml/kg/min) = 65.81 - (0.1847 x heart rate (bpm)) as per McArdle et al. (1971).

Body Mass Index (BMI): Standing height was measured using a portable stadiometer (Leicester Height Measure) in centimetres (cm) to the nearest two decimal places. Weight was measured using a portable calibrated scales (SECA) in kilograms (kg) to the nearest 0.5kg. BMI was calculated using the formula weight (kg)/height(m^2). Gender and age-specific cut points were applied to classify BMI into four weight categories: severe thinness, thinness, overweight and obese (Cole & Lobstein, 2012).

3.3.3 Statistical Analysis

Data were analysed using IBM SPSS Statistics 21. Independent sample t-tests were used to identify significant differences in terms of age, gender, and BMI between participants that met the accelerometer inclusion criteria and those that did not. Descriptive statistics and frequencies for demographic characteristics, and BMI were calculated. Data were screened for normality, with skewness and kurtosis tests. The Preacher and Hayes Bootstrapping method (Preacher & Hayes, 2004) which is used where normality does not seem like a reasonable assumption, was used to examine two mediation models using three variables: PA, VO_{2max} and FMS. Mediation was determined using the logic of Baron and Kenny (1986). VO_{2max} was the mediating variable tested in both Model 1 and Model 2. The outcome variable changed for each of the models (i.e. FMS was the outcome variable in Model 1 and

PA was the outcome variable in Model 2). Two dependent variables were examined in order to investigate the hypothesised reciprocal relationship between PA and FMS (Stodden et al., 2008). The pathway from X to Y (outcome variable) (τ), X to M (mediator; VO_{2max}) (α), M to Y (β) and X to Y taking into account the mediator (τ'), were examined in both Model 1 and Model 2 (pathways highlighted in Figure 3.1). The percent to which the mediator was accountable for the τ' pathway was investigated. The reciprocal relationship between PA and locomotor skills, and PA and object control skills, was examined using the coefficient of the pathway from X to Y (τ), and the reverse. All variables were standardised in SPSS, prior to analysis, in order to generate standardised coefficients to compare the strength of the relationships.

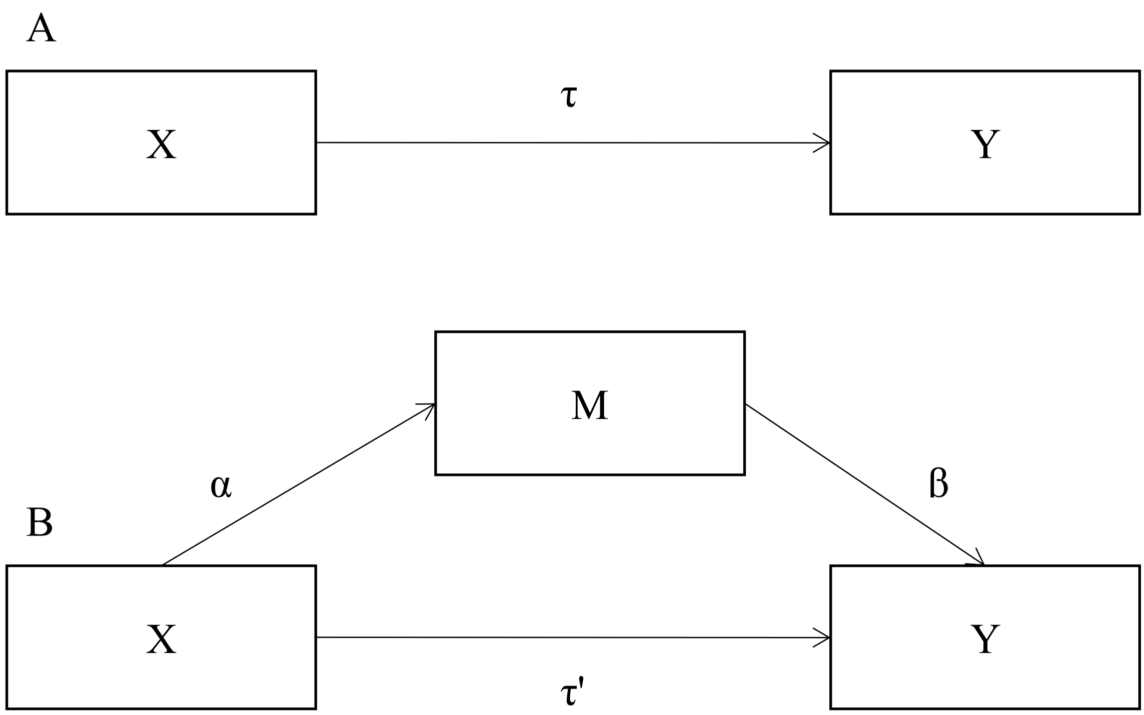

Figure 3.1. Single-mediation model. (A) Direct relationship where X affects Y. (B) Single-mediation model X affects Y indirectly through M (Mediator).

3.4 Results

Participants' Characteristics

From the original sample of 503 participants, 222 participants met the accelerometer inclusion criteria and were subject to further analysis. There were no significant differences in age, gender or BMI between the included and excluded sample. The 222 participants had a mean age of 12.8 years with an equal gender split of males to females. When BMI was classified with the four weight categories, 10% of participants were categorised as overweight or obese (17, and 5 participants respectively). Due to lack of power, mediation analyses were conducted on the whole sample as opposed to split by gender, with gender adjusted for. Descriptive statistics for VO_{2max}, MVPA and FMS are presented in Table 3.1. A total of 200 cases were included in the mediation analysis (22 cases had missing data on one or more variables in the model). There was a significant positive bidirectional relationship between PA and FMS, PA and locomotor skills, and PA and object control skills (Table 3.2). The strength of the relationships was equal in both directions.

Table 3.1. Descriptive data for the demographic characteristics and BMI, PA, FMS and VO_{2max}.

	Total Sample		Males (n = 111)		Females (n = 111)	
Variable	M	SD	M	SD	M	SD
VO_{2max}	43.74	8.29	49.27	7.82	38.15	3.83
MVPA	53.80	21.70	58.44	22.97	49.17	19.38
FMS	94.70	8.05	95.95	7.78	93.45	8.15

Note. M = mean; SD = standard deviation; MVPA = moderate to vigorous physical activity; FMS = fundamental movement skills.

Table 3.2. Reciprocal relationship between PA and FMS, PA and locomotor skills, and PA and object control skills.

Pathway	Coeff	SE	t	*P*	LLCI	ULCI
PA - FMS	0.22	0.07	3.20	0.00	0.09	0.36
FMS - PA	0.22	0.07	3.20	0.00	0.08	0.36
PA - Loco	0.21	0.07	3.04	0.00	0.07	0.34
Loco - PA	0.22	0.07	3.04	0.00	0.08	0.36
PA - OC	0.15	0.07	2.12	0.04	0.01	0.29
OC - PA	0.15	0.07	2.12	0.04	0.01	0.28

Note. Coeff = slope; SE = standard error; t = t-statistic; *P* = P-value; LLCI & ULCI = lower and upper levels for confidence intervals; PA = physical activity; FMS = fundamental movement skills; Loco = locomotor skills; OC = object control skills.

Table 3.3. presents the mediation models where VO_{2max} was examined as a mediator of the association between 1) PA and FMS ([1]) and 2) FMS and PA ([2]). All pathways within the mediation analyses were statistically significant. VO_{2max} partly mediated associations between PA and FMS in both directions, and the percent mediation explained by VO_{2max} was similar for each (17% vs 19%).

Table 3.3. Single-mediation model analyses to examine the relationship between PA and FMS when mediated by VO_{2max} (^{1}), and between FMS and PA when mediated by VO_{2max} (^{2}).

Pathway	Coeff	SE	t	*P*	LLCI	ULCI
PA - $VO_{2max}{}^1$	0.18	0.05	3.53	0.00	0.08	0.29
VO_{2max} - FMS^1	0.21	0.10	2.20	0.03	0.02	0.40
PA - FMS^1	0.22	0.07	3.20	0.00	0.09	0.36
PA – FMS'^1	0.19	0.07	2.59	0.01	0.04	0.33
ab^1	0.04	0.02			0.01	0.09
FMS - $VO_{2max}{}^2$	0.15	0.05	2.88	0.00	0.05	0.25
VO_{2max} - PA^2	0.28	0.09	2.99	0.00	0.09	0.46
FMS - PA^2	0.22	0.07	3.20	0.00	0.08	0.36
FMS - PA'^2	0.18	0.07	2.59	0.01	0.04	0.31
ab^2	0.04	0.02			0.01	0.09

Note. ' = direct effect, *ab* = indirect effect.

3.5 Discussion

This study sought to explore the reciprocal relationship between FMS competence and PA behaviour, investigate the role of HRF as a mediator of this association and assess the reciprocal relationship between FMS composite subtests (i.e. object control and locomotor) and PA (Robinson et al., 2015; Stodden et al., 2008). A reciprocal relationship was found between FMS competence and PA behaviour. The positive association found from FMS to PA is consistent with the notion that associations will be found in older children. The reverse relationship, was also significant, and of a relatively similar strength. This suggests that by the age of 12 years, FMS competence is as important to PA participation, as PA is to skill development. For adolescents, the ability to perform basic skills adequately may drive their engagement in PA whereas those who are less skilled are less likely to participate in PA. It may therefore be prudent to focus on teaching/coaching FMS competency in younger children in order to see greater improvements in PA level in this adolescent age group. It appears equally as important to encourage participation in PA, to provide adequate opportunities for development of skills.

Even though the relationship from PA to FMS was weak, a reciprocal relationship was still identified. This finding supports the ‘positive spiral of engagement' proposed by Stodden et al. (2008), whereby higher levels of FMS competency increase the likelihood of participating in PA, which subsequently further increases skill ability. Identifying a reciprocal relationship is rather novel and very important to developing a greater understanding of the complex relationship between FMS competency and PA behaviour. To our knowledge only one other study has examined this reciprocal relationship (Barnett et al., 2011) finding a similar relationship in both directions from object control skills to PA, and the reverse, in 16 year olds. The Barnett et al. (2011) study used self-report PA encouraging recording of all types of organised and non-organised activity (e.g. swimming, contact sports, cycling) that are not always captured with objective measures, and hence may help to explain the different finding with regard to the strength of the reverse relationship.

This study also found that HRF mediated the relationship between PA and FMS in both models to a similar degree. One possible explanation is that those who acquire higher skill levels do so through continued engagement in PA, through HRF, as higher levels of HRF allow prolonged engagement in PA. Similarly, those who engage in higher levels of PA are likely to demonstrate higher FMS levels, through HRF as increased HRF levels allow engagement in locomotor activities which will result in improved skills development. Sports participation may serve as the PA medium through which FMS competence and HRF are enhanced (Vandorpe et al., 2012). Khodaverdi et al. (2015), in agreement with our findings, found that aerobic fitness, as a measure of HRF, mediated the relationship between PA and locomotor skill competence in younger children (8 - 9 years). Our finding suggests that when seeking to increase PA and FMS levels, it may therefore be fruitful to promote aerobic activities.

When each subtest (i.e. object control and locomotor composites) was considered on its own, a significant positive relationship with PA was found in both directions, for both object control and locomotor skills. The reciprocal relationship between PA and locomotor skills was slightly stronger than that observed between PA and object control skills. Barnett et al. (2011) found a reciprocal relationship between PA and object control, however not for locomotor skills. Differences between our findings and those of Barnett et al. (2011), could, in part, be due to the different skills assessed. Their locomotor subdomain assessment consisted of only three skills (hop, side gallop, and vertical jump) whereas in this study a more comprehensive measure of eight locomotor skills was used. Perhaps due to the more extensive testing of locomotor FMS in this study, the relationship between locomotor skills and PA could be identified. Particularly, the inclusion of the run which involves gross whole body manipulation could be better associated with PA behaviour than the hop, side gallop and vertical jump. Cultural differences in locomotor skills due to different PA and sporting pursuits, may also explain the contrast in findings between Barnett et al. (2011) and this study, given that both object control skills and locomotor skills are contributing to the positive reciprocal relationship with PA.

3.6 Strengths and Limitations

The study strengths include the use of an adequate sample size (despite the significant loss of participants due to poor accelerometer compliance), a comprehensive battery of FMS testing, and objective measures of PA and HRF. The sample were leaner than the average Irish population (Whelton et al., 2007) and hence not truly representative of this age group. Due to a lack of power, potential gender differences could not be explored. Future research could investigate whether the reciprocal relationship between PA and FMS, and the role of

HRF as a mediator, acts similarly for both males and females. This is important as review evidence shows gender is an important predictor of FMS (Barnett et al., 2016). This study has tested part of Stodden's theoretical model, using one component of HRF. Further research into the role of the other components of HRF (muscular strength/endurance and body composition) is required to fully understand what influences PA trajectories in an adolescent population. The Queens College three-minute step test was developed for young adults McArdle et al. (1971), therefore its use as a measure of HRF in this adolescent population may be considered a limitation. The analytical technique may be somewhat limited; perhaps the use of path analysis may prove a more robust data analysis method. As the study design was cross-sectional, casual inferences regarding the relationships between PA, FMS, and HRF, are speculative. However, the findings of the present study do support and extend previous research on the potential importance of fitness in adolescents as it relates to PA and FMS (Cattuzzo et al., 2014; Robinson et al., 2015).

3.7 Conclusion and Implications

The findings suggest that FMS competence, PA levels and HRF are operating as interlocking determinants of each other. Therefore, those children who do not demonstrate adequate skill acquisition in childhood are at risk of a negative PA trajectory in adolescence. The findings support the concept of a 'positive feedback loop' (Stodden et al., 2008) which means targeting both PA levels and FMS competence simultaneously is warranted. In order to encourage lifelong PA participation (Hulteen et al., 2015), it is worthwhile to incorporate an emphasis on FMS into PE curricula and PA intervention programmes. Also, as HRF has proven to play an important role in mediating the reciprocal relationship between PA and FMS, interventions seeking to see increases in either or both variables, should also focus on increasing HRF levels.

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Link Section Chapter 3 to Chapter 4

Purpose of Chapter 3:

In Chapter 3, the hypothesised reciprocal relationship between PA and FMS and its composite groups (i.e. locomotor and object control) was explored. In addition the mediating role of HRF in this relationship was investigated. A reciprocal relationship was found between PA and FMS (τ'=0.22, P<0.01 in both directions). VO_{2max} partly mediated associations between PA and FMS in both directions, and the percent mediation explained by HRF was similar for each (17% vs 19%). Results highlight that FMS competence, PA levels and HRF are operating as interlocking determinants of each other. Children who do not demonstrate adequate skill acquisition in childhood are therefore at risk of a negative PA trajectory in adolescence. The findings support the concept of a 'positive feedback loop' (Stodden et al., 2008) which means targeting both PA levels and FMS competence simultaneously is warranted. Also, HRF has proven to play an important role in mediating the reciprocal relationship between PA and FMS. It must be noted that the relationship between PA and FMS, and the reverse, was only partly mediated by HRF (17% and 19%). Although Chapter 3 advocates for targeting PA and FMS simultaneously, our understanding of the correlates of FMS and how best to influence motor competence, is still relatively underdeveloped in some aspects. Other correlates play a role in this relationship and must be identified in an attempt to further understand the complex relationship between PA and FMS.

Purpose of Chapter 4:

Findings from Chapter 3 indicate that although HRF mediated part of the relationship between PA and FMS, other correlates and mediators may be contributing to this relationship. Biological and demographic correlates have most commonly been investigated

(Barnett et al., 2016). Notably, there is an absence in the literature of research considering psychological and psychosocial correlates, which may go some way in explaining the complex nature of FMS proficiency (Barnett et al., 2016). Given that these correlates are traditionally associated with PA, investigating the mediating role of PA in these relationships (between the psychological and psychosocial correlates, and FMS) is also advisable. Chapter 4 aims to explore the role of PA as a potential mediator in the relationship between FMS, given the relationship between PA and FMS identified in Chapter 3, and potential psychological and psychosocial correlates traditionally associated with PA (PA self-efficacy, barriers to PA, and PA social support).

Chapter 4

Are the correlates of fundamental movement skill proficiency similar to the correlates of physical activity in adolescents?

Manuscript to be submitted as: Are the correlates of fundamental movement skill proficiency similar to the correlates of physical activity in adolescents? Powell, D., Issartel, I., McGrane, B., Barnett, L., Salmon, J., Timperio, A., Belton, S.

4.1 Abstract

Objective: To investigate a) the role of physical activity (PA) as a mediator in the relationship between psychological and psychosocial correlates and fundamental movement skills (FMS), b) whether the psychological and psychosocial correlates of PA also apply to FMS, and c) the relationship between FMS proficiency and PA.

Design: Cross-sectional.

Methods: Two hundred and twenty two adolescents (50% male) aged 12.80 ± .45 years were recruited from 20 schools. Adolescent PA self-efficacy, perceived barriers to PA, and PA social support data were collected. PA (Actigraph accelerometers) and 15 motor skills (TGMD, TGMD-2, Victorian Skills Manual) were also assessed. Preacher and Hayes (2004), bootstrap method was used to assess the relationship between the psychological and psychosocial correlates, and FMS, and the potential mediating effect of PA on these relationships. Mediation was determined using the logic of Baron and Kenny (1986).

Results: Eighty one percent of the relationship between self-efficacy and FMS was mediated by PA, and 62% of the relationship between social support and FMS. A significant relationship was not found between FMS proficiency and; PA self-efficacy ($\tau = 0.05$, $p = .44$), barriers to PA ($\tau = -0.08$, $p = .24$) or PA social support ($\tau = 0.08$, $p = .29$). There was a significant positive relationship between PA and FMS in all models ($\beta = 0.21$, $p = .00$; $\beta = 0.19$ $p = .01$; $\beta = 0.20$, $p = .01$). There was a significant positive relationship found between self-efficacy and PA ($\alpha = 0.21$, $p = .00$) and social support and PA ($\alpha = 0.23$, $p = .00$). The relationship between barriers to PA and PA was not significant ($p = .75$).

Conclusion: Correlates traditionally associated with PA are not associated with FMS proficiency but PA acted as a mediator between such correlates and FMS. Hence, if seeking to increase FMS proficiency, directly targeting PA participation is recommended.

Key words: physical activity, fundamental movement skills, youth, psychosocial, psychological, correlates

4.2 Introduction

Fundamental movement skills (FMS) are basic observable movement patterns such as running, catching, throwing, and kicking (Gallahue & Ozmun, 2006). FMS give rise to more sports specific skills which allow engagement in lifelong physical activity (PA) participation (Gallahue & Ozmun, 2006; Haywood & Getchell, 2014). FMS proficiency is linked to PA participation in childhood and adolescence (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Understanding more about FMS proficiency in adolescents may be particularly important as more than 80% of 13 to 15 year olds globally (Hallal, Andersen, Bull, Guthold, & Haskell, 2012) are not meeting the PA guideline of 60 minutes per day of moderate to vigorous physical activity (MVPA - World Health Organization, 2010). Considering PA behaviour has been found to track from adolescence into adulthood (Telama et al., 2005), encouraging PA participation is essential, and targeting FMS as a way to achieve this may prove fruitful.

Extensive research has focused on identifying both the psychological and psychosocial correlates of PA behaviour in children and adolescents. Yet little has been undertaken with respect to the correlates of FMS proficiency. Barnett et al. (2016) conducted a systematic review which investigated the possible correlates of FMS in typically developing children and adolescents. Biological and demographic correlates such as age, weight, gender and socioeconomic status were the most commonly explored, with few studies investigating cognitive, emotional and psychological factors, cultural and social factors, or physical environment factors (Barnett et al., 2016). Given the association between PA and FMS proficiency, it is possible that the psychological and psychosocial correlates that are associated with PA may be similar for FMS proficiency. For instance, self-efficacy is a positive correlate and determinant of PA behaviour in both adolescents and children (Bauman et al., 2012; Dishman et al., 2004; Van Der Horst, Paw, Twisk, & Van Mechelen, 2007), but there is little understanding of whether self-efficacy is associated with FMS. It might be hypothesised that those who have higher levels of self-efficacy might be more likely to participate in PA, and hence have increased opportunity to practice their skills.

The relationship between barriers to PA and PA levels is somewhat inconclusive, with some researchers reporting that barriers to PA are not associated with PA levels (Wu & Pender, 2002; Wu, Pender, & Noureddine, 2003), whilst others suggest there is an association (Allison, Dwyer, & Makin, 1999; Neumark-sztainer, Story, Hannan, Tharp, & Rex, 2003). It is possible that barriers to PA may also be linked to lower FMS proficiency, as those with barriers are less likely to be active thus limiting the practice and development of FMS ability.

Extensive research suggests that parental and peer support have a positive influence on youth PA behaviour (Bauman et al., 2012; Duncan, Duncan, & Strycker, 2005; Mcguire, Hannan, Neumark-Sztainer, Cossrow, & Story, 2002; Neumark-sztainer et al., 2003). No investigation of the role of social support in FMS ability has been conducted however. It might be hypothesised that adolescents who feel they are encouraged and supported by parents, peers and teachers, to be physically active, are more likely to demonstrate higher FMS proficiency as a result of feeling supported to participate in PA. If social support demonstrates a positive relationship with FMS proficiency, then targeting social support when seeking to see increases in FMS proficiency may prove fruitful.

The purpose of this study is to: 1) explore the role of PA as a potential mediator in the relationship between PA self-efficacy, barriers to PA, and PA social support, with FMS, 2) examine the relationship between FMS and psychological and psychosocial variables (PA self-efficacy, barriers to PA, and PA social support), and 3) explore all other pathways in the mediation models to extend our understanding of the association between all variables (PA, FMS, PA self-efficacy, barriers to PA, and PA social support). .

4.3 Methods

4.3.1 Overview

Cross-sectional data were collected as part of a definitive randomised controlled trial evaluating the effectiveness of a school-based physical activity intervention entitled 'Youth-Physical Activity Towards Health' (Y-PATH - Belton, O' Brien, Meegan, Woods, & Issartel, 2014; O'Brien, Issartel, & Belton, 2013). All mixed-gender second level schools in the greater Dublin area were invited to participate in the study. Twenty-six schools showed interest in the project and were recruited. Of those, four schools did not meet the inclusion criteria. Twenty-two schools consented to participate. Two schools had to withdraw from the study prior to testing (due to a change in physical education [PE] teacher and principal). Participants were given project information and consent forms. Principal, PE teacher, and parental consent was sought, as well as student assent. Participants (n = 564) aged 12 to 13 years were sampled from one first year class from each of the included 20 schools. Ninety five percent of the sample (n = 534), provided consent to participate in the study. All participants were free to withdraw from the research at any stage. Ethical approval was obtained from the University Research Ethics Committee.

4.3.2 Measures

FMS: Fifteen fundamental movement skills were collected. The Test of Gross Motor Development-2nd Edition (TGMD-2; Ulrich, 2000) was used to asses 12 skills (6 locomotor: run, hop, gallop, slide, leap and horizontal jump, and 6 object control: catch, kick, throw, dribble, slide and roll). The skip (Test of Gross Motor Development: TGMD; Ulrich, 1985), vertical jump, and balance (Victorian Fundamental Movement Skills Manual; Victoria, Department of Education, 1996) were also included as they were considered relevant in an Irish sporting context (O' Brien, Belton, & Issartel, 2015). A team of 12 researchers were trained prior to testing, by four experts, on correct demonstration of each skill and testing protocol. Participants were given three attempts at each skill; one familiarisation and two trials with no feedback given at any stage. All skills were recorded and analysed at a later date by the research team. Two trained researchers (expert scorers) assessed a sample within each of the selected skills to ensure a correlational index of agreement reaching a minimum of 99% reliability. Once this was achieved, the two expert scorers trained six of the field researchers in the scoring protocols. Prior to processing, a minimum of 95% inter-rater agreement for each of the 15 skills on a pre-coded dataset was achieved between the two expert scorers and the six field researchers. As per the TGMD-2 a "0" was given where a skill component was not observed and a "1" where a component was observed. The two trials were added together to give a raw score per skill. All skills were subsequently added together to give a raw FMS score per participant.

Accelerometry: Participants were asked to wear an Actigrah accelerometer (GT1M, GT3X or GT3X+; Actigraph LLC, Pensacola, FL) on an adjustable elasticated belt above the iliac crest of the right hip (as per Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2015). Participants were asked to wear the accelerometer during all waking hours with the exception of water-based activities such as showering and swimming, and contact sports deemed unsafe for accelerometer wear (e.g. rugby). Accelerometers were set to record using a 10 second epoch (Cain, Sallis, Conway, Dyck, & Calhoon, 2013). The compliance strategies outlined by Belton, O' Brien, Wickel, and Issartel (2013), were employed. The minimum number of valid days required for inclusion in analysis was three weekdays and one weekend day (Cain et al., 2013; O'Brien et al., 2013). In line with other studies, a day was deemed valid (and included in analysis) if there was a minimum of 10 hours recorded wear-time per day (Cain et al., 2013; O'Brien et al., 2013). Non-wear time was defined as ≥ 20 consecutive minutes of zero counts (Cain et al., 2013; O'Brien et al., 2013). Counts below zero and above 15,000 were ignored due to biological plausibility (Esliger, Copeland, Barnes, & Tremblay, 2005). The mean daily minutes spent in MVPA was estimated as a measure of PA, using the validated cut points derived by Evenson, Catellier, Gill, Ondrak, and McMurray (2008) for an adolescent population: MVPA ≥2296 counts/min.

Self-Report Questionnaire: The self-report questionnaire used in this study used a combination of previously validated questionnaires to measure self-efficacy, barriers to PA, and social support. Self-efficacy was measured using the five-item self-efficacy questionnaire (SEQ) originally developed by Marcus, Selby, Niaura, and Rossi (1992), and subsequently adapted for an adolescent population by Nigg and Courneya (1998) to a 10-item self-efficacy measure. Marcus et al. (1992) reported an internal consistency of 0.82 for this measure with test-retest reliability over a two week period of 0.90 (n = 20). Nigg and Courneya (1998) reported an alpha of 0.85 when the additional five items were added to the SEQ. This 10-item measure consisted of five items measuring general self-efficacy, and five items related specifically to adolescent's exercise self-efficacy. An 11-point Likert scale from zero (*"not at all confident"*) to 10 (*"very confident"*) was used for scoring the SEQ. A mean self-efficacy score ranging from zero to 10 was computed by averaging each participant’s response to the ten items. In the current study, the Cronbach alpha coefficient was 0.89, suggesting the scale has good internal consistency.

Perceived barriers to PA were measured using an adapted version of the scale derived for the Physical Activity in Scottish Schoolchildren (PASS) study (Inchley, Kirby, & Currie, 2008). Participants were asked to what extent each statement was true for them (*very true, quite true, not very true, or not at all true*). A mean perceived barriers score, ranging from one to four, was computed by averaging responses to the 11 items. In the current study, the Cronbach alpha coefficient was 0.89.

The measure of social support was taken from the Amherest Health and Activity Study (AHA) student survey; namely family influences and peer influences on PA behaviour (Sallis, Taylor, Freedson, Pate, & Dowda, 2002). Sallis et al. (2002) reported the Cronbach's Alpha were 0.78 and 0.74, respectively. The test-retest reliability for family influences was 0.81, and 0.70 for peer influences (Sallis et al., 2002). The 'Children's Sport Participation and Physical Activity' (CSPPA) study adapted the family influences questionnaire from "*During a typical week, how often has a member of your household*..." (Sallis et al., 2002), to "*During a typical week, how often has a teacher in your school*..." to get a measure of school social support (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010). Students selected how often the statement was relevant to them (*none*, *once*, *sometimes*, *almost every day*, or *every day*). Items were coded one to five, and reverse coded where necessary. A mean social support score ranging from one to five was computed by averaging responses to the 15 items. In the current study, the Cronbach's Alpha was 0.84, suggesting the scale has good internal consistency.

Body Mass Index (BMI): Standing height was measured using a portable stadiometer (Leicester Height Measure) in centimetres (cm) to the nearest two decimal places. Weight was measured using a portable calibrated scales (SECA) in kilograms (kg) to the nearest 0.5kg. BMI was calculated using the formula; weight(kg)/height^2(m^2). Gender and age specific cut points were applied to classify BMI into four weight categories: severe thinness, thinness, overweight and obese (Cole & Lobstein, 2012).

4.3.3 Statistical Analysis

Data were analysed using IBM SPSS Statistics 21. Independent sample t-tests were used to identify significant differences in terms of age, gender, and BMI between participants that met the accelerometer inclusion criteria and those that did not. Data were screened for normality, with skewness and kurtosis tests. The Preacher and Hayes Bootstrapping method (Preacher & Hayes, 2004) which is used where normality does not seem like a reasonable assumption, was used to examine three mediation models: Model 1; self-efficacy (X-independent variable), FMS (Y-dependent variable) and PA (M-mediator), Model 2; barriers to PA (X), FMS (Y), and PA (M), and Model 3; social support (X), FMS (Y) and PA (M). Mediation was determined using the logic of Baron & Kenny (1986). The pathway from X to Y (τ), X to M (α), M to Y (β) and X to Y taking into account the mediator (τ'), were investigated in all three models (pathways highlighted in Figure 4.1). The percent to which the mediator was accountable for the τ' pathway was investigated. All variables were standardised in SPSS, prior to analysis, in order to generate standardised coefficients to compare the strength of the relationships.

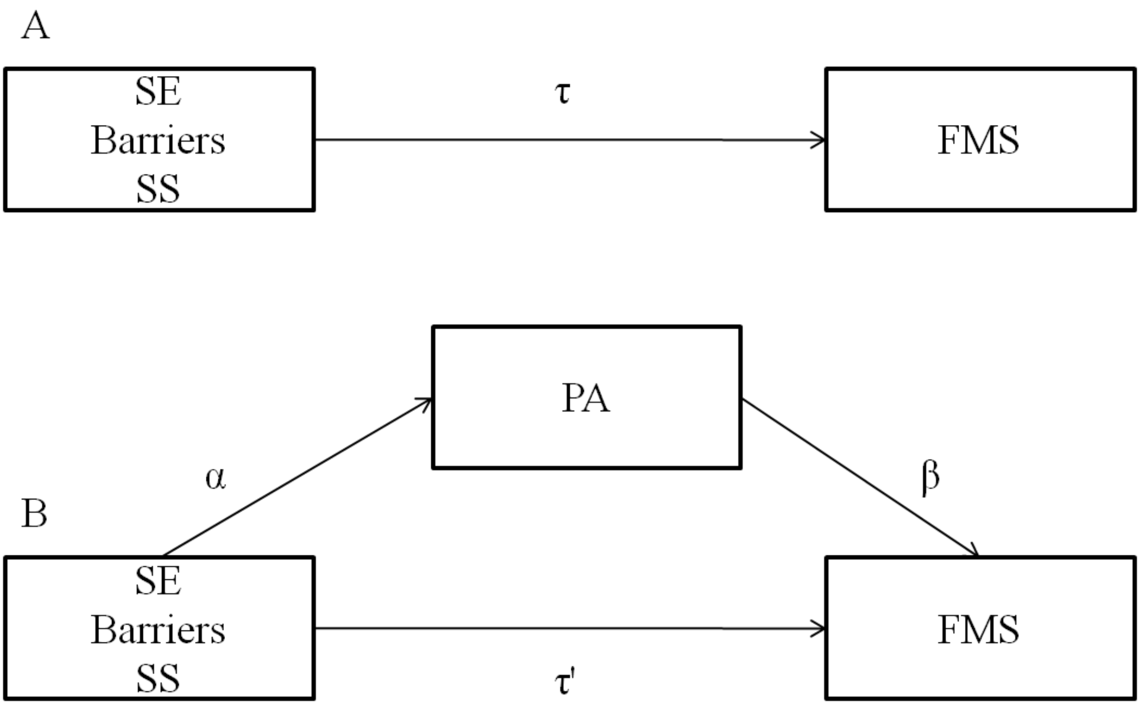

Figure 4.1. Mediating roles of PA in association between SE (self-efficacy), Barriers (barriers to PA), and SS (PA social support), and FMS.

4.4 Results

4.4.1 Participants' Characteristics

Of the original sample of 534 participants, 222 participants met the accelerometer inclusion criteria. There was no significant difference in age, gender or BMI between the original and valid sample. The 222 participants had a mean age of 12.80 years (± 0.45 years) with an equal gender split of males and females. When BMI was categorised into the four weight categories, 10% of participants were categorised as overweight or obese (17, and 5 participants respectively). Due to lack of power, mediation analyses were conducted on the whole sample as opposed to split by gender, with gender adjusted for. A total of 200 cases were included in the mediation analysis with 22 removed due to missing data (missing on one or more variables).

4.4.2 Correlates of FMS

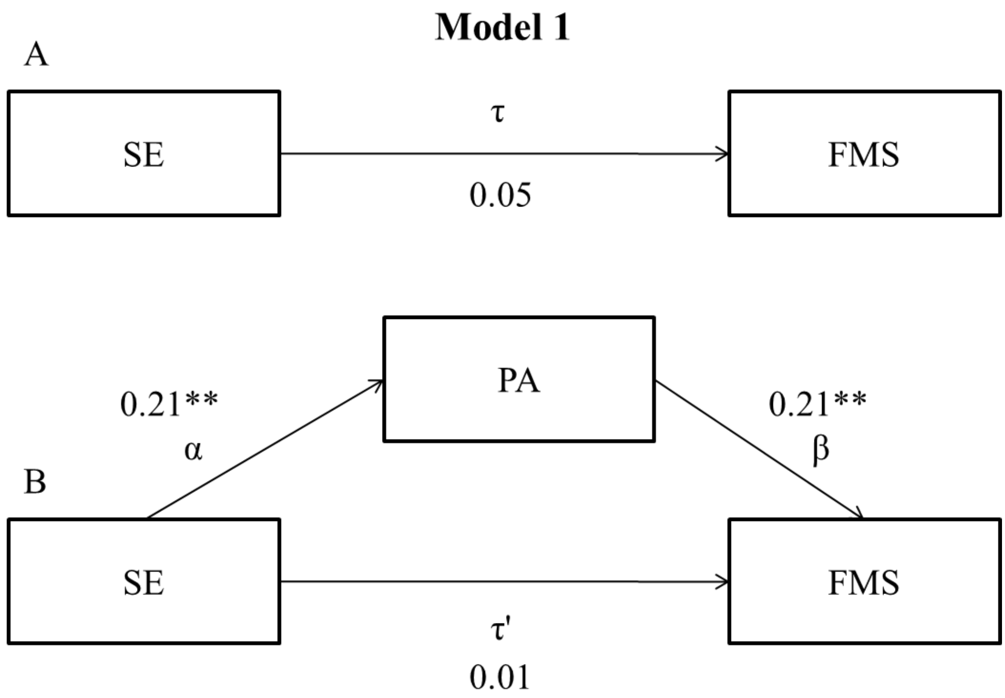

Figure 4.2. Mediating role of PA in association between SE and FMS.
Note. ** *P≤0.01*

The relationship between self-efficacy and FMS was examined in Model 1 and was not significant. There was a significant positive relationship between self-efficacy and PA (α = 0.21; p = .00), indicating that higher levels of self-efficacy were associated with higher levels of PA. There was a significant positive relationship between PA and FMS after controlling for self-efficacy (β = 0.21; p = 0.00). The mediating effect and its significance was calculated. The single-mediator model revealed the relationship between self-efficacy and FMS was partly mediated by an increase in PA. There was a significant indirect effect of self-efficacy on FMS through PA, *ab* = .05, BCa CI [0.01, 0.1]. The mediator accounts for 81% of the total effect, $P_M = .81$.

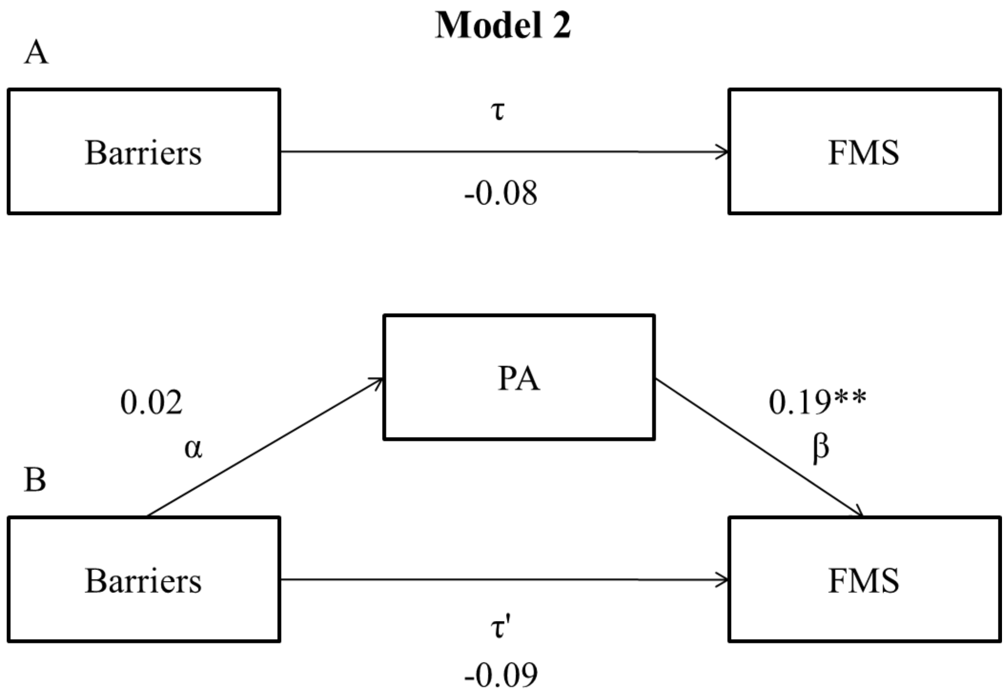

Figure 4.3. Mediating role of PA in association between Barriers and FMS.
Note. ** *P≤0.01*

The relationship between barriers to PA and FMS was examined in Model 2 and was not significant. The relationship between barriers to PA and PA was also not significant. There was a significant positive relationship between PA and FMS after controlling for barriers to PA ($\beta = 0.19$; $p = 0.01$). The mediating effect and its significance were calculated. The single-mediator model revealed that mediation of the relationship between barriers to PA and FMS by PA, was not significant, *ab* = .00, BCa CI [-0.03, 0.04].

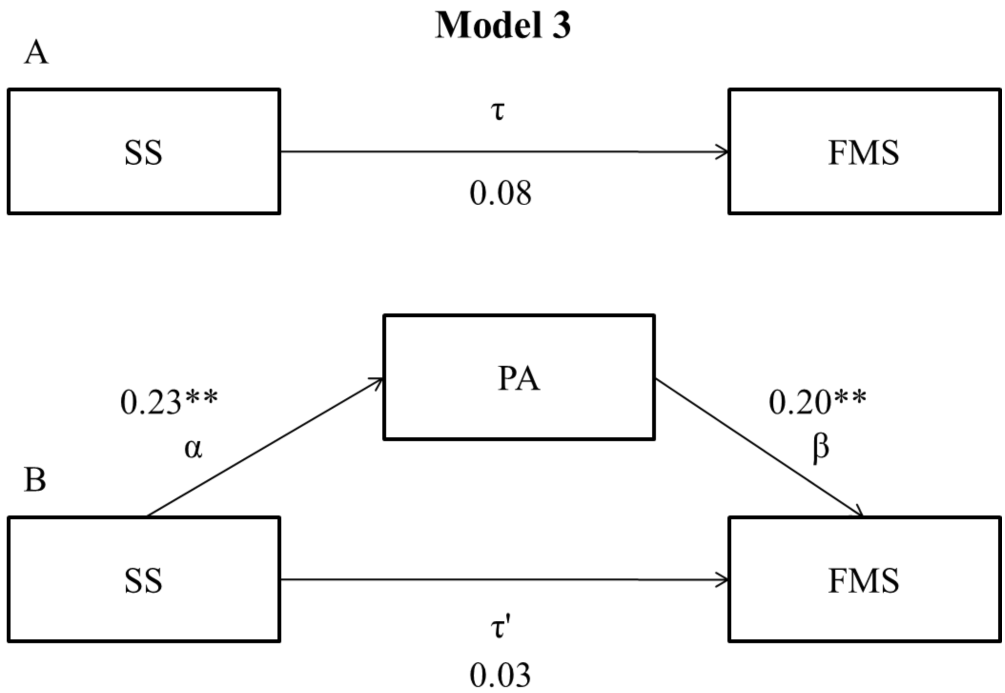

Figure 4.4. Mediating role of PA in association between SS and FMS.
Note. ** *P≤0.01*

The relationship between social support and FMS was examined in Model 3. The relationship between social support and FMS was not significant. There was a significant positive relationship between social support and PA (α = 0.23; p = .00), indicating that higher levels of social support was associated with higher levels of PA. There was a significant positive relationship between PA and FMS after controlling for social support (β = 0.20; p = 0.01). The mediating effect and its significance were calculated. The single-mediator model revealed the relationship between social support and FMS was partly mediated by an increase in PA. There was a significant indirect effect of social support on FMS through PA, *ab* = .05, BCa CI [0.01, .10]. The mediator accounts for 62% of the total effect, P_M = .62.

4.5 Discussion

Overall, results demonstrated PA mediates the relationship between self-efficacy and FMS proficiency, and the relationship between social support and FMS proficiency. These results contribute important findings to the literature. These findings are in line with the expected hypothesis. It was expected that self-efficacy would affect PA, which in turn affects FMS, as opposed to self-efficacy directly influencing FMS proficiency. Similar pathways were expected for social support and barriers to PA, although a negative pathway was expected for barriers to PA i.e. higher levels of barriers to PA were expected to affect PA resulting in lower PA levels, and subsequent lower levels of FMS proficiency, or the reverse. The results suggest the hypothesis was correct for the relationship between social support and FMS also. Given the efficacy of the mediating pathway has been established in this study, targeting PA levels is essential to influence FMS proficiency. Similarly it is important to consider self-efficacy and social support when seeking to target PA levels, in any attempts to improve FMS proficiency.

The expected results were not observed for the relationship between barriers to PA and FMS. PA did not mediate this relationship. A direct relationship between barriers to PA and PA was not identified. Previous research investigating this relationship has also been inconclusive with some studies reporting an association exists (Allison, Dwyer, & Makin, 1999; Neumark-sztainer, Story, Hannan, Tharp, & Rex, 2003), whilst others have failed to identify one (Wu & Pender, 2002; Wu, Pender, & Noureddine, 2003). Wu and Pender (2002) found that self-efficacy mediates the effect of perceived barriers on PA, hence there was a non-significant path from PA barriers to PA when controlling for the effects of other variables. They suggest a possible reason for this finding is due to a measurement challenge, as perceived barriers may be difficult to assess outside of the action context (Wu & Pender, 2002), which may also explain the findings of this research. This may in part explain why PA did not mediate the relationship between barriers to PA and FMS.

Overall these findings elaborate on the relationship between self-efficacy, social support, PA and FMS, suggesting the importance of PA and the integral role it plays in our understanding of FMS proficiency, and how to effectively intervene. This is the first study to examine the potential mediating effect of PA in an adolescent cohort between psychological and psychosocial variables and FMS. Promoting PA is warranted when seeking to influence FMS proficiency given the role PA plays in mediating relationships with FMS. Although PA mediated 81% and 62% of the relationship between self-efficacy and FMS, and social support and FMS, respectively, the influences on the remaining 19% and 38% is still unknown. Other psychological and psychosocial factors may explain these unknowns.

Self-efficacy, barriers to PA and social support have consistently been investigated in relation to PA behaviour, however few studies have considered traditional PA psychological and psychosocial correlates in relation to FMS proficiency. This study sought to identify whether self-efficacy, barriers to PA, and social support, are correlates of FMS proficiency. The results are important because understanding factors associated (or not) with FMS proficiency may be central in helping adolescents to improve their FMS ability and their willingness to do so.

A significant relationship was not found between PA self-efficacy and FMS proficiency. This would suggest that PA self-efficacy does not directly influence FMS proficiency, based on cross-sectional data. The need for analysis of longitudinal data in order to fully explore whether this relationship becomes prevalent over time is necessary. Perhaps other factors at this point in maturation are more indicative of FMS proficiency such as perceived competence in one’s skills ability with PA self-efficacy becoming more important over time.

The association between barriers to PA and FMS proficiency was not significant in this study. Perhaps associations between barriers to PA and FMS proficiency were not found as the barriers analysed were not specific to FMS, suggesting that although a relationship exists between PA and FMS, traditional PA correlates may not influence FMS proficiency. The ability of bad weather, transport and other PA barriers, to predict skills ability may not be possible. In this study, no relationship was found between PA and barriers to PA either. Therefore barriers to PA are not reducing participation in PA and hence adolescents are continuing to avail of opportunities to improve their skill levels through engagement in PA, regardless of their levels of perceived barriers to PA. Further research seeking to identify specific barriers to FMS may be useful in understanding what is hindering skills development. Understanding specifically why skills haven't been developed with questions such as *'How often did you receive skills feedback in your PE lesson'*, may help to inform interventions and teaching practices.

The role of social support in relation to FMS proficiency was investigated to identify whether it should be targeted when seeking to improve FMS. The relationship between social support and FMS was not significant. Perhaps it is more important for adolescents to have positive role models who exhibit the desired skills proficiency and whose behaviour they can attempt to model, as opposed to simply feeling supported by family, friends and teachers. As this study is the first of its kind, there is no further evidence to either support or refute our findings. Previous research has deemed social support important to PA behaviour, in particular support provided by parents and peers (Duncan et al., 2005; Prochaska, Rodgers, & Sallis, 2002). In the current study, the role of PA was evident, with it significantly mediating part of the relationship between social support and FMS. This suggests directly targeting PA when seeking to increase FMS proficiency, is recommended. Specifically, previous research suggests targeting sports participation (Ulrich, 1987) and skill specific (Raudsepp & Pall, 2006), overall moderate to vigorous PA (Fisher et al., 2005; Wrotniak et al., 2006), and organised PA (Okley, Booth, & Patterson, 2001) in children and adolescents when seeking to improve FMS proficiency. Further extensive research in this area using both cross-sectional and longitudinal data is required.

The relationship between PA and FMS was explored. A significant positive relationship was found between PA and FMS in all three models. All coefficients were relatively small, suggesting weak associations. This is in line with previous research where the mastery of FMS has been associated with higher levels of PA participation (Lloyd, Saunders, Bremer, & Tremblay, 2014). The findings from this study support previous research and suggest that it may be advantageous to target PA behaviour when seeking to influence FMS proficiency, given the relationship between PA and FMS.

The relationship between the psychological and psychosocial variables (i.e. self-efficacy, barriers to PA, and social support), with PA behaviour was also investigated in the mediation analysis. A significant positive relationship between self-efficacy and PA was found. This suggests that higher levels of self-efficacy are associated with higher levels of PA. These findings are in line with previous research (Bauman et al., 2012; Dishman et al., 2004; Van Der Horst et al., 2007). The relationship between barriers to PA and PA behaviour was not significant which is in agreement with previous literature which found no association between barriers to PA and PA behaviour in adolescents (Wu & Pender, 2002; Wu, Pender, & Noureddine, 2003), and contrary to research which reported associations exist (Allison et al., 1999; Neumark-sztainer et al., 2003). Previous research reporting associations between barriers to PA and PA behaviour in adolescents, differed from this research in that they used self-report PA compared to objectively measured PA used in this study (Allison et al., 1999; Neumark-sztainer et al., 2003). This could be one explanation for the difference in findings. Also a lack of a consistent measure of barriers to PA, across all studies, could be contributing to these differences. There was a significant positive relationship found between social support and PA behaviour. This finding is in line with previous research (Bauman et al., 2012; Duncan et al., 2005; Mcguire et al., 2002; Neumark-sztainer et al., 2003; Prochaska, Rodgers, & Sallis, 2002). Continued development of a social support system in which adolescents feel encouraged to participate in PA, is therefore important, in order to promote increases in PA behaviour.

The findings of this research suggest when seeking to effectively intervene in FMS proficiency, focusing specifically on self-efficacy, barriers to PA and social support may not be successful. Targeting PA instead with the aim of influencing FMS may prove fruitful, given its association with FMS and its role as a mediator in the relationship between self-efficacy and FMS, and social support and FMS. The role of psychological and psychosocial variables is not completely negated, considering PA self-efficacy and PA social support are associated with PA levels, hence the need for continued focus on these when attempting to affect PA behaviour.

4.6 Strengths and Limitations

Some study strengths include the use of a very comprehensive battery of FMS testing, in which a total of 15 FMS were tested. The use of an objective measure of PA is also a study strength, despite the reduction in sample size due to low accelerometer compliance. As the sample were relatively lean, analysis comparing across the different weight categories could not be examined, which may be considered a delimitation. Due to lack of power, gender differences could not be explored. Further research could seek to identify if the relationship between psychological and psychosocial (PA self-efficacy, barriers to PA, and PA social support) variables, and FMS, differ according to gender. As the data used was cross-sectional, casual inferences regarding associations and mediators are speculative and require longitudinal analysis.

4.7 Conclusion and Implications

Considering the mediating role PA plays in the relationship between self-efficacy and FMS, and social support and FMS, as well as the direct association reported between PA and FMS, directly targeting PA when aiming to improve FMS proficiency is recommended. Targeting PA self-efficacy and social support is also worthwhile as it will result in improvements in PA levels, which in turn affects FMS proficiency given the role of PA as a mediator.

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Link Section Chapter 4 to Chapter 5

Purpose of Chapter 4:

Chapter 4 investigated the mediating role of PA in the relationship between FMS and psychological and psychosocial correlates traditionally associated with PA (PA self-efficacy, social support, and barriers to PA). Results demonstrated PA mediates the relationship between self-efficacy and FMS proficiency (81%), and the relationship between social support and FMS proficiency (62%). A significant relationship was not found between FMS and; PA self-efficacy, social support, or barriers to PA, suggesting correlates traditionally associated with PA are not associated with FMS proficiency. Considering the findings in both Chapter 3 and 4, the role of PA in FMS proficiency is substantial. Both chapters suggest the importance of targeting PA when seeking to improve FMS competence. It is therefore evident that targeted PA strategies need to be better informed if they are to be successful and result in increase in FMS. Understanding when young people can and do accumulate PA across the week will help identify the most relevant time periods for intervention strategies to target.

Purpose of Chapter 5:

Chapter 5 takes a novel approach to PA behaviour in youth, investigating the daily patterns of PA across weekdays and weekends, and across varying time periods within the day. The article seeks to identify whether PA differs across weekday/weekend, gender, and activity level. The purpose of Chapter 5 is to identify times blocks where the greatest differences between the least and most active youth are observed, which are subsequently important to target for PA interventions.

Chapter 5

Where does the time go? Patterns of physical activity in adolescent youth.

Manuscript submitted as: Where does the time go? Patterns of physical activity in adolescent youth. Belton, S., O'Brien, W., Issartel, J., McGrane, B., Powell, D. (Journal of Science and Medicine in Sport - In Press)

5.1 Contribution to this Paper

Title: Where does the time go? Patterns of physical activity in adolescent youth.

My Role:

- I was responsible for the organisation of and collection of all data used in this study which included initialising and distributing monitors, checking wear compliance daily, collecting monitors, and subsequently downloading data at the end of the wear period.
- I processed and cleaned all data that was analysed for this study.
- I was involved in writing the introduction and discussion sections of the paper.
- I provided feedback and participated in the writing of the re-drafts of this paper alongside the lead author.

5.2 Abstract

Objectives: To explore daily patterns of physical activity in early adolescent youth, and identify whether patterns differed across varying activity levels.

Design: Cross-sectional.

Methods: Adolescent youth (n = 715, 11.8 – 14.4 years) were asked to wear an Actigraph accelerometer for a nine day period. Average daily and hourly minutes spent in moderate-vigorous physical activity (MVPA) were calculated for each participant. Participants were grouped into gender-specific quartiles (Q) based on average daily MVPA accumulation (Q4 most active, Q1 least active). Principal Components Analysis was used to identify, from hourly MVPA data, distinct time blocks for Weekday and Weekend days. Mixed between-within ANOVA's were conducted separately by gender to assess the impact of Quartile grouping on minutes of MVPA across the distinct time blocks.

Results: Males accumulated significantly more minutes of MVPA daily than females (55.3 ± 21.6 minutes, versus 47.4 ± 18.1 minutes). Principal Components Analysis revealed three distinct time components for MVPA during weekdays, and weekend days. The total difference between Q4 and Q1 was greatest 'Weekend Afternoons' for Males (43 minutes), and 'Weekend Midday and Afternoons' for females (20 and 23 minutes respectively) with Q4 accumulating significantly more MVPA in these time periods than the other three Quartiles ($p < 0.05$).

Conclusions: This study points to the weekend midday and afternoon periods as particular time blocks to target for intervening with inactive youth. Future research should examine the reasons why some youth choose to be active during these particular periods while others do not, with a view to developing appropriate strategies for intervention.

Key words: child, health, monitoring, time period, principal components analysis

5.3 Introduction

Lee et al. (2012) estimated that worldwide physical inactivity causes 9% of premature mortality, representing 5.3 million of 57 million deaths in 2008. In their review for the recent Lancet physical activity (PA) series, Hallal et al. (2012) report that less than 20% of young people (13 – 15 years) meet the 60 minute a day moderate to vigorous physical activity (MVPA) guideline (Hallal, Andersen, Bull, Guthold, & Haskell, 2012). Studies worldwide have consistently demonstrated an age-related decline in PA participation as children move through adolescence and towards adulthood (Hallal et al., 2012; Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010), with males significantly more active than females across the lifespan (Belton, Nrady, Meegan, & Woods, 2010; Currie et al., 2012; Sisson & Tudor-Locke, 2008). It has been previously established that adolescent PA participation tracks into adulthood at a low-to-moderate level (Kjønniksen, Torsheim, & Wold, 2008; Telama, 2009), resulting in many researchers and interest groups calling for intervention at the formative younger ages (Currie et al., 2012; Kriemler et al., 2011; Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007). While globally, habitual PA participation amongst young people is well reported in terms of total minutes (Currie et al., 2012; Eaton, Kann, & Kinchen, 2012), little is known about the daily patterns of PA participation amongst youth, and specifically whether particular time periods differentiate children who are overall, 'more' active from those who are 'less' active.

Trost, Pate, Freedson, Sallis, and Taylor (2000) demonstrated through principal components analysis (PCA) that adolescents' (aged 12.9 – 15.8 years) weekday participation in MVPA converged into three distinct time components, specifically, 7am – 11.59am, 12pm – 4.59pm, and 5pm – 8.59pm. Similarly, weekend participation also exhibited three distinct time components: 8am – 11.59am, 12pm – 4.59pm and 5pm – 8.59pm. Mota, Santos, Guerra, Ribeiro, and Duarte (2003) carried out a similar analysis with young people aged eight to 15 years. Again using PCA, they identified four distinct time components that accounted for 67% of the variance in school day MVPA; 1) school hours (10am - 12, and 2 – 7pm); 2) lunchtime and outside-school activities (12 – 2pm, and 7 – 9pm); 3) morning time before school period (9 – 10am); and 4) period before bedtime (9 – 10pm).

Garriguet and Colley (2012) found that young people (6 - 19 years) were more active on weekdays than weekend days, with the difference largely reflecting more MVPA accumulation between 7:00am and 1:00pm on weekdays. They identified that for younger children (aged 6 - 10), lunchtime was the most active period of the weekday, while for older children (10 – 19 years), PA peaked from 3:00pm to 5:00pm. When they considered the data according to MVPA levels of the cohort (participants grouped into tertiles from least to most active), they found that the 'most active' group of children and youth accumulated more minutes of MVPA within each time block (day broken into seven two-hour blocks from 7am to 9 pm) compared to the 'medium active' and 'least active' groups. The largest difference was found in the block just after school from 3:00pm to 5:00pm. In a similar analysis, Fairclough, Boddy, Mackintosh, Valencia-Peris, and Ramirez-Rico (2014) investigated weekday-weekend differences using accelerometer measured PA levels. Children were categorised into gender specific quartiles based on their MVPA levels (with quartile Q1 being the least active group, and Q4 the most active group). They reported that children in Q1 – Q3 were significantly less active on the weekends than on the weekdays, but that interestingly children in Q4 maintained their PA levels consistently across weekdays and weekends.

Findings of Kwon and Janz (2012) suggest that targeted youth PA interventions which successfully integrate PA into school day routines may be influential in helping young people (10 – 13 years) to sustain a healthy PA behavior pattern as they grow older. Hesketh et al. (2014) indicate that targeted interventions focussing on periods when children are less active may result in larger increases in children's activity. In order to successfully build MVPA into children or adolescents daily routines, we must first understand when young people can and do accumulate MVPA across the week, so that the most relevant time periods can be targeted. While the Mota et al. (2003) and the Trost et al. (2000) studies detailed above went some way to exploring daily patterns of PA participation of young people according data derived time components (PCA), neither explored the variation in these patterns according to the PA level (MVPA accumulation) of the participants, or the extent to which particular periods of the day may account for the differences between active and inactive youth. While Garriguet and Colley (2012) did examine patterns according to PA level of participants, the periods of day used were not data derived. Fairclough et al. (2014) again looked to examine patterns according to PA level of participants, but analysis was at the more macro level of weekday-weekend, and did not look deeper into the data. There is a need as such to merge the analysis methods of these four studies, to identify whether particular time components of the day may explain more fully differences between active and inactive youth.

The purpose of the current paper was to build upon the work detailed above by investigating adolescents' daily patterns of PA across weekdays and weekends, and across varying time periods within the day. A key goal in this research was to determine whether daily patterns of PA differed across weekday/weekend, gender, and activity level, and to consider how this information could be used to guide future intervention strategies.

5.4 Methods

5.4.1 Overview

This research was carried out as part of a larger study titled 'Y-PATH; Youth-Physical Activity Towards Health' (Belton, O' Brien, Meegan, Woods, & Issartel, 2014), where 109 mixed-gender schools from two geographical areas were invited to participate. Principals from 25 post-primary schools who expressed interest and consented to participate nominated one first year class (12 – 14 years) from their school. Informed parental consent and participant assent was granted for 715 from a total possible of 833 participants (86%). All participants were free to withdraw from the research at any stage. Full approval for this study was given by the Dublin City University Research Ethics Committee (DCUREC/2010/081).

5.4.2 Measures

Body Mass Index (BMI): Body mass (kg) and height (m) were directly measured using a SECA Leicester Portable Height Measure and a SECA calibrated heavy-duty scale.

Physical Activity: Participants were asked to wear an Actigraph GT1M, GT3X, or GT3X+ accelerometer (Actigraph LLC, Pensacola, FL) for a period of nine days on their right hip. Accelerometers were set to record using 10 second epochs. The strategies defined in Belton, O' Brien, Wickel, and Issartel (2013) were employed to increase student compliance with accelerometer wear. The first and last day of accelerometer data were omitted from analysis to allow for subject reactivity (Esliger, Copeland, Barnes, & Tremblay, 2005). Monitor non-wear was defined as ≥ 20 consecutive minutes of zero counts (Esliger et al., 2005; Fairclough et al., 2014). A day was deemed valid if there was a minimum of 10 hours recorded wear-time (Nyberg, Ekelund, & Marcus, 2009). The minimum number of valid days required for inclusion in analysis was three weekdays and one weekend day (Troiano et al., 2008). Minutes in MVPA were estimated from the data using the Evenson, Catellier, Gill, Ondrak, and McMurray (2008) cutpoints; MVPA: ≥ 2296 counts/min.

5.4.3 Statistical Analysis

Mean Daily, Weekday and Weekend day MVPA were calculated. Gender-specific MVPA quartile cut-off values (Fairclough et al., 2014) were calculated to categorise males and females separately into four groups based on Daily MVPA representing the least active quartile (Q1) through to the most active (Q4). All data were analysed using SPSS version 20 with alpha set at $p < 0.05$. Independent sample t-tests were used to identify significant differences in terms of BMI and age between participants that met the accelerometer inclusion criteria and those that did not. Descriptive analyses were calculated for all variables, and preliminary analyses were carried out between genders using paired sample t-tests, a MANOVA, and a Chi-quare test.

To determine whether specific time blocks during the day were representative of participants' daily participation in MVPA, the average minutes of MVPA from each 60 minute block between 8:00am and 9:00pm were subjected to a PCA with varimax rotation (as per Trost et al. (2008) and Mota et al. (2003)); analysed separately for weekday and weekend day. To test if the data set was adequate for factor analysis, a measure of sampling adequacy (MSA) of Kaiser–Meyer–Olkin was applied. A minimum eigenvalue of 1.0 was used to accept a factor as statistically meaningful. Catell's scree test was applied, and where a clear break was identified in the plot the factors above the break were retained. A coefficient of 0.3 or above was considered an important factor loading. The results of PCA were then used to guide categorisation of Weekday and Weekend day MVPA data into distinct time blocks. Data within each time block were averaged to represent minutes per hour of MVPA. A mixed between-within subjects ANOVA (4 groups x 6 time periods) was conducted to assess the impact of Quartile grouping on participants' minutes of MVPA across the distinct time blocks; post hoc analysis was carried out with Bonferoni adjustment for multiple comparisons.

5.5 Results

Of the overall sample of 715 participants, 413 (58%) met the accelerometer inclusion criteria (termed the 'valid sample'). There were no significant differences in age or BMI between the original and valid sample; therefore, remaining analyses were carried out on the valid sample only. Participants (n = 413) were 12.9 ± 0.4 years, 20.1 ± 3.2 kg/m^2, and 52.1%

male. Descriptive data is presented in Table 5.1.

Overall, 32.4% met the 60 minute MVPA per day guideline (calculated as an average over all valid days); this broke down as 41.4% for males and 22.7% for females, with a significantly greater proportion of males ($\chi 2$ (1, n = 413) = 16.39, $p<0.0005$, phi = 0.19). Significant differences between weekday and weekend MVPA accumulation were observed for females (49.14 versus 41.57 minutes respectively ($p<0.005$)), but not for males (55.48 versus 54.28 minutes respectively). A significant difference was observed between males and females (F (6, 406) = 7.04, $p < 0.005$; Wilks' Lambda = 0.906, partial eta squared = 0.094), with males accumulating significantly more MVPA than females Daily, and on both Weekdays and Weekend days.

Three-component solutions explained a total of 51.9% of variance for Weekday data, and 50% of variance for Weekend data. Tables 5.2. and 5.3. display the rotated components matrices presenting the loadings for these factors for Weekday and Weekend respectively. The shaded areas highlight the time blocks which load strongly on each component. This rotated solution revealed the presence of a simple structure (Thurstone, 1947). Weekday MVPA time blocks were calculated as follows: 'Around School' 8am – 10am and 4 - 5pm, 'During School' 10am – 4pm, and 'After School' 5pm – 9pm. Weekend time blocks were calculated as: 'Morning' 8am – 11am, 'Midday' 11am – 3pm, and 'Afternoon' 3pm – 9pm.

Table 5.1. Descriptive data for the demographic characteristics, BMI, and MVPA.

	Total Sample		**Males**		**Females**	
Variable	**M**	**SD**	**M**	**SD**	**M**	**SD**
Age	12.89	0.39	12.93	0.38	12.86	0.40
BMI	19.85	3.09	19.90	3.27	20.29	3.05
Weekday MVPA	52.44	21.12	55.48	21.73	49.14	19.98
Weekend MVPA	48.19	33.16	54.28	37.09	41.57	26.86

Note. M = mean; SD = standard deviation; MVPA = moderate to vigorous physical activity.

Table 5.2. Rotated component matrix according to Weekday MVPA hourly time blocks

Time block		Component		
	Mean (SD)	1	2	3
8-9am	5.90 (4.57)	0.099	0.149	0.762
9-10am	1.22 (0.98)	0.121	-0.1	0.467
4-5pm	5.77 (4.32)	-0.069	0.162	0.744
10-11am	1.78 (1.76)	0.68	-0.019	0.084
11am-12	2.65 (2.58)	0.842	-0.096	-0.004
12-1pm	3.60 (4.19)	0.765	-0.043	-0.078
1-2pm	5.81 (3.84)	0.429	0.073	0.354
2-3pm	2.29 (2.09)	0.667	0.01	0.188
3-4pm	4.78 (3.38)	0.364	0.263	0.313
5-6pm	4.08 (3.59)	0.068	0.693	0.165
6-7pm	4.74 (4.26)	0.02	0.849	-0.035
7-8pm	4.65 (4.28)	-0.04	0.862	-0.018
8-9pm	2.73 (2.75)	-0.092	0.652	0.112

Table 5.3. Rotated component matrix according to Weekend MVPA hourly time blocks

Time block		Component		
	Mean (SD)	1	2	3
8-9am	0.94 (2.31)	0.073	-0.169	0.627
9-10am	1.87 (4.00)	-0.013	0.002	0.855
10-11am	2.70 (4.56)	0.106	0.286	0.616
11am-12	3.89 (5.22)	0.031	0.751	0.041
12-1pm	4.05 (5.31)	0.031	0.783	0.04
1-2pm	4.20 (5.29)	0.178	0.633	-0.081
2-3pm	4.27 (4.67)	0.362	0.458	0.089
3-4pm	4.81 (5.60)	0.612	0.162	0.184
4-5pm	5.30 (6.45)	0.518	0.296	0.129
5-6pm	5.06 (6.14)	0.631	0.267	0.325
6-7pm	4.75 (5.74)	0.707	0.13	0.157
7-8pm	4.16 (5.47)	0.746	0.032	-0.128
8-9pm	2.42 (3.53)	0.631	-0.123	-0.196

Table 5.4. shows the average minutes of MVPA per hour within each time block for each quartile (Q) grouping, for males and females respectively. A significant main effect for time was found for both males ($F(5,91) = 11.02$, $p < 0.000$, partial eta squared = 0.377) and females ($F(5,60) = 8.72$, $p < 0.000$, partial eta squared = 421). A significant interaction effect between Q grouping and time was found for males ($F(15, 279) = 2.13$, $p = 0.009$, partial eta squared = 0.103) but not for females ($F(15, 186) = 1.48$, $p = 0.118$, partial eta squared = 0.057). On Weekdays males were significantly more active in the Around School period than During School ($p < 0.05$). No significant differences were observed between time periods on Weekdays for females. On Weekends, both genders were significantly less active in the Morning period than the other two time blocks ($p < 0.05$). Significant differences in MVPA accumulated in the different time periods across Quartile are shown through annotation in Table 5.4. On Weekdays Q4 males and females were significantly more active After School ($p < 0.05$) than their Q1 and Q2 counterparts. The magnitude of the differences between groups (calculated as Q4 minutes/hour minus Q1minutes/hour) was greatest in the Weekend Afternoon period for Males (7.22 minutes/hour), and in the Weekend Midday period for females (5.05 minutes/hour); with Q4 males and females both accumulating significantly more MVPA in these time periods than the other three Quartiles ($p < 0.05$).

Table 5.4. Mean (SD) minutes MVPA within each time period per Quartile grouping

Male		Around School ** ±±	During School *** ¥	After School ** ±	Weekend Morning ****	Weekend Midday ** ±±	Weekend Afternoon * ±±
Q4	(mins/hr)	6.74 (2.89)	4.87 (1.56)	7.07 (3.29)	3.70 (4.51)	7.54 (4.51)	8.97 (4.38)
Q3	(mins/hr)	5.25 (2.41)	3.41 (2.19)	5.68 (2.72)	2.27 (2.60)	6.06 (3.77)	5.08 (2.39)
Q2	(mins/hr)	3.52 (1.91)	3.75 (1.63)	3.03 (1.87)	1.65 (1.62)	3.89 (2.11)	4.39 (5.10)
Q1	(mins/hr)	2.46 (1.44)	2.21 (0.80)	1.65 (1.04)	1.19 (1.46)	2.52 (2.18)	1.75 (1.11)
Total	(mins/hr)	4.60 (2.82)	3.63 (1.86)	4.47 (3.27)	2.29 (3.09)	5.11 (3.89)	5.26 (4.53)
Magnitude of differences	(mins/hr)	4.28	2.66	5.42	2.51	5.02	7.22
Total Differences	(mins/day)	12.84	15.96	21.68	7.53	20.08	43.32
Female		**Around School *****	**During School ** ±**	**After School ***	**Weekend Morning**	**Weekend Midday ***	**Weekend Afternoon ****
Q4	(mins/hr)	5.83 (2.59)	5.05 (2.37)	5.68 (3.54)	3.03 (3.42)	7.07 (5.37)	5.67 (3.30)
Q3	(mins/hr)	3.93 (1.29)	4.80 (1.85)	2.84 (1.93)	1.98 (2.77)	3.36 (1.55)	3.82 (3.23)
Q2	(mins/hr)	4.60 (2.91)	2.56 (0.87)	2.95 (1.46)	1.75 (1.92)	2.86 (2.02)	2.63 (1.97)
Q1	(mins/hr)	3.10 (1.25)	1.78 (0.61)	1.66 (0.99)	0.66 (0.60)	2.02 (1.67)	1.87 (1.06)
Total	(mins/hr)	4.39 (2.32)	3.64 (2.11)	3.32 (2.62)	1.89 (2.55)	3.87 (3.57)	3.55 (2.93)
Magnitude of differences	(mins/hr)	2.73	3.27	4.02	2.37	5.05	3.80
Total Differences	(mins/day)	8.19	19.62	16.08	7.11	20.20	22.80

Magnitude of Differences = Q4 minus Q1; Total Differences = Magnitude of differences x number of hours in the time block

* Q4 > Q3, 2 and 1, $p < 0.05$
** Q4 > Q2 and 1, $p < 0.05$
*** Q4 > Q3 and 1, $p < 0.05$
**** Q4 > Q1, $p < 0.05$
± Q3 > Q2 and 1, $p < 0.05$
±± Q3 > Q1, $p < 0.05$
¥ Q2 > Q1, $p < 0.05$

5.6 Discussion

Consistent with previous research (Currie et al., 2012; Hallal, Victora, Azevedo, & Wells, 2006; Woods et al., 2010), male adolescents were significantly more active than females in the current study. Overall, 32.4% met the 60 minute MVPA per day guideline (41.4% male, 22.7% female). It must be noted however that accelerometers were used in the current study to determine meeting or not meeting the guidelines, while the guidelines themselves were developed largely based on self-report data; thus one must be cautious in interpreting this statistic. The Health Behaviour in School-Aged Children (HBSC) European study (Currie et al., 2012) however, which used a self-report measure of PA, similarly found that in Ireland at age 13, 36% of males and 20% of females self-reported accumulating at least 60 minutes of MVPA daily. The levels of MVPA reported in the HBSC study for Ireland was relatively consistent with almost all European countries surveyed. The findings of Woods et al. (2010) are lower than those reported in the HBSC study, with only 18% of 12 to 13 year old Irish youth self-reporting to meet the guideline.

Consistent with Fairclough et al. (2014) quartiles were chosen as the method to categorise participants in this study, so that patterns across time blocks according to activity level could be considered. Though the 60-minute PA recommendation in some ways may offer a more defined framework to categorise participants, with only 32.4% of participants meeting this guideline it did not offer sufficient differentiation between participants for the purpose of this analysis. Results of PCA revealed three distinct periods of the Weekday and Weekend day in this study, accounting for 51.9% and 50.0% of variance in MVPA time respectively. As with Garriguet and Colley (2012) and Fairclough et al. (2014) our findings indicate that the most active children (males and females) are more active because they accumulate more activity than their less active counterparts in all periods of the day and week (see Table 5.4).

If we consider male patterns of participation, we see that Q4 males were significantly more active ($p < 0.05$) than Q1 and Q2 males in all periods except for Weekend mornings (the least active period overall for males). We also find that the After School, and Weekend Afternoon periods were the times when the differences between the most and least active Quartile of males were greatest. This difference is further amplified when we consider the length of these time blocks (see Table 5.4, Total Differences (minutes/day)); the 5.42 more minutes per hour that Q4 males accumulate when compared to Q1 males in the After School period, means an actual difference of 21.68 minutes each day during this four hour time block. This is consistent with the findings of Mota et al. (2003) who found that males generally seemed to be more active in the after school period. Similarly, Garriguet and Colley (2012) reported weekday 3:00pm to 5:00pm as the period exhibiting the largest difference between the most active tertile of youth and the rest (this was not reported by gender however). Q4 males accumulate 43.32 more minutes in the Weekend Afternoon period than Q1 males; with the difference between Q3 and Q1 males in this period 19.98 minutes.

For females, we see a lower magnitude of differences between Quartiles, and also a more uniform spread of these differences across time periods. This may be explained by the lower levels of MVPA of the female cohort when compared to males, but also suggests lower variation in MVPA in this cohort. Again consistent with Garriguet and Colley (2012), the After School period stands out as a period when Q4 females were significantly more active ($p < 0.05$) than the other three Quartiles; accumulating 16.08 more minutes than their Q1 counterparts. Mota et al. (2003) reported that Q3 and Q4 females found opportunities to accumulate MVPA during the school day, Q1 and Q2 did not, and findings of the current study support this. Both Q4 and Q3 females were significantly more active in the During

School period than Q1 and Q2 females, with a total difference between Q4 and Q1 of 19.62 minutes. In terms of PA weekend behaviour, a slightly different pattern for females emerges when compared to males, with both the Midday and Afternoon periods providing similar total differences between Q4 and Q1; 20.20 and 22.80 minutes respectively.

There is now much evidence supporting multi-component school-based interventions for increasing PA among children and adolescents (Dobbins et al., 2013; Kriemler et al., 2011). Researchers highlight however, that while activity levels may be enhanced in physical education (PE) class, or in school in general, few effects are observed in overall activity (Van Sluijs et al., 2008). This raises the question of whether children 'compensate' during the rest of the day by doing less PA at other times. Findings from the present study offer researchers insight to better develop intervention strategies, as advocated by Hesketh et al. (2014), so that appropriate time periods throughout the week can be targeted by gender and activity level, for appropriate and achievable increases. Differences in activity levels between Quartiles are present in all time periods, but unsurprisingly they are largest during the periods of the day when adolescents have the most discretionary time (after school, and weekends). Strategies to entice less active males and females to participate during the key periods identified in this study, would likely be beneficial over and above many current intervention strategies that target participation during the school day only. Indeed when evaluating the effect of intervention strategies, it may be interesting to consider changes in PA according to the different time periods, to determine how and when change (if any) is happening.

It is interesting that although research frequently identifies adolescents as being more active on Weekdays when compared to Weekend days (Garriguet & Colley, 2012; Riddoch et al., 2007; Trost et al., 2000), this study found the trend to be true only for females, and furthermore highlights Weekend time periods where highly active adolescents of both genders are at their most active. In an Irish context, this may be in part explained by the fact that club sports for this age group are quite often played on a Saturday or Sunday afternoon. This is consistent to an extent with Fairclough et al. (2014), who found that the most active children maintained their activity levels at weekends.

Limitations of this study include the fact that only mixed-gender schools were invited to participate, and the potential for schools to have selected classes which they felt would be most compliant with research conditions (wearing accelerometers for nine days), though we cannot speculate as to whether, or how this potential bias may have impacted on measured PA levels. In addition the low level of students meeting the minimum wear-time criteria (58%) must be acknowledged, though we are confident that the valid sample remained representative given there were no significant differences in age or BMI between the original and valid sample.

5.7 Conclusion

Study findings point to the need for effective PA intervention strategies to simultaneously target gender and PA level specific weekday and weekend time periods to positively affect change in overall adolescent PA behavior. Future research should examine whether patterns identified are consistent across younger and older age cohorts. To better inform strategies for intervention, type of activities participated in during the different time periods, along with the reasons why the most active youth choose to be active during these particular periods, and perceived barriers to the same for inactive youth should be examined.

5.8 Practical Implications

- The afterschool and weekend midday and afternoon periods are important to target for PA interventions, as these are the times where the greatest differences between the least and most active youth are observed.

- Interventions need to prioritise the development of more effective strategies, reaching beyond the school environment, to affect change in the weekend period.
- In order to develop effective strategies to target least active youth, we need to understand the reasons why they don’t currently chose to participate in PA during these particular time periods.

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Link Section Chapter 5 to Chapter 6

Purpose of Chapter 5:

Chapter 5, sought to investigate the daily patterns of PA across weekdays and weekends, and across varying time periods within the day. The paper then identified whether PA differs across weekday/weekend, gender, and activity level. Principal Components Analysis revealed three distinct time components for MVPA during weekdays, and weekend days. Weekday MVPA blocks patterned as follows; 'Around School' 8 – 10am and 4 – 5pm, 'During School' 10 – 4pm, and 'After School' 5 – 9pm. The Weekend time blocks identified were: 'Morning' 8 – 11am, 'Midday' 11am – 3pm, and 'Afternoon'. The most active children accumulated more MVPA across all time periods when compared to their less active counterparts. This article provides specific time blocks during which interventions can target activity levels in both active and more importantly, inactive individuals. The next phase needs to identify whether a generic school-based PA intervention (i.e. the Y-PATH programme) aimed at improving overall PA, can be effective at improving PA behaviour during the weekday periods specified in Chapter 5.

Purpose of Chapter 6:

The purpose of Chapter 6 is to assess the efficacy of the Y-PATH intervention at improving school day PA levels over a two year period in adolescent youth. Data was collected at three time points; baseline (0 months), one year follow-up (12 months) and two year follow-up (24 months). Data was collected on a subsample at two year follow-up. Chapter 6 also evaluates the effect of the Y-PATH intervention at one and two year follow-up by subgroup (gender, age, weight status, FMS level, and VO_{2max}). The rigorous evaluation of interventions such as Y-PATH is essential to ensure the efficacy of the intervention longitudinally and during different time periods during the day.

Chapter 6

An evaluation of the randomised controlled trial of the Youth-Physical Activity Towards Health (Y-PATH) intervention - Can we improve physical activity levels in youth?

6.1 Abstract

Objective: To evaluate the impact of the Youth-Physical Activity Towards Health (Y-PATH) intervention on physical activity (PA) levels in youth.

Design: Clustered randomised controlled trial.

Methods: A total of 565 participants from 20 schools (n = 10 intervention) participated in the study. Data were collected on all participants at two time points; baseline (September 2013), and one year follow-up (September 2014). Data were collected on a subsample of 10 schools (intervention n = 5, total participant n = 276) at two year follow-up (September 2015). The control condition continued with normal care, while the intervention condition received a multi-component intervention which included Y-PATH physical education (PE) delivered by a specialist PE teacher over the two year period. The primary outcome measure was minutes of PA. Average moderate-to-vigorous physical activity (MVPA) per day (Actigraph accelerometers for a 9-day period) was collected. Fifteen fundamental movement skills (FMS - TGMD, TGMD-2, Victorian Skills Manual), health-related fitness (HRF - 3 minute Queens College step test used to calculate a predicted VO_{2max} value) and weight status (height and weight to calculate body mass index and classify into weight categories) were also assessed. The primary outcome (PA) was assessed from baseline to one year follow-up and from baseline to two year follow-up using 2-level (student, school) multi-level modelling adjusted for baseline values of the outcome, and potential confounders. Differences in intervention by subgroup (gender, weight status, FMS level and VO_{2max} level) were explored using statistical interaction. Statistical significance was set at $p<0.05$, and at $p<0.10$ for interaction terms (Twisk, 2006).

Results: Significant between-groups effects were observed for Total Weekday MVPA at two year follow-up ($\beta=11.66$ (5.25, 18.07) $p<0.001$). Interaction analyses revealed that the intervention was most effective for participants who are overweight and obese (OWOB),

have low VO_{2max} levels and females, during different time periods. Interactions will be presented in detail in the paper.

Conclusion: This study highlights that the Y-PATH multi-component school-based intervention resulted in significant long-term effects on Total Weekday MVPA. The Y-PATH intervention is effective for the most at risk adolescents in the population, namely i) those who are OWOB, ii) those with low aerobic capacity, and iii) the more inactive gender (i.e. female). Including targeted strategies in existing school-based interventions such as Y-PATH to increase PA behaviour in specific time periods is warranted. Future research should evaluate the efficacy of such strategies. The evaluation of the Y-PATH intervention effect over a longer duration of time (for example across the six post-primary school years) is also justified, to determine whether the observed halt of the age related decline in PA is retained over the second level school cycle.

Key words: adolescent, physical activity, accelerometry, randomised controlled trial, intervention, multi-level modelling.

6.2 Introduction

Physical activity (PA) is a complex, multifaceted behaviour (Ward, Saunders, & Russell, 2007), which has been defined and widely accepted as any bodily movement that expends energy beyond resting levels (Caspersen & Christenson, 1985). A plethora of research exists which suggests physical inactivity is responsible for high levels of non-communicable diseases such as cardiovascular disease, type II diabetes, breast cancer, colon cancer, and all-cause mortality (Lee et al., 2012). Participating in PA during youth is believed to reduce the health risks associated with inactivity from childhood to adulthood (Kohl, Fulton, & Caspersen, 2000). Widely accepted activity guidelines suggest that youth should be active for at least 60 minutes per day at a moderate to vigorous PA (MVPA) intensity (Department of Health Physical Activity Health Improvement and Protection, 2011).

Low levels of PA are observed around the world with 80.3% of 13 to 15 year olds insufficiently active (Hallal, Andersen, Bull, Guthold, & Haskell, 2012). Irish research from the ‘Children’s Sport Participation and Physical Activity’ (CSPPA) study found that only 19% of children (10 - 12 years) and 12% of adolescents (12 - 18 years) met the minimum 60 minute PA guideline (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010). Belton, O’Brien, Issartel, McGrane, and Powell (2016) more recently found using objectively measured PA, that 32.4% of Irish adolescents (11.8 - 14.4 years) met this guideline. Compared to Irish adolescents, research in Scotland (The Scottish Government, 2010), found a much higher prevalence of children (2 - 15 years), achieving the PA guideline (72%). These adherence rates are exceptionally high and are more in line with US (42% of 6 - 11 year olds) and European (39% of 14.45 year olds) findings, who report higher percentages of children and adolescents meeting the recommended PA levels (Aibar, Bois, Generelo, Zaragoza Casterad, & Paillard, 2013; Troiano et al., 2008). Canadian research found similar adherence rates as those observed in the Irish cohort, with only 9% of males and 4% of females (6 - 19 years) accumulating 60 minutes of MVPA, on at least six days in a week (Colley et al., 2011). It is important to acknowledge that different measures of PA were used namely self-report (Colley et al., 2011; The Scottish Government, 2010) and objectively measured PA (Aibar et al., 2013; Troiano et al., 2008) which may affect the comparability of the values presented. Irrespective, the majority of youth consistently fall short of the PA guideline. Given that PA levels are known to decrease between childhood and adolescence (Troiano et al., 2008; Woods et al., 2010), and that PA behaviour tracks across time (Telama et al., 2005), addressing youth and adolescent inactivity is imperative for public health.

Many intervention projects have been conducted to increase habitual PA in youth and adolescents, using single and combined strategies (de Meij et al., 2011; Haerens et al., 2006; Jamner, Spruijt-Metz, Bassin, & Cooper, 2004; Kriemler et al., 2010; McKenzie et al., 2004; Pate et al., 2005). One systematic review of the effectiveness of PA interventions in children and adolescents found 38 studies (67%) reported a positive intervention effect on PA levels ranging from an increase of 2.6 minutes of PA during physical education (PE), to a 42% increase in regular PA participation, and an increase of 83 minutes in MVPA per week (van Sluijs, McMinn, & Griffin, 2008). Research suggests that when targeting adolescent PA levels, multi-component interventions which include both school and family or community involvement, are best placed to make significant differences in PA behaviour (van Sluijs et al., 2008). Multi-component school-based interventions have the ability to increase both in-school-PA and out of-school-PA levels (Kriemler et al., 2011; Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007). The PE class is acknowledged as our best placed public health system through which to intervene, in the school setting, and has consistently delivered positive improvements in PA levels, when correctly targeted (Kriemler et al., 2010; McKenzie et al., 2001; McKenzie et al., 2004; Sallis et al., 1997). Using the PE class to deliver specialised curriculum aimed at educating adolescents on the benefits of PA and encouraging them to engage in a physically active lifestyle both in and outside of the classroom and school setting, may be fruitful (Belton, O' Brien, Meegan, Woods, & Issartel, 2014).

In order to develop interventions targeted at the individual level, understanding when kids are most active and/or most inactive is important. Belton et al. (2016) investigated patterns of PA behaviour in adolescents in an attempt to identify the most opportune time periods in a day to target with specific intervention strategies, based on gender and activity level. The weekday patterned into three time blocks; 'Around School' (8 - 10am and 4 - 5pm), 'During School' (10 - 4 pm), and 'After School' (5 - 9pm). Whether a generic PA intervention can be effective in some or all of these time periods has yet to be explored. Each time period in the day may contribute to overall increases in PA behaviour and hence should not be disregarded when considering the efficacy of a PA intervention. In addition, factors such as weight status, fundamental movement skill (FMS) level, and VO_{2max} levels may be important when creating and evaluating targeted PA interventions, as according to Stoddens conceptual framework these variables are considered mechanisms that may influence and mediate PA behaviour (Stodden et al., 2008).

Several recent studies have looked at the short-term effects of PA interventions (Baranowski et al., 2011; Cliff et al., 2011). Developing feasible interventions which are effective longitudinally; requiring minimal financial, material or organisational support, is desirable for public health improvements. The Y-PATH intervention is a multi-component school-based intervention which takes a whole-school approach towards the promotion of activity in youth (Belton et al., 2014). The Y-PATH intervention consists of three components; student, parent/guardian and teacher (whole-school) components, which will later be discussed in more detail. The PE element of the Y-PATH intervention, delivered through the educational medium of prescribed health-related activity (HRA) with a focus on FMS, focuses on creating a motivational climate and increasing PA levels.

Longitudinal research tracking PA behaviour over time is particularly important in adolescence, as adolescent PA behaviour is known to track into adulthood (Telama et al., 2005). Ensuring positive trajectories of participation are observed and maintained in adolescence is vital for the current and future health of adolescents. As such, the purpose of this research is to evaluate the long-term intervention effect on PA levels of the Y-PATH intervention, with data collected at one year follow-up (12 months), and two year follow-up (24 months). The primary objective was to examine if the intervention group would demonstrate a significant increase in minutes of MVPA in different time periods of the school day (i.e. Total Weekday, Around School, During School, and After School), when compared to the control group. Secondary to this was to identify whether differences in intervention effect by subgroup (gender, weight status, FMS level, VO_{2max} level) exist.

6.3 Methods

6.3.1 Participants and Recruitment

All second level mixed-gender schools in County Dublin (Ireland), were sent a letter inviting them to participate in a cluster randomised controlled trial of the Y-PATH intervention. Limited information about the intervention itself was supplied to prevent potential contamination of the intervention and control conditions; however details on the testing procedures and main objectives of the intervention were provided. Inclusion criteria for participation were mixed-gender school, qualified PE teacher, and a minimum of one double class (70 minutes) of timetabled PE for first year students per week; principals of 22 schools which met this criteria returned expressions of interest to participate in the study. One first year class (12 - 14 years) from each school was selected to participate by the principal. Due to a change in principal and/or PE teacher, two schools withdrew from the study. Remaining schools were paired matched prior to baseline testing, based on the following criteria: socioeconomic status (disadvantaged, non-disadvantaged, and fee paying), school size (small 0 - 299 students, medium 300 - 599 students, large >599 students), and facilities (school hall, size of hall, basketball courts etc). One school from each pair was then randomly allocated to the control group (and the other to the intervention group) using a manual number generator in blocks of 1:1.

Twenty schools completed all measures at two time points (0 months, and 12 months), with 565 participants (baseline mean age 12.78 years). Ten of these schools (n = 5 intervention) elected to continue with a second year of the Y-PATH intervention, and as such these participants remained in the study until 24 months (n = 276). Based on data from the CSPPA study (Woods et al. 2010), which showed that only 12% of youth achieved the guideline for PA, a total of 18 schools (nine per arm), with an average of 27 participants per school, will provide at least 80% power at 5% level of significance (two-sided) to detect a difference of 20% (with an ICC of 0.1) in the proportion of children meeting the PA guidelines at follow-up. Allowing for attrition an additional two schools per arm with 27 students per school were recruited; thus the study involved 20 schools with approximately 27 students per school. Parental consent for each participant was given as well as participant assent. All participants were free to withdraw from the study at any point. Ethical approval was obtained from the University Research Ethics Committee. All PE teachers in the intervention condition received a four hour in-service training on the implementation of the Y-PATH intervention, prior to the commencement of the academic school year.

6.3.2 The Y-PATH Intervention

Schools allocated to the intervention condition were asked to implement the whole-school Y-PATH intervention over the full academic year. The intervention consists of three core components:

1) Student component. Students receive HRA and FMS focused PE within the remit of the existing curriculum, delivered by their PE teacher (qualified PE specialist). A Y-PATH intervention resource manual is provided to all intervention teachers upon completion of the four hour in-service training, comprising of two main parts. The first part consists of two sets of six-lesson schemes of work (one for the first year of the intervention and one for the second year of the intervention). Each of these lessons have a HRA and PA focus, and a targeted psychosocial focus aimed at improving attitudes and beliefs towards PA. The second element is the PE teacher integration guide which assists the teacher in incorporating Y-PATH PE (i.e. HRA, PA, psychosocial and FMS centred PE) across all strands of the curriculum.
2) Parent/Guardian component. This consists of a face to face education evening on the importance on PA for health with a specially designed Y-PATH leaflet and introduction to the whole-school Y-PATH intervention. The purpose of this component is to educate parents as to why PA is so important for their child, and how they have a role to play in encouraging and promoting PA in their child.
3) Teacher component. All teachers in the Y-PATH intervention schools attend a workshop which highlights the importance of acting as an ‘active role model’ and a whole-school approach to PA promotion. A charter for PA promotion within each intervention school is produced in collaboration with the teachers.

Control schools were asked to continue with normal care, without any researcher input during the testing period. Usual care in this context consisted of regular delivery of the Irish Junior Cycle PE curriculum.

6.3.3 Measurements

Measurements were taken at three time points; September 2013 (baseline), September 2014 (1 year follow-up), and September 2015 (2 year follow-up).

6.3.3.1 Outcome Measure

Physical Activity: Participants wore an Actigrah accelerometer (models GT1M, GT3X or GT3X+; Actigraph LLC, Pensacola, FL), for a period of nine days, on an adjustable elasticated belt above the iliac crest of the right hip (as per Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2015). Participants were asked to wear accelerometers during all waking hours with the exception of water-based activities such as showering and swimming and contact sports deemed unsafe by an adult for accelerometer wear (e.g. rugby). Accelerometers were set to record using a 10 second epoch (Cain, Sallis, Conway, Dyck, & Calhoon, 2013). A number of strategies were employed to ensure compliance (Belton, O' Brien, Wickel, & Issartel, 2013): students were met in the morning of each school day to ascertain compliance with the wear instructions; an optional twice daily SMS reminder text was sent before school and in the afternoon; teachers in each school checked whether or not participants were wearing their monitors each school day; students were advised to place reminders to wear monitors in noticeable areas in their homes; a record card was provided for recording periods of non-wear; and students who were compliant with the wear-time inclusion criteria, entered a class draw for a €20 sports voucher (per class).

The minimum number of valid days required for inclusion in analysis was two weekdays (Kriemler et al., 2010). In line with other studies, a day was deemed valid (and therefore included in analysis) if there was a minimum of eight hours recorded wear-time per day (Fitzgibbon et al., 2011). Monitor non-wear was defined as ≥20 consecutive minutes of zero counts (Cain et al., 2013; O'Brien, Issartel, & Belton, 2013). Counts below zero and above 15,000 were excluded due to biological plausibility (Esliger, Copeland, Barnes, & Tremblay, 2005; O'Brien et al., 2013). The mean daily minutes spent in MVPA were estimated using the validated cut points derived by Evenson, Catellier, Gill, Ondrak, & McMurray (2008), for adolescents in this age group: MVPA ≥2296 counts/min. Based on the findings of Belton et al. (2016), weekday MVPA time periods were calculated as follows: 'Total Weekday' 7am - 11pm , 'Around School' 8 - 10am and 4 - 5pm, 'During School' 10 - 4pm, and 'After School' 5 - 9pm.

6.3.3.2 Assessment of Covariates

Weight Status: Standing height was measured using a portable stadiometer (Leicester Height Measure) in centimetres (cm) to the nearest two decimal places. Weight was measured using a portable calibrated scales (SECA) in kilograms (kg) to the nearest 0.5kg. Body mass index (BMI) was calculated using the formula weight(kg)/height(m^2). Gender-specific cut points were applied to classify BMI into four weight categories: severe thinness, thinness, overweight and obese (Cole & Lobstein, 2012).

VO_{2max}: The Queens College three-minute step test was administered to calculate an estimate of VO_{2max}. A protocol as per McArdle, Katch, Pechar, Jacobson, and Ruck (1971) was followed. After a 20 second familiarisation period, and once all participants were comfortable with the process, the three-minute trial began whereby each participant continuously stepped for three minutes up and down a pre-set height of 41cm (bench/steps) to a metronome. Cadence was set at 22 steps per minute for females and at 24 steps per minute for males. Post-trial, a trained researcher was given five seconds to find the pulse in the participants' right wrist. Once researchers had the pulse, it was counted for a 15 second period post-exercise. This was converted to beats per minute (bpm) and subsequently used to calculate VO_{2max} using the following gender specific formulae: male VO_{2max} (ml/kg/min) = 111.33 - (0.42 x heart rate (bpm)); female VO_{2max} (ml/kg/min) = 65.81 - (0.1847 x heart rate (bpm)) as per McArdle et al. (1971).

FMS: Fifteen FMS were assessed during a regular PE class. The Test of Gross Motor Development-2nd Edition (TGMD-2; Ulrich, 2000) was used to assess 12 skills (6 locomotor: run, hop, gallop, slide, leap and horizontal jump, and 6 object control: catch, kick, throw, dribble, slide and roll). The skip (Test of Gross Motor Development: TGMD; Ulrich, 1985), vertical jump, and balance (Victorian Fundamental Movement Skills Manual; Victoria, Department of Education, 1996) were included as they were considered relevant in an Irish sporting context (O' Brien, Belton, & Issartel, 2015).

A team of 12 researchers were trained prior to testing, by four experts, on correct demonstration of each FMS and testing protocol. Participants were given three attempts at each skill: one familiarisation and two trials with no feedback given at any stage. All skills were video recorded and analysed at a later date by the research team. Two trained and experienced researchers (expert scorers) assessed a sample within each of the selected skills to ensure a correlational index of agreement reached a minimum of 99% reliability. Once this was achieved, the two expert scorers trained six of the field researchers in the scoring protocols. Prior to processing, a minimum of 95% inter-rater agreement for each of the 15 skills on a pre-coded dataset was achieved between the two expert scorers and the six field researchers. As per the TGMD-2 protocol a "0" was given where a component was not observed and a "1" where a component was observed. The two assessments were summed to give a raw score per skill. All skills were subsequently summed to give a raw FMS score per participant.

6.3.4 Data Analysis

Multi-level modelling analyses was used to examine the effect of the Y-PATH intervention on MVPA (outcome measure) during the Total Weekday period, Around School period, During School period, and After School period. Multi-level analysis takes into account the hierarchical nature, clustering and dependency of the observations, where standard statistical tools would assume independent observations (Twisk, 2006). A 2-level data structure was used to account for the students nested within the schools with children defined as the first level, and school defined as the second level of analysis. Separate analyses were conducted to investigate the intervention effect between baseline and one year follow-up, and baseline and two year follow-up. Regression coefficients for the group variables (control = 0, intervention = 1), reflected between-group differences in the outcome measure, adjusted for baseline outcome measures and baseline covariates believed to influence PA levels: gender, age, weight status, FMS proficiency, and VO_{2max} levels. Separate 'crude' interaction analyses adjusted for each interaction term, group, and baseline value of the outcome measure were performed to investigate whether the intervention effect varied depending on subgroups. Where these were significant, stratified analysis for each modifier was conducted to identify where the significance lay. All modifiers were stratified using the logic that participants in the bottom 50% were classified as ‘low’ and participants in the top 50% were ‘high’ for age, FMS level and $VO_{2max.}$ Weight status was stratified according to ‘normal weight’ (NW) and ‘overweight and obese’ (OWOB). The Wald statistic was used to assess the significance of the regression coefficients in the main and interaction models. Analyses were performed using MLwiN 2.36 software (Centre for Multilevel Modelling, University of Bristol, UK). Statistical significance for all analysis was set at $p<0.05$, with $p<0.10$ used for interaction terms as suggested by Twisk (2006). All descriptive statistics presented were derived using IBM SPSS 23.

6.4 Results

6.4.1 Preliminary Results

Participant retention ranged from 99.6% (baseline), to 84.6% at one year follow-up and 45.56% at two year follow-up, in the control group. The intervention group's retention ranged from 100% at baseline to 82.0% at one year follow-up and 48.2% at two year follow-up. Retention levels were reduced significantly at two year follow-up as only a subsample of the original sample was tested. Control participants meeting the accelerometer inclusion criteria ranged from 93.4% (n = 241) at baseline, to 73.5% (n = 161) at one year follow-up and 80.5% (n = 95) at two year follow-up. The intervention group's compliance ranged from 94.7% (n = 232) at baseline, to 76.6% (n=154) at one year follow-up and 81.8% (n = 99) at two year follow-up. Characteristics of participants at baseline are presented in Table 6.1. Intervention participants recorded significantly higher BMI values (p = .02) and Around School MVPA minutes per day (p = .003) at baseline when compared to control. Control participants recorded significantly higher minutes of MVPA per day in the After School period (p = .004).

Table 6.1. Baseline descriptive characteristics, weight status, VO_{2max} levels, FMS levels and physical activity levels (Mean ± SD except gender and weight status)

	Group	
Measure	**Intervention**	**Control**
Age (years)	12.77 (0.41)	12.79 (0.42)
Gender	Male n=138 (Female n=141)	Male n=140 (Female n=138)
BMI (kg/m^2)	20.44 (3.30)	19.79 (3.02)
Weight Status:		
NW (%)	69.38	61.73
OWOB (%)	30.62	38.24
VO_{2max} (ml/kg/min)	44.74 (8.88)	43.88 (8.97)
FMS	94.83 (8.40)	94.56 (8.51)
Physical Activity:		
Total Weekday (MVPA min/day)	54.55 (19.80)	55.09 (24.53)
Around School (MVPA min/day)	13.83 (8.28)	11.82 (6.49)
During School (MVPA min/day)	23.04 (11.49)	22.83 (11.93)
After School (MVPA min/day)	14.00 (11.26)	17.51 (14.71)

6.4.2 Intervention Effects

In adjusted analyses significant between-group intervention effects were observed between baseline and two year follow-up for Total Weekday MVPA ($\beta = 11.66$ (95% CI = 5.25, 18.07), $p<0.001$). No other significant intervention effects were observed between baseline and one year follow-up or between baseline and two year follow-up for Total Weekday MVPA, Around School MVPA, During School MVPA, or After School MVPA.

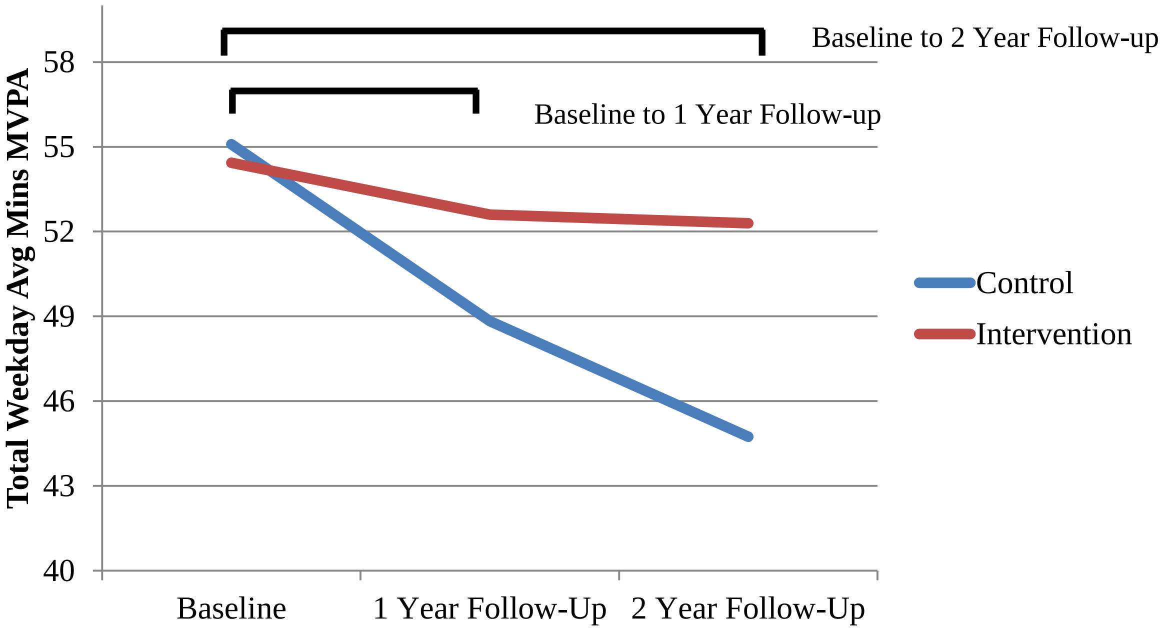

Figure 6.1. Total Weekday MVPA over time for control and intervention groups

Table 6.2. Mean minutes of MVPA during each time period and between-group differences at 1 year follow-up and 2 year follow-up

Outcome	Intervention			Control				
	Baseline	**1 Year Follow-Up**	**2 Year Follow-Up**	**Baseline**	**1 Year Follow-Up**	**2 Year Follow-Up**	**Adjusted 1 year follow-up between-group differences (95% CI)**	**Adjusted 2 year follow-up between-group differences (95% CI)**
Total Weekday	54.44	52.60	52.30	55.09	48.83	44.74	2.41 (-5.04, 9.86)	11.66 (5.25, 18.07) *
Around School	13.83	15.08	15.71	11.82	12.22	12.00	0.38 (-2.82, 3.58)	3.35 (-0.39, 7.09)
During School	23.04	20.12	20.18	22.83	19.00	18.36	0.7 (-2.30, 3.70)	3.07 (-1.01, 7.15)
After School	14.00	13.56	13.07	17.51	14.55	11.98	0.25 (-3.73, 4.23)	2.7 (-1.63, 7.03)

Note. * Significant intervention effect from baseline to 2 year follow-up (P<0.05)

6.4.3 Interaction Effects

Significant intervention effects were apparent for OWOB participants but not NW in the Around School period at both one year and two year follow-up. In all time periods with the exception of the Around School period (i.e. Total Weekday, During School, and After School) intervention effects were evident for participants with low VO_{2max} but not participants with high VO_{2max}. At two year follow-up significant intervention effects for Total Weekday MVPA were evident for females but not males, and older participants (i.e. participants in the top 50% for their age [aged 12.8 - 14.3 years] relative to the sample).

Table 6.3. Significant 1Year Follow-Up intervention subgroup interactions

	Total Weekday		Around School		During School		After School	
Interactions	**β (95% CI)**	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**
Intervention*Gender	3.38 (-9.52, 16.28)	0.61	3.46 (-2.05, 8.97)	0.22	1.27 (-4.08, 6.62)	0.64	-1.04 (-8.43, 6.35)	0.78
Males	n/a	-	n/a	-	n/a	-	n/a	-
Females	n/a	-	n/a	-	n/a	-	n/a	-
Intervention*Age	2.67 (-8.64, 13.98)	0.65	2.29 (-2.12, 6.70)	0.31	2.03 (-2.07, 6.13)	0.33	-2.37 (-9.39, 4.65)	0.51
Low Age	n/a	-	n/a	-	n/a	-	n/a	-
High Age	n/a	-	n/a	-	n/a	-	n/a	-
Intervention*Weight Status	4.58 (-6.67, 15.83)	0.42	**6.91 (2.75, 11.07)**	**0.001**	1.74 (-2.30, 5.78)	0.40	-4.86 (-11.97, 2.25)	0.20
NW	n/a	-	-1.95 (-5.01, 1.11)	0.21	n/a	-	n/a	-
OWOB	n/a	-	**4.18 (2.63, 6.81)**	**0.01**	n/a	-	n/a	-
Intervention*FMS levels	-0.11 (-0.72, 0.50)	0.72	0.06 (-0.18, 0.30)	0.62	0.07 (-0.15, 0.29)	0.53	-0.23 (-0.60, 0.14)	0.23
Low FMS	n/a	-	n/a	-	n/a	-	n/a	-
High FMS	n/a	-	n/a	-	n/a	-	n/a	-
Intervention** VO_{2max} **levels	-0.08 (-0.75, 0.59)	0.81	-0.16 (-0.43, 0.11)	0.25	0.01 (-0.24, 0.26)	0.92	0.09 (-0.32, 0.50)	0.67
Low VO_{2max}	n/a	-	n/a	-	n/a	-	n/a	-
High VO_{2max}	n/a	-	n/a	-	n/a	-	n/a	-

Note. NW=Normal Weight, OWOB=Overweight and Obese, Low Age=bottom 50% in age bracket, High Age=top 50% in age bracket, LowVO_{2max}=bottom 50% in VO_{2max} score, High VO_{2max}=top 50% in VO_{2max} score.

- Crude analyses (adjusted for interaction term, group, and baseline value of the outcome measure) of interaction terms to evaluate potential effect modification are shown.
- Where these were significant, stratified analysis for each modifier was conducted with the results for each effect modifier shown (e.g. for gender, males and females results are reported). Values in bold denote beta (95% CI) and significance values of outcomes with significant intervention effects (P<0.10).

Table 6.4. Significant 2 Year Follow-Up intervention subgroup interactions

	Total Weekday		Around School		During School		After School	
Interactions	**β (95% CI)**	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**
Intervention*Gender	**11.68 (-0.83, 24.19)**	**0.07**	1.72 (-3.55, 6.99)	0.52	4.43 (-2.10, 10.96)	0.18	5.24 (-3.52, 14.00)	0.24
Males	2.23 (-12.47, 16.93)	0.76	n/a	-	n/a	-	n/a	-
Females	**12.93 (7.52, 18.34)**	**<0.0001**	n/a	-	n/a	-	n/a	-
Intervention*Age	**12.89 (-0.99, 22.61)**	**0.07**	4.04 (-1.53, 9.61)	0.16	3.21 (-2.36, 8.78)	0.26	3.25 (-5.69, 12.19)	0.48
Low Age	3.30 (-3.76, 10.36)	0.36	n/a	-	n/a	-	n/a	-
High Age	**14.80 (5.57, 24.03)**	**0.002**	n/a	-	n/a	-	n/a	-
Intervention*Weight Status	8.73 (-5.09, 22.55)	0.22	**7.18 (1.54, 12.83)**	**0.01**	1.55 (-3.92, 7.02)	0.58	-2.01 (-11.05, 7.03)	0.66
NW	n/a	-	0.35 (-2.49, 3.19)	0.81	n/a	-	n/a	-
OWOB	n/a	-	**4.73 (0.97, 8.49)**	**0.01**	n/a	-	n/a	-
Intervention*FMS levels	-0.21 (-0.96, 0.54)	0.58	-0.21 (-0.50, 0.08)	0.16	-0.02 (-0.31, 0.27)	0.89	-0.12 (-0.61, 0.37)	0.63
Low FMS	n/a	-	n/a	-	n/a	-	n/a	-
High FMS	n/a	-	n/a	-	n/a	-	n/a	-
Intervention* VO_{2max} levels	**-1.23 (-2.03, -0.43)**	**0.003**	-0.22 (-0.53, 0.09)	0.17	**-0.45 (-0.78, -0.12)**	**0.01**	**-0.53 (-1.04, -0.02)**	**0.04**
Low VO_{2max}	**13.43 (6.81, 20.06)**	**<0.0001**	n/a	**-**	**4.83 (1.69, 7.97)**	**0.003**	**2.69 (-0.74, 6.12)**	**0.12**
High VO_{2max}	2.88 (-6.88, 12.64)	0.56	n/a	-	-0.88 (-4.23, 2.47)	0.87	-0.76 (-7.80, 6.28)	0.83

Note. NW=Normal Weight, OWOB=Overweight and Obese, Low Age=bottom 50% in age bracket, High Age=top 50% in age bracket, LowVO_{2max}=bottom 50% in VO_{2max} score, High VO_{2max}=top 50% in VO_{2max} score.

- Crude analyses (adjusted for interaction term, group, and baseline value of the outcome measure) of interaction terms to evaluate potential effect modification are shown.
- Where these were significant, stratified analysis for each modifier was conducted with the results for each effect modifier shown (e.g. for gender, males and females results are reported). Values in bold denote beta (95% CI) and significance values of outcomes with significant intervention effects (P<0.10).

Table 6.5. Mean minutes in MVPA presented for each significant interaction term stratified for each modifier

Interaction Term			Intervention Baseline	Intervention 1 Year Follow-Up	Intervention 2 Year Follow-Up	Control Baseline	Control 1 Year Follow-Up	Control 2 Year Follow-Up
Weight Status	**Around School**	NW	13.95	13.50	13.59	11.80	13.56	12.25
		OWOB	15.22	**16.59•**	22.30	10.97	11.36	**10.77***
Age	**Total Weekday**	Low	55.91	52.42	48.55	54.48	47.91	45.93
		High	53.03	52.79	**55.97***	55.77	50.17	43.35
VO_{2max}	**Total Weekday**	Low	51.92	49.48	**50.74***	49.90	45.41	38.84
		High	56.40	55.40	53.88	60.31	52.67	52.18
	After School	Low	13.24	11.80	**11.38***	14.56	14.15	8.86
		High	14.58	15.14	14.79	20.47	15.01	15.90
	During School	Low	21.45	18.52	**19.63***	21.83	17.14	16.23
		High	24.27	21.55	20.75	23.84	21.08	21.05
Gender	**Total Weekday**	Males	56.18	55.56	54.90	61.24	56.31	57.43
		Females	53.34	50.06	**50.13***	46.68	42.48	37.66

Note. NW=Normal Weight, OWOB=Overweight and Obese, Low Age=bottom 50% in age bracket, High Age=top 50% in age bracket, Low VO_{2max}=bottom 50% in VO_{2max} score, High VO_{2max}=top 50% in VO_{2max} score.
• Significant intervention effect from baseline to 1 year follow-up (P<0.10)
* Significant intervention effect from baseline to 2 year follow-up (P<0.10)

6.5 Discussion

The Y-PATH intervention was effective at attenuating the decline in MVPA promoting increases in PA behaviour over a two year time period (Table 6.2). Positive intervention effects were observed for Total Weekday MVPA from baseline to two year follow-up, suggesting it is possible to affect daily MVPA through a school-based multi-component intervention. As previously discussed, the Y-PATH intervention aims to increase overall PA behaviour through educating youth on the importance of being physically active, creating a motivational co-operative climate in PE class, and focusing on the self-efficacy, attitudes and beliefs of the student (Belton et al., 2014). The findings of this study support the efficacy of the Y-PATH intervention in reducing the decline in MVPA over a two year time period. At two year follow-up the significant age related decline in MVPA typical in adolescence is not observed in intervention participants (54.44 minutes baseline, 52.60 minutes at 1 year follow-up, 52.30 minutes at 2 year follow-up). Control participants however exhibit the expected age related decline, with time spent in MVPA during the Total Weekday period decreasing from 55.09 minutes at baseline to 48.83 minutes at one year follow-up, and 44.74 minutes at two year follow-up (see Table 6.2). The findings of this study provide encouraging evidence for the Y-PATH intervention as a model for contributing positively towards and sustaining Total Weekday MVPA in early adolescence.

Significant intervention effects were not observed between baseline and one year follow-up for any time periods (i.e. Total Weekday, Around School, During School, or After School), or between baseline and two year follow-up for any of the specific day periods (Around School, During School or After School) (Table 6.1). This could in part be explained by the inability of a generic PA intervention targeting overall PA, to influence specific time periods; and it should be noted that this was not the targeted purpose of the Y-PATH intervention. Belton et al. (2016), who carried out their analysis on the baseline sample of participants in this study, advocate for gender and time period specific intervention strategies to affect change in weekday and weekend time periods and subsequently overall PA behaviour. The findings of the current analysis provide support for Belton's recommendation (2016), as perhaps the Y-PATH intervention was not specific enough to target individual time periods, hence its efficacy in influencing Total Weekday MVPA overall, but not specific time periods. It is possible that the intervention effect may be further enhanced by the inclusion of specific strategies to target the After School period in the Y-PATH intervention, as suggested by Belton et al. (2016).

Physical activity is a complex multi-faceted behaviour which is influenced by several factors (Ward et al., 2007). The complex nature of PA may in part explain why the effect of the Y-PATH intervention was not evident after the first year of implementation. The Y-PATH intervention seeks to improve PA levels and FMS proficiency such as running, skipping and jumping, simultaneously. Stodden et al. (2008) proposed a conceptual framework of mechanisms that may influence and mediate PA levels, suggesting a 'positive spiral of engagement' exists between PA and FMS. Skilled children, according to this theory, are more likely to participate in more PA and further develop their skills (Stodden et al., 2008). It is possible that skill development may initially take precedent, and only result in increased PA participation once increased skills have been established and this positive spiral takes hold. Preliminary analysis conducted on the FMS component of this Y-PATH study suggest increases in FMS competency were observed at one year follow-up, which supports this suggestion. Hence, skills proficiency could provide the foundations for continued increases in PA behaviour in the long-term, suggesting not only the importance of PA participation but a continuing focus on skills development in youth.

Interaction analyses highlighted that the intervention effect was significant for participants with low VO_{2max} levels at two year follow-up (Table 6.4) during all time periods (i.e. Total Weekday, During School and After School) except the Around School period. Youth who have lower VO_{2max} levels have reduced aerobic capacity and hence limited ability to participate in PA. Potentially participants with low VO_{2max} levels were especially receptive to the Y-PATH intervention as educational prompts on the health benefits of PA provided the knowledge to encourage participation in addition to the provision of pathways into PA, subsequently resulting in increases in PA levels. It is probable also that the motivational climate fostered in Y-PATH PE catered better for the needs of this group, with previous research showing competitive PE class to be a barrier to participation first and foremost for the least active youth (Belton et al., 2014).

Significant intervention effects were observed for OWOB participants at both one year follow-up and two year follow-up in the Around School period (Table 6.3 and Table 6.4). Considering that in Ireland 2,000 deaths are attributed annually to obesity (The Report of the National Taskforce on Obesity, 2005), this finding suggests the Y-PATH intervention was effective in the Around School period for the youth at most risk of poor health i.e. OWOB adolescents. Ensuring this cohort of OWOB adolescents participate in PA is essential, as leading a physically active lifestyle is known to reduce the prevalence of obesity and hence alleviate the financial cost associated (Pratt, Norris, Lobelo, Roux, & Wang, 2014). This finding suggests Y-PATH provides a pathway for reinforcing and promoting PA behaviour in OWOB adolescents (particularly in the After School period), which results in sustained positive changes in PA levels, and which could potentially affect weight status. The intervention effect observed in OWOB participants during the Around School period may partly be explained by the whole-school approach to the provision of extra-curricular PA. Also encouraging engagement in accessible PA before and after school such as actively commuting may have contributed to the intervention effect identified during this period (8 - 10am and 4 - 5pm i.e. periods before and directly after school).

Total Weekday intervention effects at two year follow-up were evident for females (Table 6.4). The Y-PATH intervention focuses on providing choice in PE class, and moving from competitive sports traditionally associated with PE towards co-operative activities (Belton et al., 2014). Gender specific cultural expectations suggest males participate more often in competitive games and sports, whereas females are more likely to respond to (and develop through) co-operative activities such as dance and gymnastics (Okely & Booth, 2004). Considering the co-operative nature of Y-PATH PE, as opposed to the traditional competitive male oriented climate, there is an underlying focus on encouraging female participation which may explain the intervention effect observed for females in the Total Weekday period (Belton et al., 2016). The findings of this study confirm the efficacy of the Y-PATH intervention in improving Total Weekday MVPA in females (Table 6.3). This is a significant finding as bridging the gender inequality in PA participation is of urgent national and international concern (Troiano et al., 2008; Woods et al., 2010).

Total Weekday intervention effects at two year follow-up were also found for older participants (Table 6.4). This finding is unusual and difficult to interpret given the arbitrary categorisation of age into oldest and youngest. The Y-PATH intervention incorporates a focus on the development of positive predisposing factors for PA engagement namely self-efficacy, attitude and beliefs (Belton et al., 2014). The understanding, processing and internalising of these elements may require more sophisticated cognitive function which develops with age. Older participants were on average 0.67 years older than their younger counterparts, which is a substantial difference during this stage in adolescent cognitive and physical maturation, hence this could be one potential reason for the significant intervention effect found in older adolescents in the Total Weekday period.

6.6 Strengths and Limitations

Study strengths include the high participant consent rate at baseline (94%) which helped minimise the risk of sampling bias. The paired-randomisation of schools between control and intervention based on a set list of criteria (e.g. school size, facilities) also reduced the likelihood of sampling bias. The statistical analysis used can be considered a study strength as it accounted for the fact that students are nested in the schools. The intervention was informed by research findings (Belton et al., 2014) and developed in collaboration with local stakeholders. The intervention content was previously piloted and deemed appropriate for the population with exploratory trial results providing preliminary findings suggesting the effectiveness of the Y-PATH intervention (O'Brien et al., 2013). The longitudinal tracking of this adolescent cohort across two school years, where PE is compulsory for all students, is considered a substantial study strength considering most interventions only evaluate their effectiveness over a short period of time. The use of an objective measure of PA may also be considered a study strength, as well as the ability to control for several covariates of PA (gender, age, height and weight, FMS and VO_{2max}) because of a rigorous data collection protocol.

Due to fiscal limitations, data at two year follow-up could only be collected from half of the original schools (n = 10) which may be considered a limitation of the study. All intervention teachers received the same resources and training, however given the flexible nature of the Y-PATH intervention and the dynamic and varied nature of the 10 intervention schools, each teacher and school varied in their approach to the lessons which may have influenced the results observed.

6.7 Conclusions and Implications

This study highlights that the Y-PATH multi-component school-based intervention resulted in significant long-term effects on Total Weekday MVPA. Y-PATH was most effective in participants with low VO_{2max} at two year follow-up across all periods of the day with the exception of the Around School period. The Y-PATH intervention has also proven to be effective in the Around School period for OWOB participants at both one year and two year follow-up. The intervention was effective in females and older participants, on Total Weekday MVPA at two year follow-up. This suggests that throughout different time periods in the day the Y-PATH intervention is effective for the adolescents at most risk of inactivity; those who are OWOB, demonstrate low aerobic capacity, and females. Y-PATH and other similar school-based interventions may benefit from including targeted strategies to increase PA behaviour in specific time periods when inactive youth are most inactive. Future research should evaluate the efficacy of such strategies. More longitudinal research is also warranted to evaluate the intervention effect over a longer duration of time (for example across the six post-primary school years) to determine whether the observed halt of the age related decline in PA is retained over the entire second level school cycle. The efficacy of the Y-PATH intervention was established for Weekday MVPA. Future research should include Weekend MVPA, to identify the overall efficacy of the Y-PATH intervention in improving MVPA. Finally, the inclusion of robust process evaluation strategies is warranted in future research, as they would have assisted in explaining the outcome effectiveness of the intervention. Future research should seek to identify the intervention implementation fidelity of each school, in an attempt to further understand the outcome effectiveness findings.

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Chapter 7

Overview and Discussion of Thesis

7.1 Overview of Thesis

The longitudinal evaluation of the efficacy of the Youth-Physical Activity Towards Health (Y-PATH) intervention in increasing physical activity (PA) levels was the main objective of this thesis. It also provided the opportunity to examine PA and its correlates in adolescent youth. According to Woods and colleagues (2010) Irish adolescents are insufficiently active with just 12% of 12 to 18 year olds self-reporting to meet the 60 minute PA guideline. O' Brien and colleagues (2015) also identified low FMS proficiency levels in Irish youth. Given the association between PA levels and FMS proficiency, it can be hypothesised that low levels of FMS observed can potentially have a knock on effect of PA participation (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; O'Brien, Issartel, & Belton, 2013). Interventions seeking to address the low levels of PA observed globally have been advocated for by the World Health Organisation (Currie et al., 2012). Strategic advice for improving Irish adolescent PA levels provided by the 'Children's Sport Participation and Physical Activity' (CSPPA) study suggest the development of fundamental motor skills will ultimately provide pathways to PA participation (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010). Hence the development, implementation and evaluation of an intervention targeting PA and FMS simultaneously was justified.

During the development process of a targeted PA intervention careful consideration must be given to the known and potential correlates of PA, in order to effectively intervene. In a study conducted by Belton and colleagues (2014) self-efficacy, attitudes, perceptions of health, and perceived barriers were found to determine PA participation, hence their inclusion in tailored PA interventions. From this evidence base the Y-PATH intervention was developed. This intervention aimed to provide a cost effective low maintenance youth PA intervention (Belton et al., 2014). The Y-PATH intervention as guided by the Youth Physical Activity Promotion (YPAP) model (Welk, 1999) aims to: i) improve low locomotor and object control FMS levels, ii) develop positive predisposing factors for engagement in PA such as self-efficacy and attitude, iii) provide choice in physical education (PE) lessons, and iv) educate adolescents on the health benefits associated with PA participation (Belton et al., 2014). As a first step, the efficacy of the Y-PATH intervention was evaluated in an exploratory trial where positive results were observed with increases in youth PA levels and FMS proficiency (O'Brien, Issartel, & Belton, 2013). This thesis sought to identify if the results observed by O'Brien and colleagues (2013) were reproducible on a larger scale study.

The Medical Research Council (MRC - Campbell et al., 2000) proposes a framework for the design and evaluation of complex interventions. According to these guidelines following an exploratory trial (as described above) which has compared the intervention with an alternative (i.e. control group), a definitive randomised controlled trial (RCT) should be conducted to compare a fully defined intervention with a control condition in an attempt to identify if the intervention is reproducible and defensible when implemented with appropriate statistical power (Campbell et al., 2000).

The thesis content and direction was introduced in Chapter 1, including an outline of the research questions. Chapter 2 provided a thorough review of the relevant literature regarding PA, FMS and interventions, which provided the rationale for the studies conducted in Chapter 3 to 6. Chapters 3 and 4 aimed to develop our understanding of the relationship between PA and FMS, in addition to the correlates and mediators of this relationship. With better understanding comes the ability to further tailor targeted interventions which may have a greater capacity to be effective. More specifically, in Chapter 3 one of the key gaps identified in the literature in the area of FMS is the suggested reciprocal relationship between FMS and PA, and also the mediators of this relationship (Robinson et al., 2015). According to Stoddens (2008) conceptual framework of mechanisms influencing and mediating PA levels, the relationship between PA and FMS is reciprocal and demonstrates a 'positive spiral of engagement'. This suggests that children who are skilled are more likely to participate in PA and hence have greater opportunities to further develop their skills, which provides greater motivation and ability to be active (Stodden et al., 2008). Barnett and colleagues (2011) went some way in exploring the reciprocal relationship between FMS and PA in a cohort of 16 year olds. Their findings suggest a reciprocal relationship exists between PA and object control only (Barnett, Morgan, Van Beurden, Ball, & Lubans, 2011). Stodden and colleagues situated health-related fitness (HRF) as a mediating variable between FMS competence and PA behaviour (Stodden et al., 2008). In theory this suggests that youth with higher levels of HRF have greater aerobic capacity, and hence the ability to participate in prolonged bouts of PA and subsequently refine their skills, rather than (or in addition to) the reverse. Findings of Khodaverdi and colleagues (2015) suggest HRF (aerobic fitness) mediates the relationship between FMS (locomotor composite) and PA in children. Chapter 3 aimed to identify whether a reciprocal relationship exists between PA and FMS (overall and composite subtests i.e. object control and locomotor) and investigate the role of HRF as a mediator in this association. The findings of Chapter 3 provide support for the hypothesised reciprocal relationship between PA and FMS, and the HRF mediating pathway (Stodden et al., 2008).

The findings suggest that FMS competence, PA levels and HRF are operating as interlocking determinants of each other. Therefore, those children who do not demonstrate adequate skill acquisition in childhood are at risk of a negative PA trajectory in adolescence and reduced fitness levels. The findings support the concept of a 'positive feedback loop' (Stodden et al., 2008), which means targeting both PA levels and FMS competence simultaneously is likely to have a greater impact on encouraging lifelong PA participation (Hulteen et al., 2015) than targeting either individually. Also, as HRF has proven to play an important role in mediating the reciprocal relationship between PA and FMS, interventions seeking to see increases in either or both variables, should also focus on increasing HRF levels. It should be noted however that the direct role of this variable within the Stodden model has yet to be tested, and is something that future research studies should investigate.

Chapter 4 went further in an attempt to progress our understanding of FMS and its potential correlates. Through developing greater understanding of the correlates of FMS, efforts to improve FMS competence can be more specified and hence effective. According to Barnett et al. (2016) biological and demographic correlates as well as behavioural correlates such as PA are most commonly explored in relation to FMS. Few studies have explored the cognitive, emotional and psychological factors, cultural and social factors, or physical environment factors which may help explain FMS development (Barnett et al., 2016). Considering the association between PA and FMS, it was hypothesised that the psychological and psychosocial correlates associated with PA also apply to FMS proficiency. This study therefore examined frequently investigated PA correlates (PA self-efficacy, barriers to PA, and social support) in relation to FMS proficiency, and investigated the role of PA as a mediator of these relationships. The findings suggest that correlates traditionally associated with PA are not associated with FMS proficiency, but that PA acted as a mediator between self-efficacy and FMS, and social support and FMS. Considering this mediating role PA plays, as well as the direct association reported between PA and FMS, directly targeting PA when aiming to improve FMS proficiency is recommended. Targeting PA self-efficacy and social support is also worthwhile as it will result in improvements in PA levels, which in turn affects FMS proficiency given the role of PA as a mediator. This provides further support for the importance of targeting PA and FMS simultaneously. Hence, if seeking to increase FMS proficiency, directly targeting PA participation is recommended, and vice versa.

The case for increasing PA participation has been widely recognised given the associated health benefits (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010) and precedence of low PA levels globally (Hallal, Andersen, Bull, Guthold, & Haskell, 2012). A positive relationship between PA and FMS has consistently been identified in the literature (Lubans et al., 2010). The development of FMS is a prerequisite for more sports specific skills necessary for lifelong PA participation (Gallahue & Ozmun, 2006). This suggests a clear rationale for the need to improve FMS proficiency. Chapter 3 and 4 presented new findings supporting the need to increase PA participation in view of its reciprocal relationship with FMS and its composites (object control and locomotor) as well as the efficacy of its mediating role between FMS and psychological and psychosocial variables. Although it is accepted that increases in PA levels are essential, outside the remit of habitual PA participation and total minutes of PA, little is known in terms of daily patterns of PA, and specifically whether time periods differ in terms of when the 'most active' youths are active compared to the 'less' active (Belton, O'Brien, Issartel, McGrane, & Powell, 2016). Chapter 5 used baseline RCT data to investigate daily patterns of PA behaviour in adolescents on weekdays and weekend days (Belton et al., 2016). This analysis also aimed to determine whether daily patterns of PA differed across time periods, gender, and activity level, and to consider how this information could be used to guide future intervention strategies. The findings from Chapter 5 suggest males are more active than females, with both genders failing to meet the PA guideline. Weekday and weekend PA behaviour both grouped into three distinct time components. The 'most' active participants were more active in the Afterschool, Weekend Midday and Afternoon periods. Hence, the findings of Chapter 5 suggest PA interventions should specifically target the Afterschool, Weekend Midday and Afternoon periods. The findings of Chapter 5 suggest it may be beneficial to develop specific interventions which target these time periods outside of the school environment. Interventions of this nature however tend to be costly, require large volumes of man-power and resources, and hence are often not sustainable such as the school-based obesity programme implemented by Warren and colleagues (2003). A generic PA intervention with the ability to improve PA across all time periods would be more cost effective than the development of several targeted interventions. Hence testing the efficacy of a generic PA intervention during these time periods is warranted.

The Y-PATH intervention is a multi-component school-based intervention which takes a whole-school approach towards the promotion of activity in youth. The delivery of the Y-PATH intervention occurs through the educational medium of prescribed health-related activity (HRA) with a focus on FMS, aiming to increase PA levels and impact public health. Results of the evaluation of the efficacy of the Y-PATH intervention over a two year period in improving and sustaining PA levels in youth across all school day time periods (i.e. Total Weekday, Around School, During School, and After School) are presented in Chapter 6. This analysis also sought to identify whether differences in intervention effect by subgroup (gender, weight status, FMS level, VO_{2max} level) existed, in an attempt to identify specific individuals for which the Y-PATH intervention was most effective. Results show that the Y-PATH multi-component schools-based intervention resulted in significant long-term effects on Total Weekday moderate to vigorous PA (MVPA). Throughout different time periods in the school day the Y-PATH intervention is effective for the most at risk adolescents in the population, namely i) those who are overweight and obese, ii) those with low aerobic capacity, and iii) the least active gender (i.e. female). Y-PATH and other similar school-based interventions may benefit from including targeted strategies focusing on at risk populations and aimed at increasing PA behaviour in specific time periods when inactive youth are most inactive. Prior to discussing the future directions of the Y-PATH research programme in more detail, it is important to note the strengths, and limitations of the study which despite researcher rigor, were outside of their control.

7.2 Research Strengths

Results from this thesis inform the reader about a variety of themes encompassing youth PA participation including FMS proficiency, psychological variables and psychosocial, HRF, mediators of the relationship between PA and FMS, patterns of PA behaviour and the role of targeted PA interventions in improving PA behaviour. The Y-PATH intervention provides strong evidence for the targeted promotion of PA and FMS, and also provides a tested and validated multi-component school-based intervention with a specialised PE programme component, which has proven to influence PA behaviour and understanding of health-related factors in youths.

A major strength of this research are the measurement tools utilised. Objectively measured PA was used in order to obtain a clear insight into youth habitual PA behaviour. A very comprehensive battery of FMS testing was also conducted with 15 skills tested at all three time points. This data has been collected in line with stringent testing protocol, and carried out by trained researchers who underwent rigorous training prior to testing and analysis. The use of validated questionnaires to assess the psychological and psychosocial determinants of PA participation was also a study. Measures aimed to identify perceived barriers to PA, perceived benefits of PA, social support for PA, PA self-efficacy, physical self-confidence and basic psychological needs and motivation towards PE. Some of this data has formed the basis of this thesis and aided in the development of our understanding of PA participation and FMS proficiency.

In addition to the extensive array of variables measured in this study, another strength is the tracking of these variables across three time points in a large sample of Irish adolescents. Much research has investigated the efficacy of interventions over short time frames; however few look at the longitudinal intervention effect over one year and two year follow-up.

The use of a number of robust strategies to ensure accelerometer compliance (Belton, O' Brien, Wickel, & Issartel, 2013) is also considered a study strength: i) students were met in the morning of each school day to ascertain compliance with the wear instructions, ii) an optional SMS reminder text was sent before and after school, iii) teachers in each school checked whether or not participants were wearing their monitors each school day, iv) all students were advised to place reminders to wear monitors in noticeable areas in their homes, v) a record card was provided for recording periods of non-wear and vi) students who were compliant with the wear-time inclusion criteria, entered a class draw for a €20 sports voucher (per class). Few studies use the number of extensive compliance strategies observed in this study.

A further strength of this study is the sophisticated statistical analysis used. The use of principal components analysis by the lead author in Chapter 5 revealed distinct Weekday and Weekend time components where PA behaviour patterns in adolescents. Using hour by hour PA was exceptionally stringent considering previous research traditionally uses overall minutes (Currie et al., 2012; Eaton, Kann, & Kinchen, 2012). Also the use of multi-level modelling analyses was a study strength as it accounted for the students being nested in the schools, where other statistical analysis such as repeated measures ANOVAs would not.

The evaluation of the Y-PATH intervention has followed the MRC guidelines (2000), which is a further strength of the research process of this thesis. In addition the CONSORT guidelines were adhered to.

7.3 Research Limitations

1. *Physical Activity Compliance:* Across all time points compliance in wearing the monitor was a limitation of this study. Despite the use of several compliance strategies, as described in the previous section, substantial amounts of data were lost due to non-compliance. The strategies employed were extremely time consuming and required substantial man-power, yet failed to achieve optimum compliance levels. Perhaps future research should use incentives which are more meaningful to the participants, as raffles for €20 vouchers did not seem to encourage the current generation of youth. It is important to bear in mind that Y-PATH was intended to be a cost efficient intervention and so did not have the financial capacity to offer any further incentives. Also due to ethical regulations, it is not permitted to provide financial remuneration to subjects for participating in any study carried out under the Dublin City University banner.
2. *Accelerometer Inclusion Criteria:* The stringent inclusion criteria (wear-time, number of valid weekdays and weekend days etc) used in Chapter 3 to 5 (3 valid weekdays and 1 weekend day, and 10 hours recorded wear-time) was a study strength. It did however result in a smaller sample size. As a result the inclusion criteria had to be reconsidered when dealing with longitudinal data. Less stringent criteria was subsequently applied (2 valid weekdays, and 8 hours recorded wear-time) when processing longitudinal data to ensure an adequate sample was included, from which conclusions could be drawn regarding the effect of the Y-PATH intervention.
3. *Fundamental Movement Skills:* FMS were measured using the TGMD-2. This measurement tool was designed to measure gross motor development in children aged three to 10 years (Ulrich, 2000). Its validity (content and concurrent) and reliability has been long since established in this child cohort (content validity = acceptable; concurrent validity: total scores = 0.63, locomotion = 0.63 and object control = 0.41; test-retest reliability = 0.88 - 0.96), however the Y-PATH study sampled adolescents aged 12 to 16

years; hence the use of the TGMD-2 may be considered a limitation. The purpose of using the TGMD-2 in this study was to give a measure of FMS proficiency, as opposed to for comparison purposes against pre-determined norms. A validation article for this specific age group, conducted by the Y-PATH research time, is currently under-review but could not be included in this PhD.

4. *Incomplete Data across Multiple Variables:* The data analysis conducted in Chapter 3 and Chapter 4 required complete data for all variables tested. As a lot of variables were collected and subsequently analysed in these chapters, inevitably some were missing for some people due to absenteeism or injuries, and as such our available sample was reduced.
5. *Efficacy of the Y-PATH Intervention:* The Y-PATH intervention was proven effective in Chapter 6, at attenuating the decline in Total Weekday MVPA at two year follow-up. There is however the possibility that adolescents may compensate for the intervention effect observed by doing less PA at the weekends. Evaluating the Y-PATH intervention across the entire week, including a weekend day, is essential to ensure that this is not the case.

7.4 Future Directions for Y-PATH

- Results of this study suggest that the Y-PATH intervention is effective at attenuating the decline in Total Weekday PA levels of adolescents. Future analysis on the Y-PATH study should seek to identify the intervention effect on overall PA (including weekend activity) and the full range of variables for which data was collected (fitness, BMI, and psychological and psychosocial variables). In addition the overall interaction of all of these variables with each other, PA, and FMS, should be considered. Potentially elements of the psychological and psychosocial variables could provide explanation as to why the intervention was effective for certain subgroups and not others, thus providing rich information on specific at risk individuals that need to be targeted by interventions.
- The Y-PATH intervention tested FMS using the Test for Gross Motor Development-2 (TGMD-2). As mastery of FMS is expected to be achieved by age 10, there is currently no valid assessment tool for use in an adolescent population. Future research should seek to address this issue by validating the TGMD-2 or other instrument for use with older children and adolescents. The Y-PATH research team currently has a validation article for this specific age group under-review but it could not be included in this PhD.
- This thesis used objectively measured PA (accelerometry) in all studies. Despite stringent compliance strategies, there was a substantial decrease in sample size due to a lack of compliance. Less stringent accelerometer inclusion criteria had to be used in Chapter 6, in order to have an adequate sample size. Future studies should investigate why youth fail to wear the monitors and whether wrist worn monitors may be a better alternative with the aim to find appropriate solutions to this issue.

- The Y-PATH intervention is currently a two year programme. The second year of the intervention was designed and implemented as part of this thesis. Irish Junior Cycle PE runs from 1st to 3rd year with students aged from 12 to 15 years. It is therefore advisable to develop a 3rd year of the Y-PATH intervention to allow the implementation of Y-PATH across all Junior Cycle years.
- To date, Y-PATH has solely been implemented and evaluated in mixed-gender schools (the exploratory trial and RCT). Given the cultural context in Ireland, the prevalence of single-gender schools is high (33% of post-primary schools). Evaluating the intervention effect of the Y-PATH programme in single-gender schools is warranted to confirm the generalisability and transferability of the positive Y-PATH findings to date, to different school contexts.
- Independent of research, it is essential that the Y-PATH intervention be disseminated in line with the MRC framework to mixed-gender schools as it has been proven to work in improving Weekday MVPA. Dissemination will identify if the intervention can be sustained and effective without researcher input, which is the long-term goal.
- Y-PATH as a generic school-based PA and FMS intervention has proven to be effective in halting the age related decline in PA in adolescents. Within the adolescent population there are however many subgroups such as those with special educational needs, and individuals of low social economic status. Future research should seek to examine the success of this intervention in specific cohorts within the population, and identify potential adaptations which may assist in the transferability of Y-PATH across the populace.

7.5 Closure

The PhD Journey

The primary purpose of this thesis was to evaluate the efficacy of Y-PATH, a school-based multi-component intervention, in improving school day physical activity behaviour. Chapter 6 detailed the success of Y-PATH in improving Total Weekday MVPA from baseline to two year follow-up in the intervention group. Y-PATH was effective for the most at risk adolescents in the population, namely i) those who are overweight and obese, ii) those with low aerobic capacity, and iii) the more inactive gender (i.e. female). However, in the wise words of Ernest Hemingway, *'It is good to have an end to journey toward; but it is the journey that matters, in the end'*. Along the journey many valuable lessons were learned in relation to PA behaviour and FMS proficiency, which addressed gaps in the literature and will inform future interventions. This thesis provided support for the reciprocal relationship between PA and FMS, and the mediating role of HRF as shown in Chapter 3. Further importance was attributed to the role of PA when seeking to improve FMS proficiency in Chapter 4, as it was found to explain part of the relationship between FMS and PA self-efficacy and social support. Whilst Chapter 3 and 4 highlighted correlates and mediators which assist in our understanding of the relationship between PA and FMS, Chapter 5 offered strategic advice on specific time periods when researchers and practitioners should intervene. Chapter 6 completed the journey and identified the efficacy of the Y-PATH intervention during the specific time periods as proposed in Chapter 5.

'Difficult roads often lead to beautiful destinations' (Author Unknown). At times the PhD road was difficult and rocky. Throughout the PhD process I have been challenged to not only learn research skills, but life skills. The development, implementation and evaluation of a PA intervention is a complex process. Attempting to do this using a modest allocated

research budget, and sometimes limited resources, posed some difficulty but ultimately encouraged me to become a diligent, meticulous, conscientious and resourceful researcher while also increasing the chance for future national and international dissemination. The Y-PATH intervention has proven effective in improving PA levels in adolescents. With further development to a three year programme and dissemination, the Y-PATH intervention can go some way in addressing the inactivity epidemic. Indeed the destination is beautiful.

7.6 References

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<u>**Appendix A**</u>

Self-Efficacy, Barriers to Physical Activity, and Social Support Questionnaire

1. Self-Efficacy Questionnaire Y-PATH

1. Use the scale below (0-10) to indicate how confident you are to be physically active in each of the following situations.

0= Not at all confident
5= Somewhat confident
10= Very confident

I am confident that I can participate in regular physical activity when................

	0	1	2	3	4	5	6	7	8	9	10
I am tired	○	○	○	○	○	○	○	○	○	○	○
I am in a bad mood	○	○	○	○	○	○	○	○	○	○	○
I feel I don't have time	○	○	○	○	○	○	○	○	○	○	○
I am on vacation	○	○	○	○	○	○	○	○	○	○	○
It is raining or snowing	○	○	○	○	○	○	○	○	○	○	○
I have homework to do	○	○	○	○	○	○	○	○	○	○	○
My friends call me to go out	○	○	○	○	○	○	○	○	○	○	○
I need to do house chores	○	○	○	○	○	○	○	○	○	○	○
There is a good TV show on	○	○	○	○	○	○	○	○	○	○	○
I am on my own	○	○	○	○	○	○	○	○	○	○	○

2. Barriers to Physical Activity Questionnaire Y-PATH

1. Below are some reasons why people do NOT do physical activity.
Please show how much each statement is true for you.
Please tick ONE box for each line.

	Very true	Quite true	Not very true	Not at all true
I don't have enough time	◯	◯	◯	◯
It is difficult for me to get to places where I can do physical activities	◯	◯	◯	◯
I am not interested in physical activity	◯	◯	◯	◯
I would rather do other things with my time	◯	◯	◯	◯
I am not very good at physical activities	◯	◯	◯	◯
I don't have the right equipment	◯	◯	◯	◯
The weather is too bad	◯	◯	◯	◯
I feel embarrassed when I do physical activity	◯	◯	◯	◯
I have too much homework to do	◯	◯	◯	◯
I don't have the money	◯	◯	◯	◯
I don't have the right clothing	◯	◯	◯	◯

3. Social Support Questionnaire Y-PATH

1. During a typical week, how often: Please tick ONE box only per question

	None	Once	Sometimes	Almost every day	Every day
1) Do you encourage your friends to do physical activities or play sports?	○	○	○	○	○
2) Do your friends encourage you to do physical activities or play sports?	○	○	○	○	○
3) Do your friends do physical activities or play sports with you?	○	○	○	○	○
4) Do other kids tease you for not being good at physical activities or play sports with you?	○	○	○	○	○
5) Do friends tell you that you are doing well in physical activities or sports?	○	○	○	○	○

2. During a typical week, how often has a member of your household: Please tick ONE box only per question

	None	Once	Sometimes	Almost every day	Every day
1) Encouraged you to do physical activities or play sports?	○	○	○	○	○
2) Done a physical activity or played sports with you?	○	○	○	○	○
3) Provided transportation to a place where you can do physical activities or play sports?	○	○	○	○	○
4) Watched you participate in physical activities or sports?	○	○	○	○	○
5) Told you that you are doing well in physical activities or sports?	○	○	○	○	○

3. During a typical week, how often has a teacher in your school: Please tick ONE box only per question

	None	Once	Sometimes	Almost every day	Every day
1) Encouraged you to do physical activities or play sports?	○	○	○	○	○
2) Done a physical activity or played sports with you?	○	○	○	○	○
3) Provided transportation to a place where you can do physical activities or play sports?	○	○	○	○	○
4) Watched you participate in physical activities or sports (not including supervision)?	○	○	○	○	○
5) Told you that you are doing well in physical activities or sports?	○	○	○	○	○

<u>Appendix B</u>

Health-Related Activity Lesson 1-6 Year 1

HEALTH RELATED ACTIVITY
LESSON 1
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

"Low active students must believe that they can succeed in physical activity situations" – *Improve Self - Efficacy*

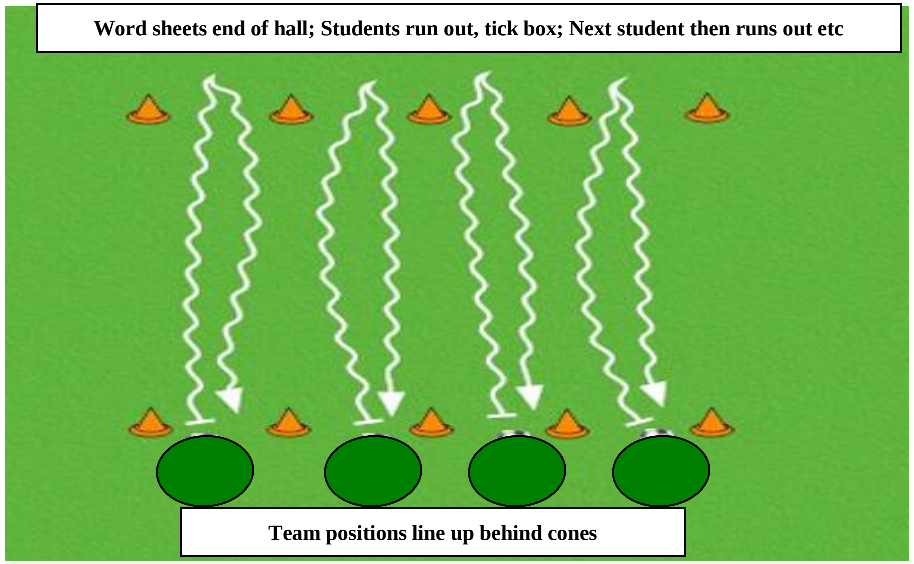
AIM: Teacher will introduce 1st year students to the general principles and guidelines associated with regular physical activity. It is important that the teacher creates a learning environment in which physical activity is attainable, fun and universal to each class member within the unit.

HRA Topic Lesson 1 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Health benefits of physical activity: *self esteem* *sense of well-being* *lifelong physical activity* 	Psychomotor: Engage in a variety of physical activities specific to individual, pair and teamwork challenges. Cognitive: Comprehend the importance of meeting the physical activity (PA) daily guidelines. Affective: Participate in class discussions and show ability to problem solve collectively.	Warm-Up (15 mins) 1.Team Challenge –Word Run *Principles and Guidelines of PA taught* – Progress Intensity. Development Stage 1 (10 mins) 2. Rats & Rabbits or alternative. *PA is fun, enjoyable and helps student make friends.* Development Stage 2 (20 mins) 3.Students exposed to 3 mins each of individual, pair, team and sedentary activities. *Students explore different types of activities.* Cool-Down (15 mins) 4.Thematic expression: students express the number "60" on the ground followed by PA Journal week 1. *Students lower heart rate (HR) through group reflection.*	Warm-Up: Teacher needs true / false statement sheet, word options sheets & pencils/pens. Development Stage 1: Cones or court markings for boundaries in rats & rabbits. Development Stage 2: Cones to divide 4 zones into individual, pair, team and sedentary areas. Writing paper and task card for sedentary task. Specific equipment for activities pending the teacher decision. Cool-Down: No equipment needed: maximum use of hall and space for final activity. PA journal week 1.	Teacher Assessment: Visually observe both child motor skill proficiency and activity engagement in lesson 1. Self-Assessment: Individual student must reflect upon content of lesson within the re-capitulation phases particularly during the cool – down activity. Peer Assessment: Students give feedback to each other during development stage 2 and the Cool-down activity. Homework: Fill out student physical activity journal week 1.

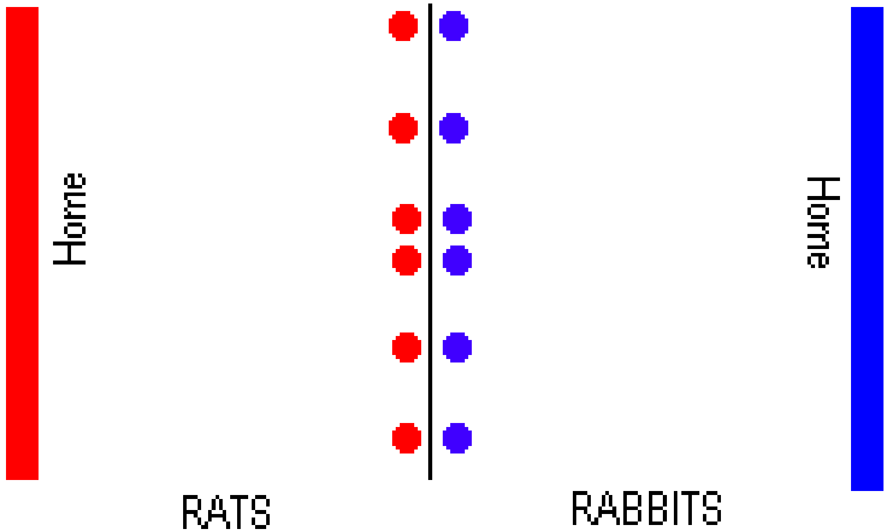
HEALTH RELATED ACTIVITY
LESSON 1
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

1. Team challenge: word run
"Run out to sheet on ground, tick box and return back"



2. Fun game: rats & rabbits
Teacher calls rats or rabbits; students then run to their zone



3. Individual, pair, team & sedentary activities
Students exposed to 3 minute activities including sedentary writing task

4. Thematic expression
Class challenge: represent number 60 on floor or alternative word if time

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HEALTH RELATED ACTIVITY
LESSON 2
School of Health & Human Performance, Dublin City University

Y-PATH
Youth - Physical Activity Towards Health

"Low active students must believe that they can succeed in physical activity situations" – <u>*Improve Self - Efficacy*</u>

AIM: Teacher will further enhance students' knowledge of the concept of physical activity. Teacher will strive to create a learning environment in which pupils can positively engage and adapt to the health related education lesson.

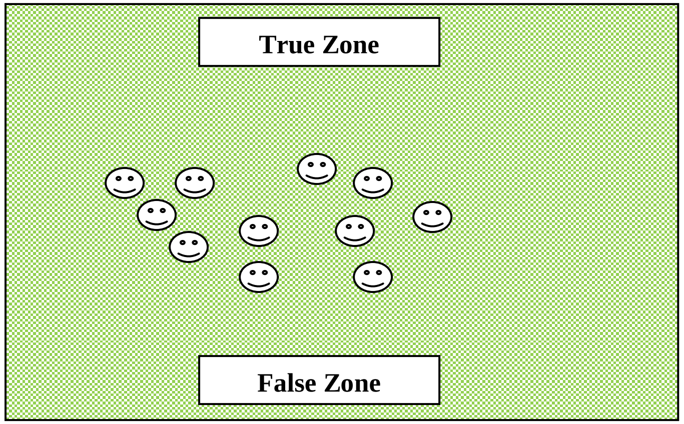
HRA Topic Lesson 2 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Health benefits of physical activity: *self esteem* *sense of well-being* *lifelong physical activity* 	Psychomotor: Partake in a selected variety of physical activities specific to general exercises (jogging, jumping) and sport (basketball, dancing). Cognitive: Recognise and appreciate that physical activity choice is specific to individual preference. Affective: Conceptualise the importance of comradeship and teamwork within physical education; Respect individual choice within the physical activity environment.	<u>Warm-Up (15 mins)</u> 1.Moderate Dance Warm-Up True/false statements – zones. *Re – cap lesson 1 through activity.* <u>Development Stage 1 (10 mins)</u> 2. Students recap 5 key words & design fun body movement. *Task to express PA.* <u>Development Stage 2 (20 mins)</u> 3. Six stations – MVPA activities. Individual choice at each station – autonomous decision making. *PA highly individualised.* <u>Cool-Down (15 mins)</u> 4.Group Interaction – students given task card to perform. *Focus on variety within PA.*	<u>Warm-Up:</u> Music player, cones for designating zone A (true) and zone B (false) and true/false statement sheet. <u>Development Stage 1</u>: Worksheet to jot down 5 key words associated with lesson 1 & 2 – learning to date. Task card for prompts – dictionary of movement. Pencils and pens. <u>Development Stage 2</u>: each station pending teacher decisions will have specific equipment – e.g. skipping ropes, benches, basketballs, footballs. <u>Cool-Down:</u> Task Cards with specific group performance – cater for 4 groups within the lesson (4 physical activity scenarios need to be set).	Teacher Assessment: Teacher question students understanding of previously acquired knowledge during recap phases : Warm-up and development stage 1 Self-Assessment: Within this lesson, students are expected to make independent activity choices highlighting that physical activity is individualised : development stage 2 Peer Assessment: Work collaboratively to recap during the pair work task within development stage 1 Homework: Fill out student physical activity journal week 2.

HEALTH RELATED ACTIVITY
LESSON 2
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

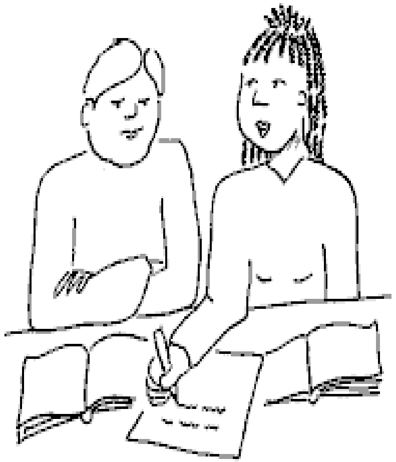
1. Moderate dance warm-up

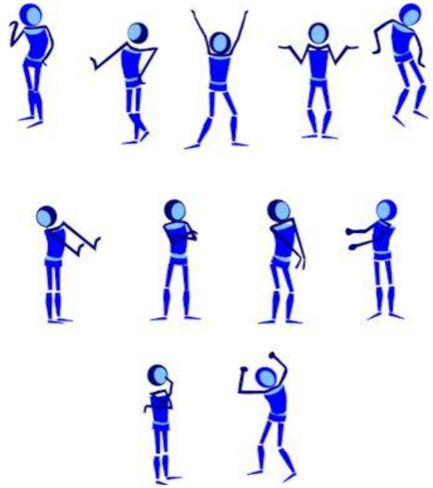
Dance to music - when question asked, run to either true or false zone



2. Recap & design fun body movement

Students in pairs write 5 key words, then proceed to design body action





3. Six stations – choice in physical activity

Students have an option at each station e.g. type/speed of skipping

4. Group interaction

Groups given a physical activity scenario to rehearse and perform e.g. wash car

HEALTH RELATED ACTIVITY
LESSON 3
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

"Low active students need to develop positive physical activity perceptions and awareness" – *Improve physical activity attitude*

AIM: During lesson 3, the teacher shifts the learning towards the body's response during physical activity. The teacher within this lesson must emphasise that physical activity has a positive effect on the body; In particular, teacher will familiarise students with the concept of increased Heart Rate (HR).

HRA Topic Lesson 3 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: *heart* *increased HR* Health related fitness: *different intensity levels* 	Psychomotor: Practice recording their HR through 2 x pulse taking methods (radial wrist and carotid neck regions). Cognitive: Identify that their HR increases as a result of activity intensity. Affective: Students demonstrate a strong class rapport through peer work activity tasks.	Introduction (15 mins): 1.Teach pulse taking. Record resting HR. Warm-Up (15 mins) 2.Moderate intensity Warm-up station choices: individual, peer & group tasks- record HR *Re – cap lesson 2 through activity choice Warm-up.* Development Stage 1 (10 mins) 3.Moderate activity engagement – record HR *Students understand intensity.* Development Stage 2 (10 mins) 4. Vigorous activity engagement – record HR *Students understand intensity.* Cool-Down (10 mins) 5.Slow walk modified game *Resting HR post-exercise.*	Introduction: Worksheet for student to record HR in introduction, Warm-up and development stage 2. Pencils and pens. Warm-Up: 3 zones laid out, pending the tasks specific sporting equipment may be needed Development Stage 1 & 2: Pending the teacher's decisions for moderate and vigorous activities specific equipment will be needed for pupil engagement. Cool-Down: Worksheet as needed in development stages 1 & 2 to record HR post exercise in Cool-down. Also modified game equipment.	Teacher Assessment: Teacher visually observes pupils adaptation and application to the pulse taking methods during introduction Self-Assessment: Students ability to differentiate HR at varying activity levels within their engagement of light, moderate and vigorous activities: development stage 2 Homework: Fill out student physical activity journal week 3.

HEALTH RELATED ACTIVITY
LESSON 3
School of Health & Human Performance, Dublin City University

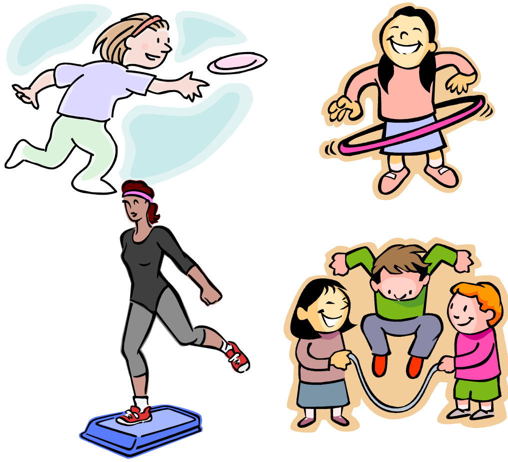
Youth - Physical Activity Towards Health

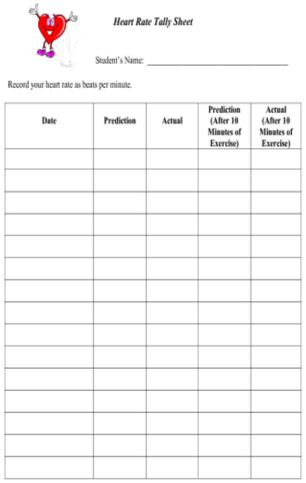
1. Introduction- pulse taking (radial & carotid)

Teacher introduces students to 2 x pulse taking methods at resting heart rate (HR)

2. Moderate Intensity Warm-up Choices

Students different types of moderate activity - record HR on sheet after each





Heart Rate Tally Sheet

Student's Name: ______________

Record your heart rate as beats per minute.

Date	Prediction	Actual	Prediction (After 10 Minutes of Exercise)	Actual (After 10 Minutes of Exercise)

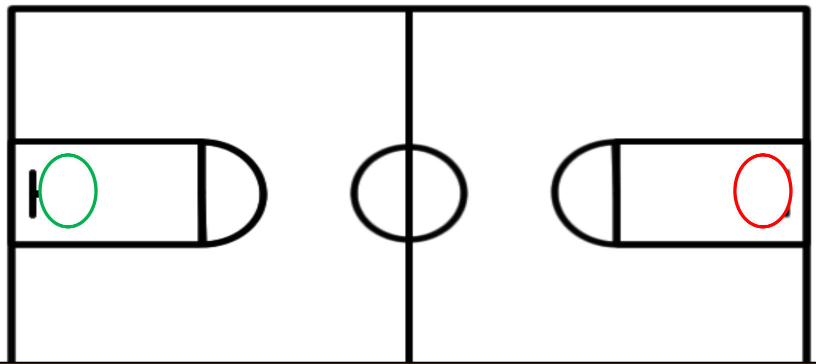
3 & 4. Moderate & vigorous activity engagement

Students recognise difference in HR intensity – record HR after both intensities

Moderate activity – e.g. crab soccer/volleyball *Vigorous activity – tag belt snatch*

5. Cool-down – walking modified game

Slow walking pace activity – students HR back to normal (record on sheet)



Walking Game: Example Olympic Handball shoot in hula hoop (no running)

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HEALTH RELATED ACTIVITY
LESSON 4
School of Health & Human Performance, Dublin City University

Y-PATH
Youth - Physical Activity Towards Health

"Low active students need to develop positive physical activity perceptions and awareness" – Improve physical activity attitude

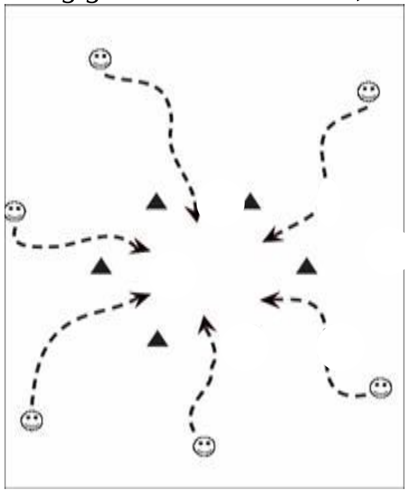
AIM: During lesson 4, the teacher will introduce and practically engage students within two components of health – related fitness. The lesson will aim to educate students on the importance of both flexibility and cardiovascular endurance within physical activity.

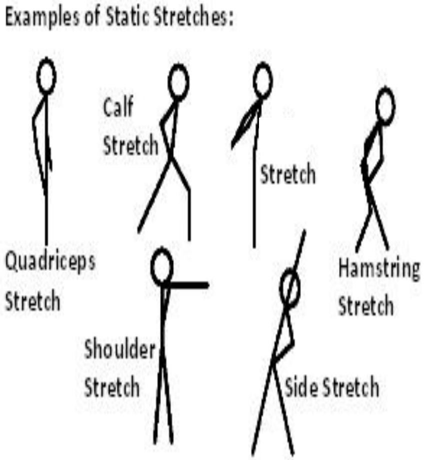
HRA Topic Lesson 4 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: *heart* *increased heart rate* Health related fitness: *cardiovascular endurance* *flexibility* Warm-up and cool-down: *distinction and purpose*	Psychomotor: Perform flexibility stretching exercises with an emphasis on the major muscle groups. Cognitive: Identify the principle of endurance within activity: sustained and continuous period of activity. Affective: Recognise individual differences associated with flexibility and cardiovascular endurance.	Warm-Up (15 mins) 1.Increased HR Warm-up Everybody's it/ Stuck in the mud 2.Flexibility –stretch *Recap HR intensity & introduce purpose of warm-up.* Development Stage 1 (15 mins) 3.Fun Game – e.g. Dodge Ball/parachute *Increase HR, teamwork & fun.* 4. Student recap: brainstorm questioning session on HR. Development Stage 2 (20 mins) 5.Cardiovascular endurance – 4 activities x 3 minute duration Record HR after each activity *Long periods – continuous PA at 120-140 HR fat burning. *** Cool-Down (10 mins) 6.Walking game endzone ball 7.Flexibility – teacher led *HR & purpose of cool-down.*	Warm-Up: Court markings needed for the boundaries within everybody's it game/ stuck in the mud. Task card prompts for major muscle group stretching. HR record sheet. Pencils/pens. Development Stage 1: Dodge ball activity requires foam balls/ Parachute Whiteboard/ flipchart brainstorming recap. HR record sheet. Development Stage 2: The 5 stations may require skipping ropes, footballs, basketballs, music players, benches & steps. HR record sheet for students after each activity. Cool-Down: Endzone ball activity requires benches/ cones as goals and ball.	Teacher Assessment: Teacher will visually observe and monitor students control and technique of stretching during flexibility phases – Warm-up and Cool-down Self Assessment: Students will have to self evaluate and record their HR after each of the 4 CVE activities in development stage 2 Homework: Fill out student physical activity journal week 4. Go home and find out a new muscle stretch in advance of next week's lesson. Teach that to your partner.

HEALTH RELATED ACTIVITY
LESSON 4
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

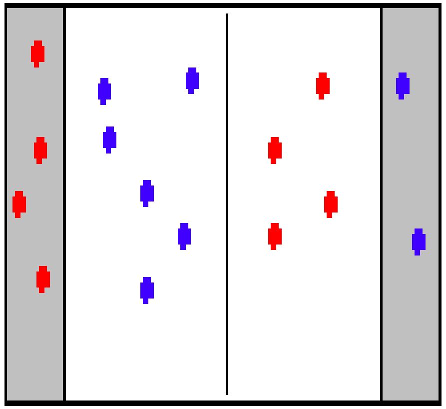
1 & 2. Warm-Up- increase HR activity & flexibility
Tag game to increase HR; teacher led stretching exercise





Everybody's it – tag game/ stuck in the mud   *Teacher led flexibility in Warm-up*

3 & 4. Fun game & brainstorm session (teacher led)
Students engage in fun, inclusive game followed by lessons 1-4 recap



Dodge ball- hit opposing team with sponge balls from shoulder down to get them out

Brainstorm- teacher led recap lessons 1-4

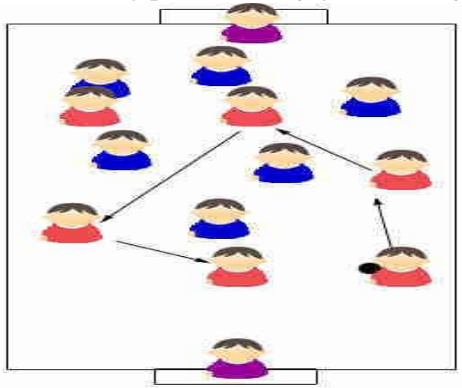
5. Cardiovascular endurance activities
Students record HR after each of the 3 min CVE activities
These can be any CVE activities such as running, obstacle course, jumping jacks

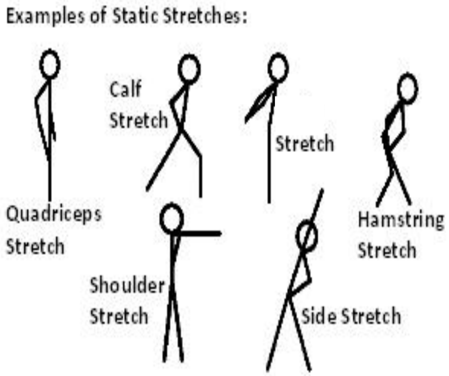
Dance aerobics 3 mins

Skipping with or without rope 3 mins

6 & 7. Cool-down – walking modified game & flexibility

Slow walking pace activity followed by teacher led Cool-down stretching





HEALTH RELATED ACTIVITY
LESSON 5
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

"Low active students must believe that they can succeed in physical activity situations" – Improve Self - Efficacy
"Low active students need to develop positive physical activity perceptions and awareness" – Improve physical activity attitude

AIM: Lesson 5 will introduce students to the principles of pedometer step counts. The teacher will implement activities of intensity progression. Students are required to make independent decisions in order to meet the moderate intensity recommendation of "100 steps per minute".

HRA Topic Lesson 5 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: *heart* *increased HR* Health related fitness: *flexibility* *use of pedometer* Warm-up and cool-down: *distinction and purpose*	Psychomotor: Engage in light and brisk walking movements; carry out the physical movements necessary to obtain the pre – determined goal of "100 steps per minute" Cognitive: Apply the mathematical formula needed to calculate the average step count per minute based on the pedometer output. Affective: Experience success based on the completion of the pedometer step challenge and achievement of the target step count.	Warm-Up (15 mins) 1.Crab soccer 2.Peer led stretching *pulse raise/reciprocal teaching* Development Stage 1 (15 mins) 3.Pedometer introduction; demo& explanation teacher 4.Slow walk challenge 3mins *device introduction and arithmetic avg. step / min.* Development Stage 2 (20 mins) 5.Brisk walk, jog & run challenge – 3 mins per activity Development Stage 3 (time**) 6.Modified game – step count Cool-Down (10 mins) 7.Flexibility stretching in pairs *Peer work – reciprocal method*	Warm-Up: 2 separate courts for crab football games; Bibs to differentiate between teams; cones and increase number of sponge balls as required. Development Stage 1: Zone or grid layout for step challenge – 30 x pedometers. Students need sheets to record avg. steps/min and HR. Pencils/pens. Development Stage 2: Progression within intensity during the challenge of stage 2; 30 x pedometers needed again. Cool-Down: No equipment needed for closing activity.	Teacher Assessment: Teacher will formally assess student ability to increase step count within the lesson (development stage 1 & 2). Self-Assessment: Students will attempt to calculate avg. step/min following completion of 3 min tasks (development stage 1 & 2). Peer Assessment: Peers observe and correct partner's stretching technique; warm-up and cool-down phases of lesson. Homework: Fill out student physical activity journal week 5.

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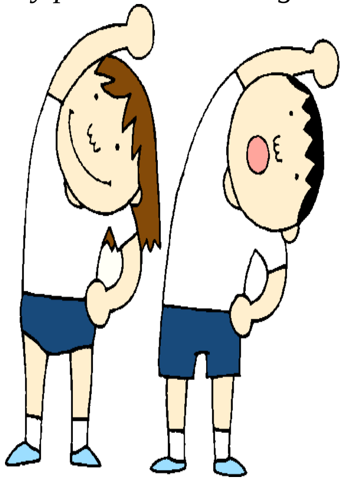
HEALTH RELATED ACTIVITY
LESSON 5
School of Health & Human Performance, Dublin City University

Y-PATH
Youth - Physical Activity Towards Health

1 & 2. Warm-Up – crab soccer & flexibility

Moderate intensity crab soccer followed by peer led stretching



Crab Soccer – Fun team game Warm-up *Peer led stretching*

3 & 4. Pedometer introduction followed by 3 mins light walking

Teacher introduces device: 3 minutes walking challenge – record steps & HR

How to wear and use device *3 mins slow walk task students – record steps*

5 & 6. Brisk walk, jog, run and mini game – pedometer record steps

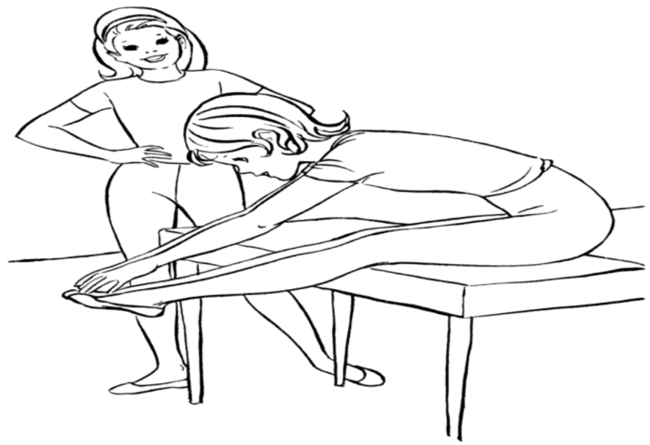
Students record step count and HR after each 3 minute activity

Moderate intensity = 100 steps per minute

Average step count per minute and HR after different intensities

7. Cool-down – flexibility stretching with partner

Peer assessment – observe and correct stretching technique



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HEALTH RELATED ACTIVITY
LESSON 6
School of Health & Human Performance, Dublin City University

Y-PATH
Youth - Physical Activity Towards Health

"Low active students must believe that they can succeed in physical activity situations" – Improve Self - Efficacy
"Low active students need to develop positive physical activity perceptions and awareness" – Improve physical activity attitude

AIM: The final health related education lesson plan will incorporate the central learning criteria from the previous 5 weeks. The teacher has designed activities specific to the learning content within lessons 1 – 5 with a particular emphasis towards students self efficacy and physical activity attitudes.

HRA Topic Lesson 6 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: *heart* *increased HR* Health benefits of physical activity: *self esteem* *sense of well-being* *lifelong physical activity* Health related fitness: flexibility Warm-up and cool-down: *distinction and purpose*	Psychomotor: Participate in a variety of moderate to vigorous physical activities through individual and team based challenges. Cognitive: Recap on previously learned subject matter. Recognise the health concepts associated with the body, the benefits of physical activity and the components of health related fitness. Affective: Demonstrate a positive attitude towards physical activity engagement. Experience success and feel included within the learning environment.	Warm-Up (15 mins) 1.Resting HR recorded 2.Pulse raiser: ladders or other 3.Self-led stretching *Recap HR & warm-up.* Development Stage 1 (15 mins) 4.Individual challenge – 500 steps within 5 minute duration 5.Team challenge – Tank tracks carry gym mats overhead *HR, step count & PA benefits.* Development Stage 2 (15 mins) 6.Student Choice – Fun, inclusive game; student decide. *Well-being, self-esteem, heart.* Cool-Down (15 mins) 7. Peer-led stretching: teacher observes. Pupils brainstorm. *Summative HRE assessment.*	Warm-Up: Cones set up boundaries for ladders game; pending teacher decision for pulse raiser equipment may vary. Worksheet for resting HR- pens/pencils. Development Stage 1: Pedometers x 30 for individual challenge, 2 x gymnastic mats for team challenge. Worksheet for HR and step count. Development Stage 2: Based on student enjoyment, desired activity chosen. 2 x playing areas for fun activity choices. Cool-Down: Brainstorming, 30 student worksheets Gold standard summary sheet at end of class to students.	Teacher Assessment: Teacher will assess students at end of 6 week HRA through prescribed brainstorming task during closing phase of lesson. Teacher will collect sheet for grading. Self-Assessment: Individual challenge development stage 1. Identification of individual activity preference development stage 2. Peer Assessment: Peer stretching during cool-down. Homework: Fill out student physical activity journal week 6.

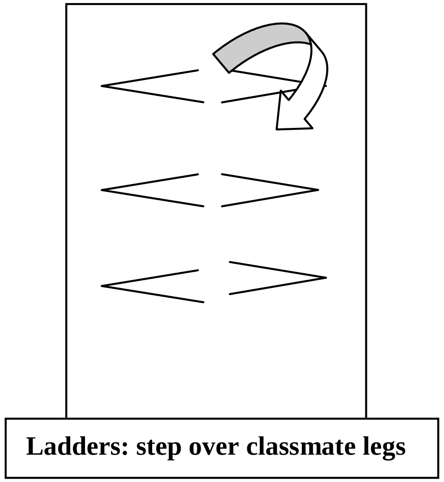
HEALTH RELATED ACTIVITY
LESSON 6
School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

1, 2 & 3. Resting HR, pulse raiser & flexibility

Students record resting HR, engage in pulse raiser & self led stretching

Resting HR recorded



Ladders Mini Game

Self led stretching

4 & 5. Individual challenge & team challenge

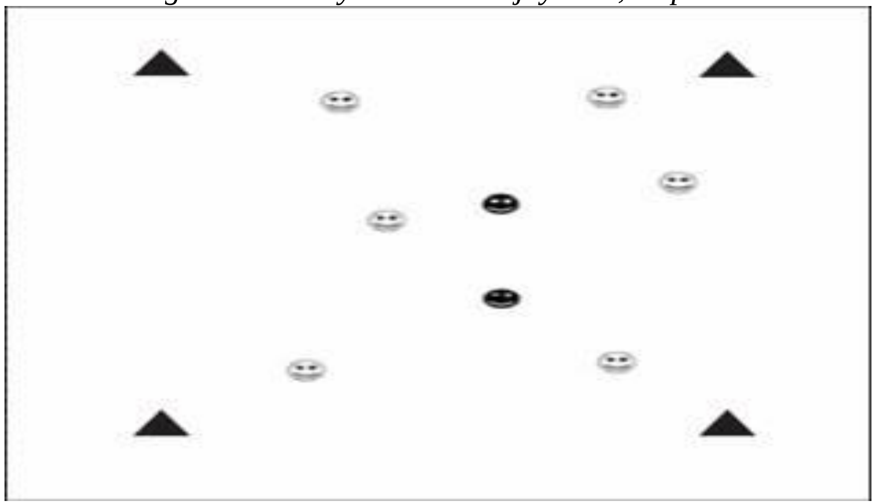
Individual challenge: 500 steps in 5 minutes / Team challenge e.g. tank tracks

> 500 steps in 5 mins timeframe

Team building activity – fun & inclusive

6. Student choice – record step count post activity

Culminating HRA activity – student enjoyment; step count & HR recorded



Teacher decision based on student enjoyment e.g. cannon ball, dodgeball, dance aerobics

7. Cool-down – flexibility with partner & summative assessment

Peer assessment – observe and correct stretching technique

Student recap closure: brainstorm sheet

Appendix C

Health-Related Activity Lesson 1-6 Year 2

HRA LESSON 1
Integrating HRA & FMS into Unit
School of Health & Human Performance Dublin City University

Y-PATH
Youth - Physical Activity Towards Health

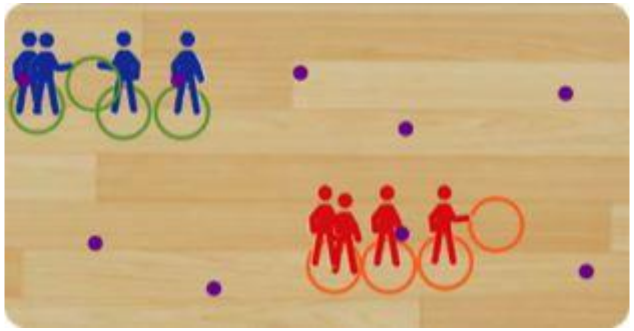
Equipment:
30 x Hula Hoops
Teacher Resource 1
Circuits (Resource 1)
30 x circuit worksheet (Resource 2)
Muscle poster & labels (Resource 3)

Aim: To introduce students to the major muscle groups, and their role in generating movement through participating in a variety of exercises and stretches.

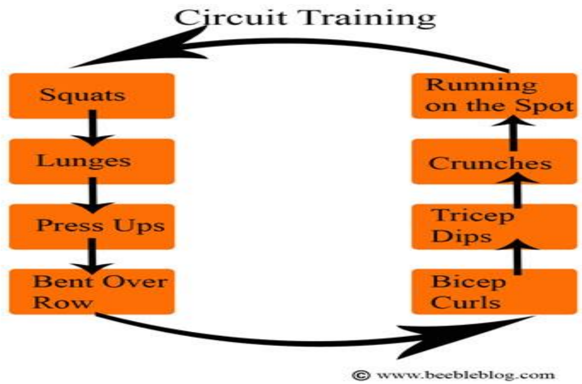
Learning Outcomes	Class Structure & Content	HRA and/or FMS focus	Assessment
Cognitive Identify the major muscle groups of the body, and explain their role in everyday movements e.g. tying your shoes, walking, playing with friends. Identify different ways to be physically active which will focus on specific identified muscles and 'keep them -working' - use it or lose it **Affective** Work cooperatively as part of a team throughout the lesson creating movement solutions to challenges and agreed team responses to question posed. **Psychomotor:** Execute and perform a variety of skills, movements and stretches specific to the major muscle groups of the body.	**Introduction (5 minutes)** Brief discussion on the role of the major muscle groups (*Teacher Resource 1*) in the body. Focus on 'Use it or lose it' message. Ask students; squat with 2 feet flat on the floor and stand back up unaided. Count number that can do this. Explain as babies all students could do this-lost it due to lack of practice. Promote physical activity as the solution. Refer to everyday examples and the muscles needed to perform the activity; tying shoes, carrying school bag (relate to your specific school environment). **Warm-Up (10 minutes)** ***Caterpillar Caterpillar:*** Aim is to use different body parts to move from one end of the hall to the next. Groups of 4-5 (stay in group for lesson) - cannot step outside of the hula hoops (4 per group) as they proceed towards the end of the hall. Progression: collect objects on way across hall, reduce number of hoops. **Development Stage 1 (15 minutes)-(Resource 1 and 2)** ***Modified Circuits targeted at major muscle groups:*** Students identify through participation the functions of the major muscles in the body through specifically targeted circuit stations (30 seconds on, 15 seconds off, etc.) **Development Stage 2 (15 minutes)** ***Muscle Group Obstacle Course:*** Set specific tasks relating to the major muscles of the body which students must accomplish e.g. crawling along the floor using the gluteus, quadriceps and biceps etc. **Cool-Down/Debrief (15 minutes) - (Resource 3)** ***Simon Says Stretch Game:*** The teacher stands at the top of the hall facing the students and says *"Simon says stretch your ..."* The students are indirectly reflecting on their content knowledge from the lesson through this final activity. Given muscle names in groups and must place on poster of body. Peers correct muscle location and classmate postures.	**Introduction (5 minutes)** Lead Q and A on muscles. Prompt students to name the major muscles in the body e.g. quads and locate them on themselves/peer. Highlight role of muscles in generating movement- look at specific movements e.g. what muscles work in the legs when walking/ crouching/tying shoes etc.? Promote moving more and sitting less as the solution to improving muscle function. **Warm-Up (10 minutes)** Teacher/students calls out body part students must use to cross hall. Q students on muscles located in body part; scientific names only e.g. calf must be gastrocnemius. Q students; which movement was most difficult; do you use this muscle in everyday life/sport etc.? Highlight importance of training muscles through physical activity. **Development Stage 1 (15 minutes)** Students learn correct technique and exercises for all major muscles in body. Each station develops a different aspect of movement e.g. squats improve crouching technique. Students complete handout; identify muscles worked and their action in the movement. Introduce terms such as contraction, flexion etc. Students must fill in what physical activity they can do 'to keep each muscle group working'? - use it or lose it message. **Development stage 2 (15 minutes)** Students identify number of -muscle groups and use them to transfer from A to B. Q students on the muscles used to achieve the action. Promote the idea that muscles do not work in isolation. More than one muscle is used to create any one movement (co-contraction). **Cool-down (15 minutes)** Take home message - movement is key to muscle function; move well and move often or muscle function declines - what will you no longer be able to do that you can now, due to lack of movement?	**Teacher assessment** Diagnostic assessment of previous knowledge of muscles Observation and feedback on circuit technique **Self-assessment** Muscles worksheet **Peer assessment** Correction of muscle placement on the body poster and peers postures during stretches. **Homework** Research the difference between muscular strength, muscular endurance and aerobic fitness.

Youth - Physical Activity Towards Health

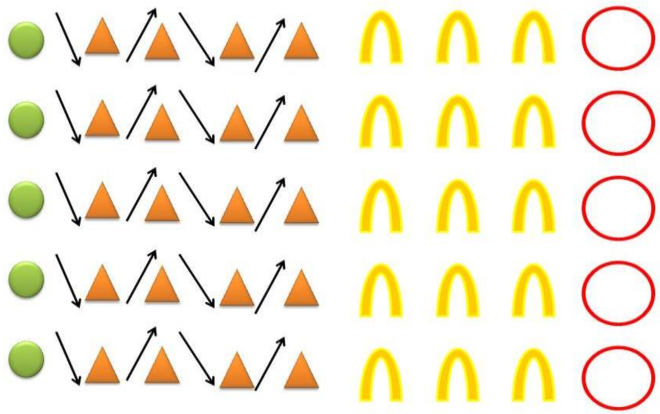
1. *Warm-up:* Caterpillar Caterpillar



2. *Development Stage 1*: Modified Circuits



3. *Development Stage 2:*Muscle Groups Obstacle Course



Starter Disc Cones Hurdles Hula Hoop

4. *Cool-down:* Simon Says

HRA LESSON 2

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

Youth - Physical Activity Towards Health

Equipment:
30 x *Resource)*
15 x beanbags
Music
6 x *Resource 5*
12 x dice

AIM: To explore/introduce the principles of muscular strength and muscular endurance using a variety of activities to guide their knowledge and understanding.

Learning Outcomes	Class Structure & Content	HRA and/or FMS focus	Assessment
Cognitive Explain the difference between muscular strength and muscular endurance. Students identify examples of how and when muscular strength and muscular endurance are needed in everyday life activities. **Affective** Work collaboratively in groups to complete the activities through encouraging and supporting peers helping classmates successfully complete the lessons challenges. Show consideration and compassion for peers and be gracious in both success and defeat (pair competitions). Identify a muscular endurance activity that targets specific muscles and help achieve MVPA guidelines; appreciate different ideas amongst peers and that different people achieve PA goals in various ways. **Psychomotor** Execute and perform a variety of skills and movements which demonstrate muscular strength and muscular endurance.	**Introduction (5 minutes)-*(Resource 4)*** Recap on major muscle groups and importance of physical activity (PA) for enhanced muscular functioning. Complete sheet outlining current muscular strength and endurance (MSE) knowledge; benefits of improved MSE (higher metabolism, stronger tendons, stronger ligaments, reducing the risk of serious injury). **Warm-Up (10 minutes)** **Animal walks;** students line up across hall. Move from one end of hall to other using a variety of animal like movements, ex. crabs, frogs, bears or worms. **Development Stage 1 (15 minutes)** **Bean bag battle;** bean bag between two. Both in push up position (correct technique), bean bag in middle (equal distance, arms reach from both). On 'go' must battle to win beanbag and return to push up position. Student that touches floor with any body part other than their hands/feet loses point. Students keep track of points-try to get highest score. Differentiate; change from push up to lunge (alter rules accordingly). **See-saw squats;** Pairs, students face each other few feet apart. Teacher starts music; students take turns performing squat (correct technique). Aim is not to get caught in a squat when the music stops (every 30 secs). **Development Stage 2 (20 minutes) -*(Resource 5)*** **Muscular strength and muscular endurance bingo;** teams 4/5. Roll two dice. Complete corresponding exercise to the numbers rolled. 1st team to perform all exercises wins. Continue until all get 'bingo'. **Cool-Down/Debrief (10 minutes)-*(Resource 4)*** **Student led stretch;** in teams, student led stretch focusing on muscles worked during lesson; name, identify and stretch them. Return to individual sheet from start of lesson; what was learnt about MSE. One person from each team share answer with class.	**Introduction (5 minutes)** Explain muscular strength (MS) (exert force against resistance) and muscular endurance (ability of a muscle/ group of muscles to exert force repeatedly). Explain link between two (strength required to initiate movements -muscles endurance capacity enables it to continue for multiple efforts). Highlight use in everyday life; open jars, carry heavy school bag etc. **Warm-Up (10 minutes)** Introduce students to different types of weight bearing resistance exercises. Highlight; repetitive use of same muscle builds muscular endurance (ME). ME can be achieved through fun activities-PA is for everybody. **Development Stage 1 (15 minutes)** Introduce students to exerting muscles in safe and fun way. Explain concept of muscular fatigue which indicates muscles are working hard as opposed to injury pain. Students identify whether MS or ME activities. **Development stage 2 (20 minutes)** Introduce terms; reps and sets. Students identify how many sets of each activity they did before 'bingo'. Explain reps and sets are gradually increased as is needed to adequately stress the body. Students give examples of how each exercise can be seen in real life. Each student identifies muscle to work on in body and picks activity which helps meet MVPA guidelines. **Cool-down (10 minutes)** Identify what was been learnt about MSE, how they are independent concepts that complement each other. Explain importance in everyday life activities and health benefits. Highlight specific ways to be physically active that help work on these components of health related fitness. Illustrate guidelines on how often strengthening exercises should be done per week.	**Teacher assessment** Diagnostic assessment of previous knowledge of muscular strength and muscular endurance **Self-assessment** Assessment sheet - 'What I knew at the start of the lesson...what I now know at the end of the lesson' **Homework** Write a paragraph on the following: a muscular endurance activity you can do, that also helps you meet the MVPA. Try the activity-does it get your heart rate up above 140 beats per minute-note your heart rate after the activity.

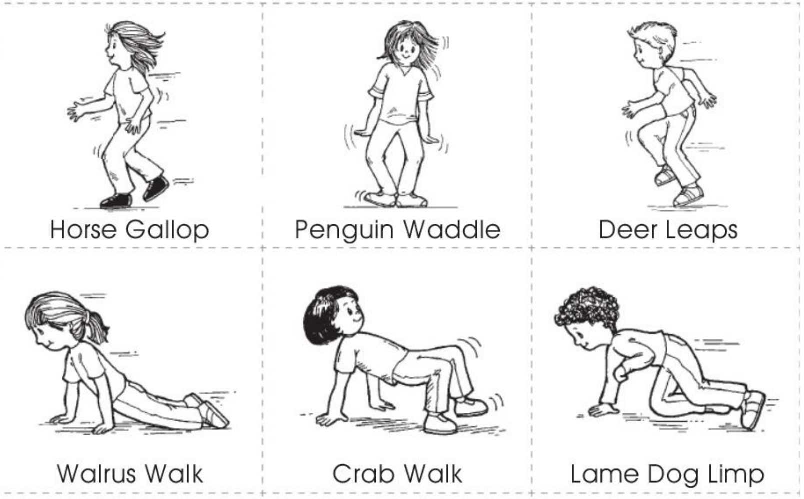
HRA LESSON 2

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

Youth - Physical Activity Towards Health

1. *Warm-up:* Animal walks



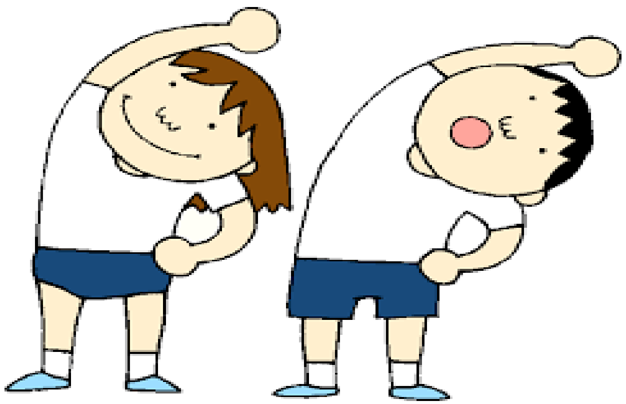
2. *Development Stage 1*: Fun muscular endurance games

3. *Development Stage 2:*MSE bingo

MSE Bingo Card

1 – Bicep Curl Sets/Reps:	2 – Squat Sets/Reps:	3 – Lunge Sets/Reps:
4 – Bent Over Row Sets/Reps:	5 – Chest Press Sets/Reps:	6 – Russian Twists Sets/Reps:
7 – Triceps Extensions Sets/Reps:	8 – Pec Fly Sets/Reps:	9 – Calf Raises Sets/Reps:
10 – Pointing Dogs Sets/Reps:	11 – Push Ups Sets/Reps:	12 – Abdominal Crunches Sets/Reps:

4. *Cool-down:* Student led stretch



HRA LESSON 3
Integrating HRA & FMS into Unit
School of Health & Human Performance Dublin City University

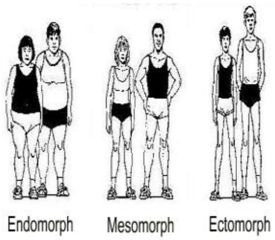
Youth - Physical Activity Towards Health

Equipment:
Picture of 3 body types
5xset of pictures for relay
5xset of food labels
5xactivity sheet
8xcircuit Healthy Lifestyle cards
Statement sheet

AIM: To develop an understanding of body composition, nutrition and physical activity and how they lead to a healthy body.

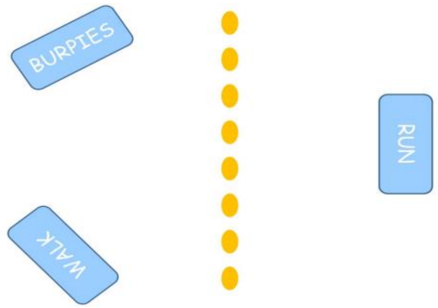
Learning Outcomes	Class Structure & Content	HRA and/or FMS focus	Assessment
Cognitive Explain what is meant by body composition; endomorph, mesomorph and ectomorph. Distinguish between a healthy body and a fashionable body. Describe healthy lifestyle choices versus unhealthy lifestyle choices. **Affective** Work -as a team to identify the calorie count of certain foods, and come up with activity solutions to expend the equivalent energy. **Psychomotor** Participate in a variety of activities which increase the heart rate, burn calories, and contribute to students daily MVPA.	**Introduction (5 minutes)** Recap on the importance of strength exercises which not only improve muscular strength and endurance but help increase MVPA. Introduce today's lesson: body composition (BC), nutrition and healthy lifestyle. Explain BC using three pictures of celebrities/sports stars with different somatotypes ***(Teacher Resource 2 & Resource 6)***. Refer to endomorph, mesomoprh and ectomorph. **Warm Up (10 minutes) - *(Resource 7)*** BC relay; teams 4/5. Line up at cone-work from one end of hall to the other. Teacher calls command e.g. jog, lunge, skip. Students move in designated way from one cone to next. At cone collect picture and return it to team. Next person goes. All pictures collected; body types categorised into endomorph, mesomorph and ectomorph. **Development Stage 1 (15 minutes) - *(Resource 8)*** Food facts; same teams. Line up in teams across middle of hall. Teacher holds up a picture of a food and gives one fact about it e.g. apple - 'makes up one of your 5 fruit and veg a day'. Students in their team must run to one of three zone and do the activity at that zone which they best feel will burn the food item **Development Stage 2 (15 minutes) - *(Resource 9)*** Energy expenditure (EE) bonanza; Recap how to read a food label. Same teams as warm-up. Each team is given food labels and an activity sheet with calorie equivalents. Team pick food label-figure out calories per serving. Pick activity which will burn the calories. Complete the activity. Repeat with next label. **Cool-Down/Debrief (15 minutes) - *(Resource 10)*** Students stand in middle of hall in line. Teacher calls out a statement. Students on teachers command e.g. jog, calf stretch etc. move to wall on right if statement is true, to wall on left if statement is false. Student led stretch in their teams.	**Introduction (5 minutes)** Introduce the term BC; refers to how much of your body is made up of muscle, bone, fat and other tissues. Lean body weight (muscles, ligaments, tendons, bones and body organs) and fat body weight (essential fat for survival, and storage of fat in adipose tissue). Introduce concepts of the lesson; linking BC, nutrition and PA. **Warm Up (10 minutes)** Commands called by teacher; warm up the body and stretch involving weight bearing activities. Class discussion-which body goes in which category; introduce fashionable body (FB) versus healthy body (HB). Students come up with words that describe fashionable body and healthy body. Introduce importance of nutrition for a healthy body-energy intake and EE. Explain calorie intake is important and not a bad thing but need to make careful food choices. **Development Stage 1 (15 minutes)** Discovery learning; encourages students to think about what they put in their body-energy in and energy out. **Development stage 2 (15 minutes)** Explain how to read food label. Discuss MVPA activities they could do to burn off calories in their food label. PA is independent of eating i.e. eating healthy does not mean you don't have to do PA. Relate labels to foods students eat regularly e.g. energy drinks, chicken rolls, chocolate bars, crisps and perceived healthy snacks e.g. cereal bars. Students write down snacks they will eat today and activities to expend the energy. Compile class list that can be displayed. HB is more than eating well and exercising-promote healthy lifestyle choices. **Cool-down (15 minutes)** Statements summarise lesson and check understanding of BC, nutrition, healthy lifestyle choices leading to HB as opposed to FB.	**Teacher assessment** Correction of picture activity Observation of true or false game **Self-assessment** True/False activity **Homework** Look at three food labels from everyday food items you eat and identify whether they are a 'healthy food' and the activity required to expend the equivalent energy of one serving. Explain the importance of making careful healthy food choices and a balanced diet; fruit, veg, ater etc..

1. *Warm-up:* Body Comp Relay

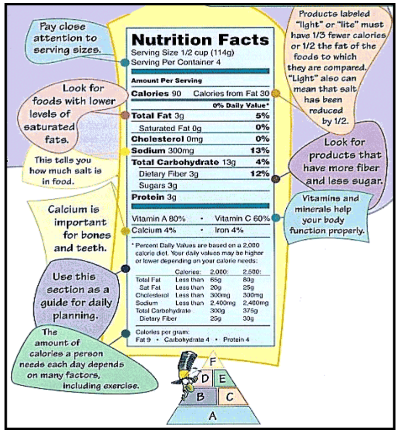


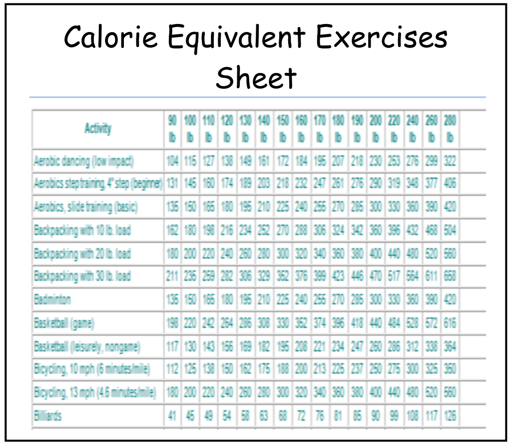
2. *Development Stage 1*: Food facts

'Counts as one of your 5 a day'



3. *Development Stage 2:* Energy Expenditure Bonanza

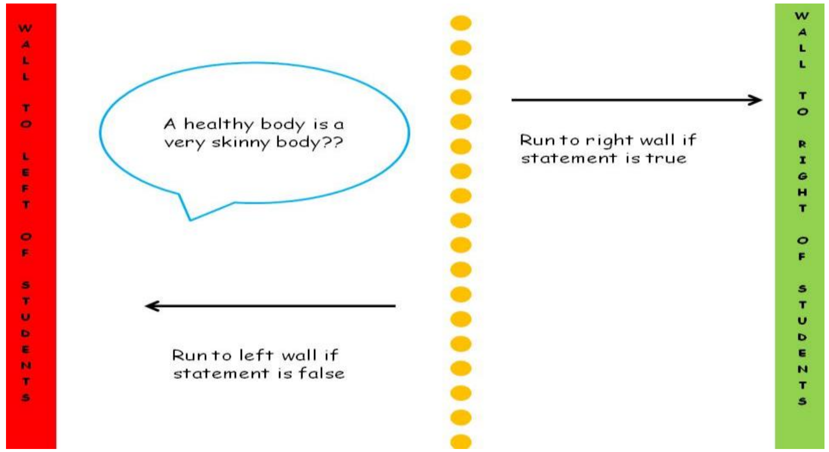




Calorie Equivalent Exercises Sheet

Activity	90 lb	100 lb	110 lb	120 lb	130 lb	140 lb	150 lb	160 lb	170 lb	180 lb	190 lb	200 lb	220 lb	240 lb	260 lb	280 lb
Aerobic dancing (low impact)	104	115	127	138	149	161	172	184	195	207	218	230	253	276	299	322
Aerobics step training, 4" step (beginner)	131	145	160	174	189	203	218	232	247	261	276	290	319	348	377	406
Aerobics, slide training (basic)	135	150	165	180	195	210	225	240	255	270	285	300	330	360	390	420
Backpacking with 10 lb. load	162	180	198	216	234	252	270	288	306	324	342	360	396	432	468	504
Backpacking with 20 lb. load	180	200	220	240	260	280	300	320	340	360	380	400	440	480	520	560
Backpacking with 30 lb. load	211	235	259	282	306	329	352	376	399	423	446	470	517	564	611	658
Badminton	135	150	165	180	195	210	225	240	255	270	285	300	330	360	390	420
Basketball (game)	198	220	242	264	286	308	330	352	374	396	418	440	484	528	572	616
Basketball (leisurely, nongame)	117	130	143	156	169	182	195	208	221	234	247	260	286	312	338	364
Bicycling, 10 mph (6 minutes/mile)	112	125	138	150	162	175	188	200	213	225	237	250	275	300	325	350
Bicycling, 13 mph (4.6 minutes/mile)	180	200	220	240	260	280	300	320	340	360	380	400	440	480	520	560
Billiards	41	45	49	54	58	63	68	72	76	81	85	90	99	108	117	126

4. *Cool-down:* True or False Statement Game



HRA LESSON 4

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

Youth - Physical Activity Towards Health

Equipment:
Anagrams *(Resource 11)*
15 x Food pyramid jigsaw *(Resource 12)*
5 copies x sets of dinner plates & food (*Resource 13*)
1 x healthy lifestyle cards *(Resource 14)*
Teacher Resource 3

AIM: To build on students current knowledge of nutrition introducing the concept of a balanced diet & healthy lifestyle choices.

Learning Outcomes	Class Structure & Content	HRA &/or FMS focus	Assessment
Cognitive: Students will be able to explain the food pyramid in detail; food groups, examples of each & the amounts per day of each food group that should be eaten. Students will be able to design a daily balanced diet plate whilst also identifying foods that should be eaten rarely due to high sugar, salt or fat content. **Affective:** Students will be able to work in teams to identify small ways they can lead a more healthy lifestyle. Students will learn to be considerate & compassionate of the fact that each individual has their personal challenges & changes they need to make. **Psychomotor:** Students will be able to participate in a variety of stretching, cardio & conditioning exercises in order to meet the demands of the lesson with intensity levels increasing from previous lessons.	**Introduction (5 minutes)** Recap on nutrition & body composition from previous lesson. Ask students 'why do we need a balanced diet'. Give students time to come up with reasons. In pairs get them to unscramble the anagrams ***(Resource 11)*** to get the reasons why a balanced diet is important & discuss. **Warm Up (10 minutes)** **Food Pyramid relay:** pairs line up at cone with row of different coloured cones in front of them. Teacher calls colour-1st student jogs to this coloured cone, collects jigsaw piece ***(Resource 12)*** (if there is one at the cone) of food pyramid & returns to end line. Next student goes on teachers call. Teacher can vary movement-jog, skip, lung, squat etc. Once all pieces are collected in pairs students make the jigsaw of food pyramid & must note important information from it for next activity. **Development Stage 1 (15 minutes)-*(Resource 13)*** **Dinner time:** teams of 4/5. Each team is given 2 plates. 1 plate is a 'balanced diet' plate the other is a 'should be eaten rarely' plate. Stations around the hall of different foods e.g. potatoes, pasta, chocolate etc. 1 person at a time runs out & collects a piece of food to put on the correct plate. Must keep going until all foods are collected. **Development Stage 2 (20 minutes)-*(Resource 14)*** **Healthy Lifestyle Circuit (in teams):** 8 stations set up *(can use Resource 1 Lesson 1)*. Teacher has numbered cards; Smoking, Healthy Eating, Stress, Physical Activity & Sleep. 1 student picks number at random. Perform activity for amount of time indicated on corresponding card. Healthy behaviours are rewarded with less activity time. Repeat circuit 3 time (40 secs per station). **Cool-Down/Debrief (10 minutes)** Student led stretch. Teams; come up with 2 small changes they can make to ensure they lead a more healthy lifestyle; refer to nutrition choices, PA & lifestyle choices.	**Introduction (5 minutes)** Recap on different body types, the importance of nutrition for a healthy body & the concept of energy in-energy out. Provide more in-depth information on what constitutes a balanced diet & its importance. **Warm –Up (10 minutes)** Students participate in a pulse raising warm up. Commands called by teacher encourage students to work the muscles in different ways as well as stretch. Students collect pieces of the food pyramid. Once they have made the jigsaw conduct class discussion on what components make up a balanced diet, amounts of these foods that should be eaten & food that should be avoided. Refer to food types that students eat regularly e.g. energy drinks, chips etc. Discuss healthy alternatives. **Development Stage 1 (15 minute)** Students work as a team to collect all food options. Students allocate foods either to 'balanced diet' or 'should be eaten rarely' plate. Ensure students have allocated only the recommended amount of each food group to plates. Discuss with students- 'Can you have too much of a good thing'. Illustrate that over eating healthy options can also lead to weight gain. Highlight the importance of fuelling the body for the demands of physical activity. Nutrition alone is not the remedy to a healthy lifestyle & body ***(Teacher Resource 4)***. **Development stage 2 (20 minutes)** Use circuit to illustrate bad lifestyle decisions make leading a healthy life more difficult & often counteract positive choices such as being physically active. **Cool-down (10 minutes)** Student responsibility for cool down. Class discussion on simple steps to a more healthy lifestyle. Note each teams suggestion down & encourage them to try implement these changes during the week.	**Teacher assessment** Questioning on food pyramid. Knowledge of food pyramid through plate activity. **Self-assessment** Check understanding of PA, nutrition & healthy lifestyle choices covered to date by assessing own lifestyle & identifying areas for change. **Homework** Try to implement the small lifestyle changes you & your team came up with for the next week. Once during the week note any changes you feel or difficulties you experienced.

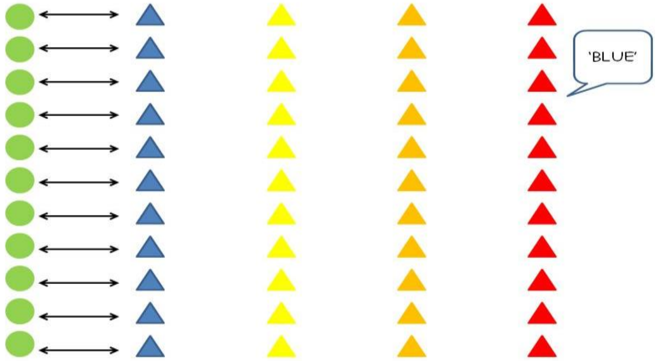
HRA LESSON 4

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

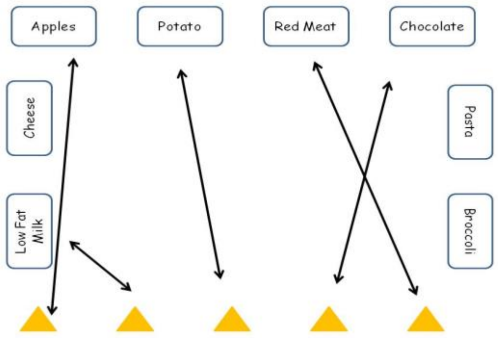
Youth - Physical Activity Towards Health

1. *Warm-up:* Food Pyramid Relay



Teacher calls colour cone. Students run to that cone, collects the jigsaw piece & returns to green cone. Next person goes. Teacher varies commands. Make jigsaw when all pieces are collected.

2. *Development Stage 1:* Dinner Time



Teams 4/5 at each orange cone with two 'plates'. Run to each food station, one at a time & collect the food. Place it on correct plate & in correct amount to make balanced diet.

3. *Development Stage 2:* Healthy Lifestyle Circuit

Eight hours sleep most nights 15 seconds of activity	Only four hours sleep most nights 30 seconds of activity	8 glasses of water most days 15 seconds of activity	No water every day 30 seconds of activity
Active for 60 minutes most days 15 seconds of activity	Only active for 10 minutes most days 30 seconds of activity	Watching sport on TV 15 seconds of activity	Playing sport 30 seconds of activity
Chips 1 day a week 15 seconds of activity	Chips every day 30 seconds of activity	Fizzy drinks some days 15 seconds of activity	Fizzy drinks every day 30 seconds of activity
Non smoker 15 seconds of activity	Smoking cigarettes every day 30 seconds of activity	Active outdoor pastimes 15 seconds of activity	Watching TV most nights 30 seconds of activity
Sweets some days 15 seconds of activity	Sweets every day 30 seconds of activity	Taking the stairs instead of the lift 15 seconds of activity	Always taking the lift 30 seconds of activity
5 portions of fruit / vegetables a day 15 seconds of activity	Never eating fruit or vegetables 30 seconds of activity	Study plan in place 15 seconds of activity	No Study plan 30 seconds of activity

Create an 8 station circuit. Choose your own activities or use the circuit cards from Lesson 1 Resource 1. Teams 4/5. One student from 1 team picks a card above. Must do the activity at the station for recommended amount of time. Unhealthy behaviours give longer activity times.

4. *Cool-down:* Stretch & Aims for Change

HRA LESSON 5

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

Youth - Physical Activity Towards Health

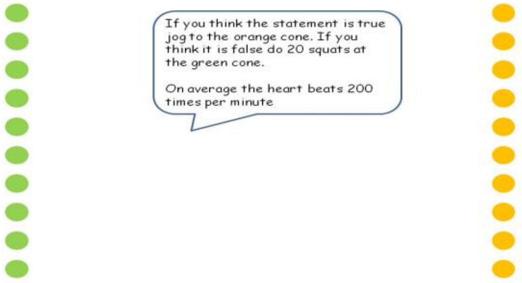
Equipment:
T/F *(Resource 15)*
Cardio sheet *(Resource 16)*
Heart labels (Resource 17)
6x diagram *(Resource 18)*
6 x cardio h/o *(Resource 19)*

AIM: To educate students about the importance of a healthy heart, the structures of the heart & how the cardiovascular system works.

Learning Outcomes	Class Structure & Content	HRA &/or FMS focus	Assessment
Cognitive: Name & label the structures of the heart on a diagram. Identify the blood flow through the structures of the heart & use this information to complete a 'heart structure circuit'. **Affective:** Work cooperatively as a team in a problem solving situation to identify the route you should follow in the 'Blood flow circulation' based on the heart structures & heart diagram provided. Each team create a series of circulatory system questions which are considerate of varying student abilities & are not intended to trick students. **Psychomotor:** Complete a variety of cardiovascular activities individually & as part of a team.	**Introduction (5 minutes)** Recap on the key components of balanced diet & healthy lifestyle-recap on healthy lifestyle choices made last week. Students identify whether they implemented them or not. Introduce students to idea that a healthy body is not just what we can see on the outside but also what is inside the body-the organs & systems. Students name the most important organs in body & give reasons why they are important. Focus on heart - relate to HR. **Warm-Up (10 minutes)-*(Resource 15)*** **Hearty Facts:** Students line up at end line. Teacher gives command 'If you think statement is true then jog to end of hall, if you think it is false stay on the end line & do 20 squats'. Teacher reads statement & students decide whether its T/F. Teacher changes the activities for each statement. Correct answers & discuss heart facts. **Development Stage 1 (15 minutes)** **Blood flow circulation:** Teams 4/5. Set up 10 station cardio circuit ***(Resource 16)***-each station named after structure in the heart ***(Resource 17)***. Each team is provided with heart diagram ***(Resource 18)*** & an individual team starting point ex. left atrium. Students perform activity there. When whistle is blown move to the next activity using the heart diagram to guide them i.e. left atrium group move to left ventricle station. All teams must complete one full circuit. **Development Stage 2 (20 minutes)-*(Resource 19)*** **Cardio Creation:** Teams create 6 station cardio circuit e.g. activities from ***Resource 16***. Teacher provides ropes, ladders etc. Each team given circulatory system sheet & creates 6 questions from it (1 for each station). Write answer to Q at each station. Do 2 circuits time permitting. **Cool-Down/Debrief (10 minutes)-(Resource 20)** Peer led stretch. Label structures on heart poster. Recap key heart & circulatory system teaching points.	**Introduction (5 minutes)** Recap on BC, balanced diet & healthy lifestyle including PA. Highlight the exterior can hide what's going on inside the body ex. people eat very unhealthy but don't gain weight-internally the effects of this lifestyle can be seen. Healthy heart vs. unhealthy ***(Teacher Resource 4)***. Discuss main organs in body & roles e.g. brain, heart etc. Focus on heart, blood & blood vessels which make up the cardiovascular system. **Warm-Up (10 minutes)** Use different commands for each statement to ensure body is fully warmed up e.g. high knees, lunges etc. Diagnostic assessment to identify current knowledge of heart, blood & vessels. Ensure to correct any misconceptions at this point. Refer to the importance of a healthy heart to ensure efficient pumping of blood around the body. Introduce heart structure. **Development Stage 1 (15 minutes)** Take resting HR before commencing cardio exercises. Refer to previous knowledge of HR & exercises effect on it. What exactly is the heart doing to be beating faster. Focus students on learning the structures of the heart & how blood flows through each in order to get to the lungs & become oxygenated or to the body to deliver oxygenated blood & collect waste substances. **Development stage 2 (20 minutes)** Check student understanding of cardio activities. Students learn facts about circulatory system through designing questions. Go through answers with students orally when all circuits are completed-students that created the circuit questions give correct answer (peer teaching). Collect answer sheets. Reinforce key points. **Cool-down (10 minutes)** Student responsibility. Give heart labels to each team-students label structures of heart & blood flow.	**Teacher assessment** Diagnostic assessment of current knowledge of the heart & circulatory system using T/F statements. **Self-assessment** Check understanding of cardio activities by creating a cardio circuit. **Peer-assessment** Peer assessment through student designed questions. **Homework** Write a paragraph starting with 'The heart is one of the most important organs in the body...' Include five points to support this sentence.

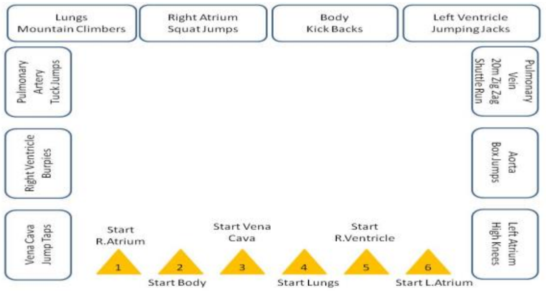
Youth - Physical Activity Towards Health

1. *Warm-up:* Hearty Facts



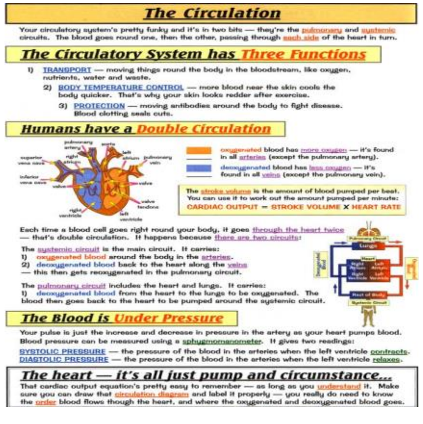
Teacher decides on activity for if you think the answer is true & a different activity for if you think the answer is false. Teacher calls out statement & students individually decide whether it is T/F & perform corresponding activity. Change activities for each statement.

2. *Development Stage 1*: Cardio Circuit



Teams of 4/5. Layout 10 station cardio circuit. Each team is given a diagram of the heart & starting station e.g. Right Atrium (squat jumps).The team must go to that station do the exercise for 40 seconds. Rotate on teachers whistle. Teams must figure out their next station using the heart diagram & following the direction of blood flow in the heart.

3.*Development Stage 2:* Cardio Creation



The Circulation

Your circulatory system's pretty funky and it's in two bits — they're the pulmonary and systemic circuits. The blood goes round one, then the other, passing through each side of the heart in turn.

The Circulatory System has Three Functions

1) TRANSPORT — moving things round the body in the bloodstream, like oxygen, nutrients, water and waste.
2) BODY TEMPERATURE CONTROL — more blood near the skin cools the body quicker. That's why your skin looks redder after exercise.
3) PROTECTION — moving antibodies around the body to fight disease. Blood clotting seals cuts.

Humans have a Double Circulation

oxygenated blood has more oxygen — it's found in all arteries (except the pulmonary artery).
deoxygenated blood has less oxygen — it's found in all veins (except the pulmonary vein).

The stroke volume is the amount of blood pumped per beat. You can use it to work out the amount pumped per minute:
CARDIAC OUTPUT = STROKE VOLUME X HEART RATE

Each time a blood cell goes right round your body, it goes through the heart twice — that's double circulation. It happens because there are two circuits:

The systemic circuit is the main circuit. It carries:
1) oxygenated blood around the body in the arteries.
2) deoxygenated blood back to the heart along the veins — this then gets reoxygenated in the pulmonary circuit.

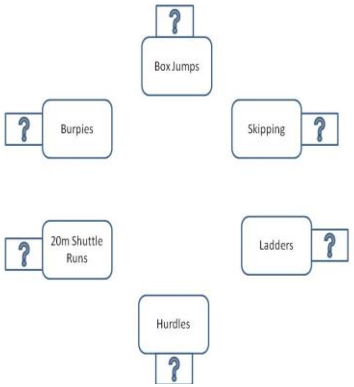
The pulmonary circuit includes the heart and lungs. It carries:
1) deoxygenated blood from the heart to the lungs to be oxygenated. The blood then goes back to the heart to be pumped around the systemic circuit.

The Blood is Under Pressure

Your pulse is just the increase and decrease in pressure in the artery as your heart pumps blood. Blood pressure can be measured using a sphygmomanometer. It gives two readings:
SYSTOLIC PRESSURE — the pressure of the blood in the arteries when the left ventricle contracts.
DIASTOLIC PRESSURE — the pressure of the blood in the arteries when the left ventricle relaxes.

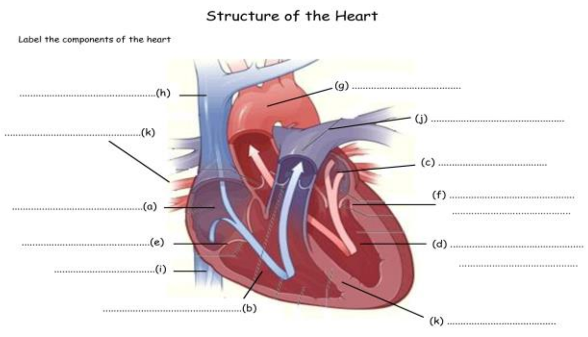
The heart — it's all just pump and circumstance...

That cardiac output equation's pretty easy to remember — as long as you understand it. Make sure you can draw that circulation diagram and label it properly — you really do need to know the order blood flows though the heart, and where the oxygenated and deoxygenated blood goes.



Students remain in teams. Teacher gives a 'cardiovascular system information sheet' to each team. Each team uses the sheet to make up 6 questions. The teams design a 6 station cardio circuit & place a question at each station. Each team does another teams circuit & answers their questions. Try do two circuits in the time & answer two sets of questions. Correct questions at the end (Peer teaching).

4. *Cool-down:* Stretch & Heart Poster



HRA 6
Integrating HRA & FMS into Unit
School of Health & Human Performance Dublin University

Y-PATH
Youth - Physical Activity Towards Health

Equipment:
1x*Resource 21*
7xhoops
6x*Resource 22*
6xlabels & respiratory w/sheet *(Resource 23, 24 & 25)*
6x *Resource 26*

AIM: To highlight the importance of a healthy cardio respiratory system, with specific emphasis on physical activity's effect on the heart & lungs

Learning Outcomes	Class Structure & Content	HRA &/or FMS focus	Assessment
Cognitive: Students will be able to list the effects of physical activity on the heart & lungs. Students will be able to label the structures of the respiratory system & subsequently, identify their function. Students will be able to critically reflect on the key teaching points from lessons 1-6. **Affective:** Students will be able to choose how they participate in physical activity as part of a team - taking ownership of tasks. **Psychomotor:** Students will be able to perform a variety of team & individual-based cardiovascular & muscle strengthening activities.	**Introduction (5 minutes)** Recap: structures of heart & blood flow, namely oxygenated blood to the muscles & body/deoxygenated blood back to the lungs. Discuss the effects of physical activity on heart ***(Resource 21)***. What other major system is utilised during physical activity: respiratory system (RS). **Warm-Up (10 minutes)** **Cups & Saucers:** divide class into 2 teams. Before starting activity describe breathing before exercise & count rate & heart rate (HR) for 30 secs ***(Resource 22).*** Cones scattered in area with some upside down. 1 team must turn up 1 way & other must do opposite. Team with most cones up their way wins. Run for 1min 30secs. Count breathing rate (BR) & HR again after physical activity. Repeat 2nd time-2mins. **Development Stage 1 (20 minutes)** **Label dash:** teams 4/5. Place hoop in middle with 16 labels per team to be collected ***(Resource 23)***. Labels are for respiratory system & functions of each structure. 1 student from each team runs in, collects label & returns to team. Next person goes. Teams are given diagram ***(Resource 24)***. Once all labels are collected, teams match 1 set of labels to the diagram of respiratory system ***(Resource 24)*** & the other to statements ***(Resource 25)***. Take HR & BR. **Development Stage 2 (15 minutes)** **6 Circuits:** Teams 4/5. Teacher sets up 6 station circuit. Choice at each station. Use ***Resource 1, Resource 16*** & available equipment e.g. ladders, etc. 'Overall 6 Week Student Summary' card per team ***(Resource 26)***. Before completing activity (40s), give 20s to fill in 1 box. Repeat circuit-2nd chance to fill in sheet & then rotate groups to next station. Take HR & BR. **Cool-Down/Debrief (10 minutes)** Teams give 1 thing learnt from lesson 1. Move through all lessons-summarise what was learnt in scheme. Watch video & summarise importance of PA & PA is for everyone!	**Introduction (5 minutes)** Recap on structures of heart & blood flow. Q students on importance of a healthy heart & conditions that result from having an unhealthy heart. Discuss long & short-term effects of PA on the heart. Link to effects on lungs. **Warm-Up (10 minutes)** Pulse raising, fun competitive game. Discovery style learning to get students thinking before & after exercise about the effects exercise has on the breathing & RS-using BR before & after exercise to discuss. Discuss with students the effect of exercise on the RS-correct any misconceptions. Introduce the structures of the system. **Development Stage 1 (20 minutes)** Previous knowledge of RS. Students match 1 set of labels to diagram & other set to description of part. Correct labelling orally & discuss each structure of the system & its function in the process of breathing- relate to breathing before & after exercise. Discuss BR & HR; some BR & HR might be lower than others before & after exercise-exercise trains heart-trained heart can pump more blood per beat than an untrained heart. Lower HR for high intensity activity for fit person than unfit person. Same for lungs-fit person can breathe more deeply & supply blood vessels with more oxygen per breath than unfit person i.e. PA strengthens lungs. **Development stage 2 (15 minutes)** Choice at station-empowering students, many ways to be active. Recap; don't take basic answer e.g. lesson 1; muscles. Probe deeper-what muscles are used in squat etc. Relate 6 lessons to life & PA for a healthy lifestyle. **Cool-down (10 minutes)** Summarise scheme-student summary sheets. Focus on bringing these elements forward into life & all PE lessons. Use video to reinforce this.	**Teacher assessment** Questioning Observation Collection of student summary sheets **Self -assessment** Summary sheet activity **Homework** Write a paragraph starting with 'Being physically active is not just done in PE. It is important to physically active because...' Use what you have learnt in the 6 lessons to complete this.

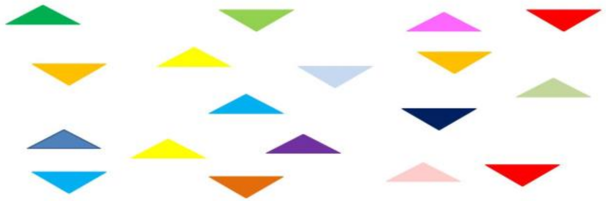
HRA LESSON 6

Integrating HRA & FMS into Unit

School of Health & Human Performance Dublin City University

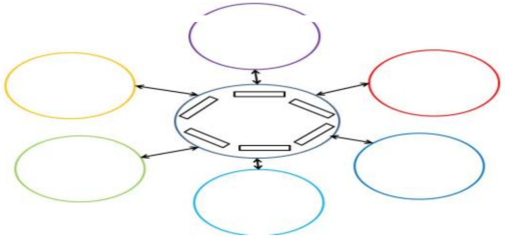
Youth - Physical Activity Towards Health

1. *Warm-up:* Cups & Saucers



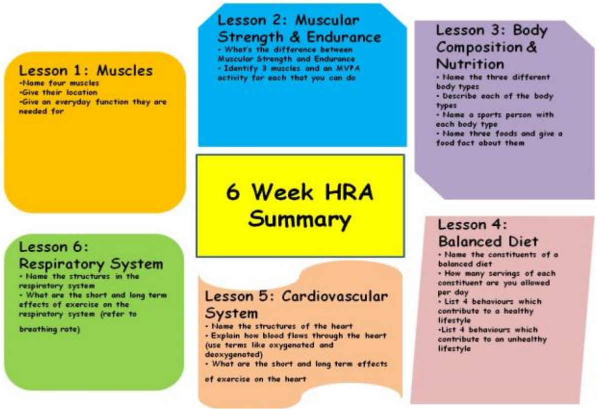
Cones scattered in area, some upside down & some normal. One team must turn up one way & the other must do opposite. Team with most cones up their way at end wins. Run for 1min 30secs. Students fill out a sheet describing BREATHING BEFORE EXERCISE & HR. Complete warm-up game. Describe BREATHING AFTER EXERCISE & HR. Repeat for 2 mins.

2. *Development Stage 1*: Label Dash



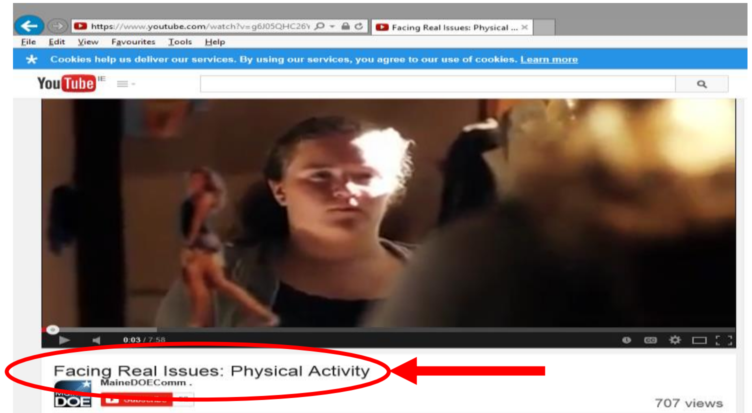
Teacher places hoop in the middle with labels in it..Each team has 16 labels in the centre hoop stacked in front of them. One by one they must collect the labels & return them to their team. Once all labels are collected the team uses them to 1)label diagram of respiratory system & 2) match the structure to the function. 1st team to do this correctly wins.

3. *Development Stage 2:*6 Circuit Summary



Create a 6 station circuit with choice of activity at each station-use a mix of cardiovascular & strengthening activities. Each team is given a Summary Sheet to fill out. At each station they are given 20 seconds to answer the Qs about the lesson e.g. station one-fill in Qs about lesson one. Students then complete the activity at that station. Students do the circuit twice-this gives them a second chance to fill in anything they may have forgotten on the summary sheet from the first round of the circuit.

4. *Cool-down:* Summary Sheet & YouTube clip



Class discussion on what was covered in the scheme. Watch YouTube clip & discuss key concepts regarding PA.

https://www.youtube.com/watch?v=g6J05QHC26Y

Clip is 7.58 min. Can cut & watch 0-3.12, 4.47-6.13 & 7.09-7.58.

Appendix D

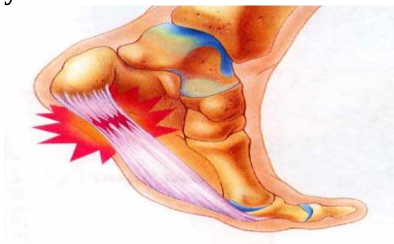
In Strand FMS and HRA Activities

ADVENTURE ACTIVITIES

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

Y-PATH Youth - Physical Activity Towards Health

Health Related Activity(HRA) Focus: Meeting the daily 60 minutes guideline **Fundamental movement skill (FMS) Focus:** Improving ability to crouch	**HRA Focus:** Exposure to individual and team-based activities **FMS Focus:** Improving ability to land on the balls of feet	**HRA Focus:** Success and choice in the PA environment **FMS Focus:** Improving arm/leg co-ordination
Activity: *Leap Frog Tag & Blind Leap Frog* 	**Activity:** *Individual & Team Orienteering* 	**Activity:** *Rock-climbing* 
HRA Focus: Student must reach the target based on fellow student directions. Teacher highlights the importance of meeting the 60 min guideline through these two activities, drawing attention to the many daily activities that can contribute to the 60 mins. **FMS Skills:** Horizontal and vertical jump addressed in this crouched action. Components of skip and run incorporated also.	**HRA Focus:** Students participate in orienteering individually and as part of a team, teacher helps them identify the pros and cons of each, students can start to identify their PA preferences, **FMS Skills:** Run and skip addressed through the balls of feet action. Components of both vertical and horizontal jump incorporated also.	**HRA Focus:** Students introduced to rock-climbing – 3 optional routes ranging from easier to more challenging identified. Students self-select their own choice in route. **FMS Skills:** Arm/leg co-ordination inadvertently integrated in this adventure activity. Arm/leg co-ordination is a component of skip, run and balance.
Teacher Reflection: Crouch component addressed in this unit? Students aware of the 60 minute guideline?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students aware of individual and team activities?	**Teacher Reflection:** Arm/leg co-ordination addressed in this unit? Students aware of choice in physical activity?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

HRA Focus: Exposure to individual and team-based activities **FMS Focus:** Improving arm/leg co-ordination	**HRA Focus:** Success and choice in the PA environment **FMS Focus:** Improving ability to crouch	**HRA Focus:** Meeting the daily 60 minutes guideline **FMS Focus:** Improving ability to land on the balls of feet
Activity: *Team skis* 	**Activity:** *Obstacle course* 	**Activity:** *Orienteering* 
HRA Focus: Students have 2 skis which are made up of a plank of wood with string handles for each participant. Students place feet on wood and hold handle forcing them to lift handle and feet to move one ski at a time. Begin with one person and progress into whole team on the pair of skis working together to move. **FMS Skills:** Arm/leg co-ordination component is addressed as well as the balance skill.	**HRA Focus:** Students split into teams create their own obstacle course. Students choose what activities to include which must incorporate specific criteria such as jumps, leap frog etc, but within each activity students must allow at least two different ways to complete it (differentiation). **FMS Skills:** Crouch component is developed while doing the horizontal and vertical jump in obstacle course.	**HRA Focus:** Students split into teams and participate in orienteering. At each station they will collect an exercise instruction which they bring back to base and perform before going to next station. Exercises will include jumping jacks, tuck jumps, knees up etc. Highlight how long students have been active for and the different intensity levels, and how these contribute to the 60 mins. **FMS Skills:** Students will address a variety of FMS such as run and vertical jump and more specifically FMS components such as arm/leg co-ordination and ability to land on balls of feet.
Teacher Reflection: Arm/leg co-ordination addressed in this activity? Students aware of individual and team activities?	**Teacher Reflection:** Crouch addressed in this activity? Students aware of choice in physical activity?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students aware of the 60 minute guideline?

AQUATICS

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

HRA Focus: Meeting the daily 60 minutes guideline **FMS Focus:** Improving ability to crouch	**HRA Focus:** Exposure to individual and team-based activities **FMS Focus:** Improving ability to extend arms	**HRA Focus:** Success and choice in the PA environment **FMS Focus:** Improving hand/eye co-ordination
Activity: *Aqua fitness – Water Aerobics* 	**Activity:** *Individual & Relay swimming* 	**Activity:** *Water Polo* 
HRA Focus: Teacher highlights that aqua fitness is an alternative approach to meet the 60 minute guideline. **FMS Skills:** Components of both the horizontal and vertical jump actions incorporated in the water aerobics lesson including the crouch component.	**HRA Focus:** Students exposed to individual and team relay activities in the water. **FMS Skills:** Components of the over-arm throw, horizontal and vertical jump incorporated in the arm extension criteria of freestyle swimming	**HRA Focus:** 2 x simultaneous games of water polo (fun and competitive) – students self select which they prefer to participate in. Teacher facilitates student movement between games as needed. **FMS Skills:** The catch and over-arm throw addressed during water polo game improves hand/eye coordination component of skills.
Teacher Reflection: Crouch component addressed in this unit? Students aware of the 60 minute guideline?	**Teacher Reflection:** Extending arms addressed in this unit? Students aware of individual and team activities?	**Teacher Reflection:** Hand/eye co-ordination addressed in this unit? Students aware of choice in physical activity

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

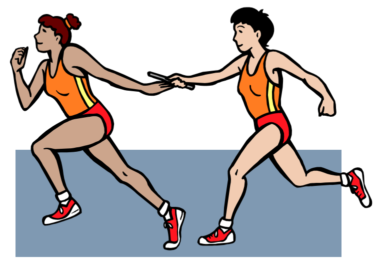
HRA Focus: Exposure to individual and team-based activities, Success and choice in PA **FMS Focus:** Improving hand/eye co-ordination	**HRA Focus:** Meeting the daily 60 minutes guideline **FMS Focus:** Improving ability to extend arms	**HRA Focus:** Success and choice in the PA environment **FMS Focus:** Improving ability to crouch
Activity: *Volleyball* 	**Activity:** *Aquafit* 	**Activity:** *Diving* 
HRA Focus: Students begin playing volleyball in the water 1v1 passing ball over and back to each other. Allow progression to a game of team volleyball in the water for students who choose. **FMS Skills:** Hand/eye co-ordination component is addressed when passing the ball.	**HRA Focus:** Students will take part in aquafit which will consist of various exercises in the water to music aiming to raise their heart rate and to add to their 60 minutes PA guideline. Exercises will include shoulder press with foam float, raising arms over head etc. **FMS Skills:** Will incorporate extending the arms, arm/leg coordination and components of the vertical and horizontal jumps.	**HRA Focus:** Students will be introduced to the concept of diving by allowing them to explore the different ways of entering the water, moving ultimately to entering hands first. Allow students to progress from a seated 'fall' hands first into pool to the standing dive as they are able. **FMS Skills:** Will incorporate components such as arm extension, arm/leg coordination and aspects of the vertical and horizontal jumps including the ability to crouch.
Teacher Reflection: Hand/Eye co-ordination addressed in this activity? Students aware of individual and team activities?	**Teacher Reflection:** Ability to extend arms addressed in this activity? Students aware of the 60 minute guideline?	**Teacher Reflection:** Ability to crouch addressed in this activity? Students aware of choice and success in PA?

ATHLETICS

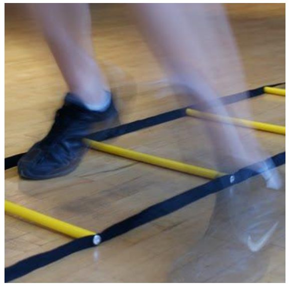
Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

HRA Focus: Intensity levels – moderate and vigorous **FMS Focus:** Improving ability to crouch and extend arms	**HRA Focus:** Record heart rate (HR) – pulse taking **FMS Focus:** Improving ability to land on balls of feet	**HRA Focus:** Step count increase - pedometers **FMS Focus:** Improving hand/eye & leg/arm co-ordination
Activity: *Jogging and Sprinting* 	**Activity:** *Hurdles* 	**Activity:** *Relay Running* 
HRA Focus: By measuring and recording heart rate allow students to learn the different effect walking (initially) jogging and sprinting have on HR. Students must gauge own pace necessary to work at moderate intensity (>120 bpm) and vigorous intensity (> 140 bpm). **FMS Skills:** The starting position for the sprint addresses both the ability to crouch and extend arms. Run is also addressed in this activity	**HRA Focus:** Students record HR pre and post hurdles activity. Determine whether they are working at moderate or vigorous threshold. **FMS Skills:** Landing on the balls of feet is addressed when jumping hurdles. Run is also addressed in this activity. Components of skip (arm/leg co-ordination) may also be addressed.	**HRA Focus:** Wear pedometer during relay running, record step count. Determine whether meeting the moderate intensity threshold (>100 steps/minute). **FMS Skills:** Baton exchange addresses hand/eye co-ordination. Run (leg/eye co-ordination) is addressed in this activity.
Teacher Reflection: Crouch and arm extension addressed in this unit? Students aware of moderate/vigorous intensity?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students able to record pulse pre/post activity?	**Teacher Reflection:** Body co-ordination addressed in this unit? Students aware of step increase in relay run?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

HRA Focus: Record heart rate (HR) – pulse taking **FMS Focus:** Improving ability to crouch and extend arms	**HRA Focus:** Intensity – moderate and vigorous **FMS Focus:** Improving co-ordination of hand/eye & leg/arm	**HRA Focus:** Step count increase - pedometers **FMS Focus:** Improving ability to land on the balls of the feet
Activity: *Jumps* 	**Activity:** *Relays* 	**Activity:** *Speed, agility, quickness (SAQ)* 
HRA Focus: Students begin jumps doing standing jumps either into sand pit or onto high jump mat. Get students to take pulse to highlight that jumping is PA as it increases their HR. **FMS Skills:** Components of vertical and horizontal jumps addressed such as crouch, arm extension and landing on balls of feet.	**HRA Focus:** Students practice baton changeover and progress into race situation. Highlight the change in intensity levels from practice to race situation through paying attention to breathing and HR. **FMS Skills:** Run (leg/eye co-ordination) addressed in this activity. Hand/eye co-ordination also addressed when exchanging the baton.	**HRA Focus:** Students will wear pedometers while doing SAQ training. SAQ training will include ladders, hurdles, shuttle runs. Students will make a note of the amount of steps they are taking over the duration of the activity and try to determine intensity level. **FMS Skills:** Run (leg/eye co-ordination) and balance addressed in this activity. Emphasis on landing on balls of the feet.
Teacher Reflection: Crouch and arm extension addressed in this unit? Students able to record pulse pre/post activity?	**Teacher Reflection:** Body co-ordination addressed in this unit? Students aware of moderate-vigorous intensity in practice and race situations?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students aware of step increase in speed training?

DANCE

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

HRA Focus: Cardiovascular endurance (CVE) **FMS Focus:** Improving ability to crouch and extend arms	**HRA Focus:** Flexibility **FMS Focus:** Improving ability to land on balls of feet	**HRA Focus:** Intensity levels – moderate and vigorous **FMS Focus:** Improving hand/eye co-ordination
Activity: *Dance Aerobics* 	**Activity:** *"Cha Cha Slide" Routine* 	**Activity:** *"Hip-Hop Sequence"* 
HRA Focus: Students engage in sustained and continuous periods (3 – 5mins) of dance aerobics. **FMS Skills:** Crouch movement and arm extension components included in aerobic routine.	**HRA Focus:** Flexibility addressed during warm up and cool down, students identifying the importance of flexibility in dance. **FMS Skills:** Landing on the balls of feet is addressed in this specific dance routine. Arm/leg co-ordination and balance are also addressed.	**HRA Focus:** Moderate intensity introduction, then perform at vigorous intensity (with music). Heart rate should be recorded and interpreted. **FMS Skills:** Leg/eye co-ordination addressed in the step routine actions. Components of balance skill also addressed.
Teacher Reflection: Crouch and arm extension addressed in this unit? Students aware of cardiovascular endurance?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students conscious of flexibility component?	**Teacher Reflection:** Leg/eye co-ordination addressed in this unit? Students aware of moderate/vigorous intensity?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

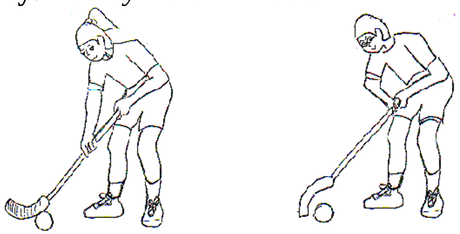
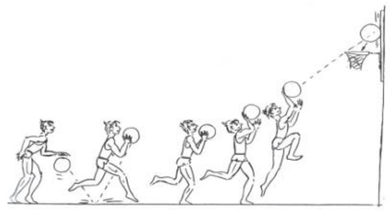
HRA Focus: Intensity – moderate and vigorous **FMS Focus:** Improving ability to crouch and extend arms	**HRA Focus:** Flexibility **FMS Focus:** Improving leg/eye co-ordination	**HRA Focus:** Step count increase - pedometers **FMS Focus:** Improving ability to land on balls of feet
Activity: *Routine Creation* 	**Activity:** *Capoeira* 	**Activity:** *Zumba* 
HRA Focus: Students in groups must create a dance routine including specific criteria. Routines will include a mix of intensity e.g. fast forward and slow motion, students should be able to recognise this. **FMS Skills:** Criteria for the routine will include crouch and extension of arms. Using balls of feet will also be addressed.	**HRA Focus:** Students will learn part of a capoeira routine, they will then create their own endings to this routine. Students will be aware of the importance of flexibility in this style of dance. **FMS Skills:** Leg/eye co-ordination will be addressed along with aspects of vertical and horizontal jumps addressed such as crouch, arm extension and dancing on balls of feet.	**HRA Focus:** Students will take part in a zumba class. Students will be aware of increasing the step count while performing zumba. **FMS Skills:** Students will be dancing on balls of the feet. Leg/eye co-ordination will also be addressed.
Teacher Reflection: Crouch and arm extension addressed in this unit? Students able to identify difference in moderate and vigorous intensity in dance?	**Teacher Reflection:** Leg/eye co-ordination addressed in this style of dance? Students conscious of flexibility component?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students aware of step increase in dance?

INVASION GAMES

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

Youth - Physical Activity Towards Health

HRA Focus: Increased Heart Rate (HR) and Cardiovascular Endurance (CVE) **FMS Focus:** Improving arm/leg co-ordination	**HRA Focus:** Physical activity (PA) - well being/self-esteem, success and choice in the PA environment **FMS Focus:** Improving leg/eye co-ordination	**HRA Focus:** Flexibility **FMS Focus:** Improving hand/eye co-ordination
Activity: *Hockey Indian Dribble* 	**Activity:** *Punt Kick Countdown* 	**Activity:** *Basketball Lay-Ups* 
HRA Focus: Possession games x 2 (light and moderate intensity). Record HR after each game. Identify intensity of the activity and the importance of CVE. Students develop fun modified games to improve CVE through hockey. **FMS Skills:** Students ability to co-ordinate opposite arm/leg and hand/eye co-ordination is addressed along with the balance skill.	**HRA Focus:** Fun, inclusive and physically engaging gaelic football activity; students kick as many points possible in 60 second time frame (retrieve and collect football after each kick). Repeat a few times with students aiming to beat their OWN previous score, avoid peer comparisons. **FMS Skills:** Leg/eye co-ordination is addressed when punt kicking. Balance and kick skills are also addressed.	**HRA Focus:** Teacher sets up competitive and fun lay-up activities – student choice. Flexibility addressed during warm up and cool down, Students identify the muscles working most in basketball, and develop a flexibility/stretching routine based on this. **FMS Skills:** Hand/eye co-ordination addressed. Components of vertical jump, run, catch and bounce also incorporated in this lay-up activity.
Teacher Reflection: Arm/leg co-ordination addressed in this unit? Students aware of increase in HR with intensity and importance of CVE?	**Teacher Reflection:** Leg/eye co-ordination addressed in this unit? Students can identify benefits of PA participation?	**Teacher Reflection:** Hand/eye co-ordination addressed in this unit? Students conscious of flexibility component?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

HRA Focus: Increased Heart Rate (HR) **FMS Focus:** Improving hand/eye co-ordination	**HRA Focus:** Flexibility, Self-esteem/Self-efficacy **FMS Focus:** Improving leg/eye co-ordination	**HRA Focus:** Meeting the daily 60 minutes guideline **FMS Focus:** Improving arm/leg co-ordination
Activity: *Ultimate Frisbee* 	**Activity:** *"Keepy Uppies"* 	**Activity:** *Rugby* 
HRA Focus: Students will take part in a game of ultimate Frisbee. They will take their pulse before, during, and after this class and see how much it changes. **FMS Skills:** Hand/eye co-ordination will be addressed in this game as well as using balls of feet and arm extension.	**HRA Focus:** Students will take part in a game of 'keepy uppies'. They must keep the ball off the ground using their feet, allow students to modify game (e.g. allow one bounce) as needed to ensure reasonable success. The team able to do this the longest wins. Students will see how important it is to be flexible in this game as they will be force to stretch to keep the ball off the ground. **FMS Skills:** Leg/eye co-ordination will be addressed as well as balance and aspects of the kick.	**HRA Focus:** Students will take part in a small sided game of rugby. Highlight how long students have been active for and the different intensity levels, and how these contribute to the 60 mins. **FMS Skills:** Arm/leg coordination will be addressed in this game as well as balance and aspects of the kick.
Teacher Reflection: Hand/eye co-ordination addressed in this unit? Students aware of increase in HR with intensity?	**Teacher Reflection:** Leg/eye co-ordination addressed in this unit? Students aware of importance of flexibility?	**Teacher Reflection:** Arm/leg co-ordination addressed in this unit? Students can identify benefits of PA participation and the 60 minutes guideline?

NET & FIELDING GAMES

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

HRA Focus: Meeting the daily 60 minutes guideline **FMS Focus:** Improving ability to crouch	**HRA Focus:** Working with a partner, Choice and success in PA environment **FMS Focus:** Improving ability to land on balls of feet	**HRA Focus:** Physical Activity (PA) –wellbeing/selfesteem, Choice and success in PA environment. **FMS Focus:** Improving ability to extend arms
Activity: *The Dig, Volleyball* 	**Activity:** *Court Positioning, Badminton* 	**Activity:** *Over arm throw, Rounders* 
HRA Focus: Student 1 feeds the ball 10 times, student 2 returns the ball through the dig action (rotate roles); 60 minute PA guideline addressed by teacher, students asked to identify other volleyball activities they could do to practice the dig but also to contribute to their 60 mins. **FMS Skills:** The ability to crouch is addressed when performing the dig. The balance skill is also addressed here and the hand/eye co-ordination component.	**HRA Focus:** Students respond to partner commands such as “right”, “left”, “forward” and “back”. Without racket initially, add in racket after few minutes. The pair can decide to modify the activity further by adding in more commands and including shuttle cock. **FMS Skills:** Moving on balls of feet is addressed here. Hand/eye co-ordination component and the balance skill may also be addressed in this activity.	**HRA Focus:** Students have choice to use underarm or over arm throw to hit target on wall. Students encouraged to move further back as they get better (this will encourage use of over arm to get greater distance). **FMS Skills:** Over arm throw skill is addressed in this activity, specifically the ability to extend arms.
Teacher Reflection: Crouch skill addressed in this unit? Students aware of the 60 minute guideline?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students aware of individual and partner activities?	**Teacher Reflection:** Arm extension addressed in this unit? Element of choice in physical activity?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

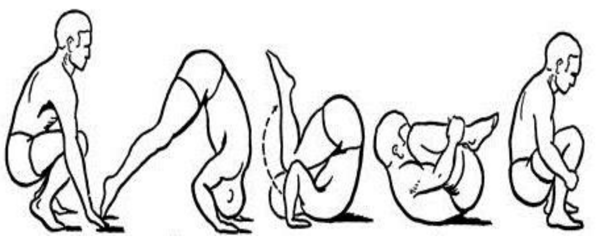
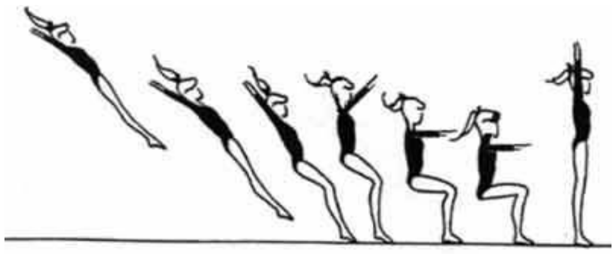
Youth - Physical Activity Towards Health

HRA Focus: Increased Heart Rate (HR)- Pulse taking **FMS Focus:** Improving ability to crouch and hand/eye co-ordination	**HRA Focus:** Individual and partner-based activities **FMS Focus:** Improving ability to extend arms	**HRA Focus:** Meeting the daily 60 minutes guideline **FMS Focus:** Improving ability to land on the balls of feet
Activity: *Badminton* 	**Activity:** *Handball* 	**Activity:** *Tennis* 
HRA Focus: Students play conditioned games of badminton while taking pulse before and after each game to see how the HR changes. **FMS Skills:** Hand/eye co-ordination will be addressed in this game as well as using balls of feet, arm extension and the ability to crouch.	**HRA Focus:** Students will take part in a game of handball first 1v1 and then in teams. They will note the difference in being a member of a team, and be able to recognise the value of both types of games. **FMS Skills:** Hand/eye co-ordination will be addressed in this game as well as using balls of feet and arm extension.	**HRA Focus:** Students will take part in a reactions game. Their partner will throw the ball anywhere in a defined zone and the player must run and return the pass. Highlight how active students are and the importance of the 60minute guideline. Link in with length of a real tennis match. **FMS Skills:** Hand/eye co-ordination will be addressed in this game as well as using balls of feet and arm extension.
Teacher Reflection: Crouch skill addressed in this unit? Students aware of increase in HR and know how to take their pulse?	**Teacher Reflection:** Ability to extend arms addressed in this unit? Students aware of individual and team activities?	**Teacher Reflection:** Landing on balls of feet addressed in this unit? Students aware of importance of 60 minute physical activity guidelines?

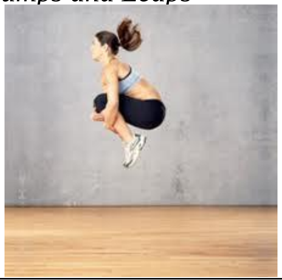
GYMNASTICS

Integrating HRA & FMS into Unit

School of Health & Human Performance, Dublin City University

HRA Focus: Cardiovascular Endurance (CVE) **FMS Focus:** Improving ability to crouch	**HRA Focus:** Flexibility **FMS Focus:** Improving ability to land on balls of feet	**HRA Focus:** Choice and Success in the PA environment **FMS Focus:** Improving leg/eye and arm/leg co-ordination
Activity: *90 second Gymnastics Routine* 	**Activity:** *Springboard Landing* 	**Activity:** *Balance on beam/bench* 
HRA Focus: Students work in groups and conduct a continuous 90 second gymnastics routine. Encourage students to make the routine challenging from a CVE perspective (without compromising safety), discuss the fitness levels of elite Gymnasts. **FMS Skills:** The ability to crouch is addressed when performing the forward roll in the routine. Balance, skip and run addressed in the routine performance. Components of horizontal and vertical jump incorporated also.	**HRA Focus:** Teacher introduces springboards to gymnastics lesson. All students opportunity to use equipment in class – working to own ability levels. Flexibility addressed during warm up and cool down, importance of flexibility in Gymnastics discussed. **FMS Skills:** Landing on balls of feet is addressed here. Run, vertical and horizontal jump addressed in this activity. Components of balance incorporated also. .	**HRA Focus:** Students have the option to walk, crawl, skip or jump etc on beam or bench. Students encouraged to challenge themselves and to try another mode of travel once one has been successfully accomplished **FMS Skills:** Use of beam and bench improves leg/eye and arm/leg co-ordination and balance.
Teacher Reflection: Crouch skill addressed in this unit? Students aware of the 60 minute guideline?	**Teacher Reflection:** Landing on balls of the feet addressed in this unit? Students conscious of flexibility component?	**Teacher Reflection:** Leg/eye and arm/leg co-ordination addressed in this unit? Element of choice in physical activity?

Don't be afraid to mix and match
the HRA focus to a different FMS focus.
For example:

HRA Focus: Choice and success in the PA environment **FMS Focus:** Improving ability to land on the balls of feet	**HRA Focus:** Flexibility **FMS Focus:** Improving ability to crouch	**HRA Focus:** Cardiovascular Endurance (CVE)**,** Choice and success in PA environment. **FMS Focus:** Improving leg/eye and arm/leg co-ordination
Activity: *Jumps and Leaps* 	**Activity:** *Floor exercises* 	**Activity:** *Routine Performance* 
HRA Focus: Students will be given a resource card/ shown a variety of jumps and leaps. They will then choose 3 and perform them. **FMS Skills:** Landing on balls of feet will be addressed in this activity as well as balance and aspects of the vertical and horizontal jump.	**HRA Focus:** Students will complete a variety of floor exercises such as the forward roll, teddy bear roll and straddle forward roll. They will see the importance of flexibility in executing these rolls, and discuss ways in which flexibility could be improved, and how this would impact the aesthetics of performance. **FMS Skills:** Ability to crouch will be addressed in this activity.	**HRA Focus:** Students will create and perform a routine including specific criteria such as 2 jumps, 2 rolls, 1 balance, but allowing individual choice within the criteria so that all can challenge themselves and experience success.. The importance of CVE when performing a routine like this will be discussed. **FMS Skills:** Leg/eye and arm/leg co-ordination will be addressed along with landing on balls of feet and balance.
Teacher Reflection: Landing on balls of the feet addressed in this unit? Element of choice in PA?	**Teacher Reflection:** Ability to crouch addressed in this unit? Students aware of flexibility in this activity?	**Teacher Reflection:** Leg/eye and arm/leg co-ordination addressed in this unit? Students aware of CVE and element of choice?