



**The design, development, implementation
and 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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The design, development, implementation and evaluation of the Youth-Physical Activity Towards Health (Y-PATH) intervention.

Wesley O' Brien

Abstract

Introduction: Recent evidence suggests that young people are insufficiently active to benefit their current and future health, and of particular note is the age related decline occurring during adolescence. Underpinning the necessity of an active lifestyle, fundamental movement skills (FMS) are deemed the building blocks for movement. Most recently, the World Health Organisation (WHO) identified the need for school-based policy interventions to increase physical activity (PA).

Purpose: The purpose of this research was the design, development, implementation and evaluation of a targeted whole school PA intervention (Y-PATH: Youth-Physical Activity Towards Health) for early adolescent youth (12 to 14 years) in Irish post-primary schools.

Methods: Information was gathered on participants (n = 256) levels of PA, BMI, and FMS proficiency. A sub sample of participants (n = 59) also participated in focus group interviews to explore their perceptions of health. Based on this data, and an exploration of the literature, the Y-PATH intervention was developed. A quasi-experimental, non-randomised controlled trial involving two schools was implemented to evaluate the Y-PATH intervention efficacy. Participants' data (n=174) was collected at 3 time points (pre, post and retention) on the following variables; PA levels, FMS proficiency and BMI.

Results: Both schools showed significant increases in daily PA and FMS proficiency over the three time periods. A repeated measures ANOVA showed a significant interaction effect between school attended and time for PA ($F(2, 38) = 6.177, p=0.005$) and FMS ($F(2, 100) = 4.132, p=0.019$), with a significantly greater increase in PA and FMS observed in the intervention school.

Conclusion: Preliminary findings provide support for the simultaneous focus on health related activity (HRA) and FMS in school PE class, along with parent and teacher involvement, in efforts to improve PA levels of adolescent youth. Further research involving a randomised trial with a larger sample size is warranted.

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Chapter 1

Introduction to the Thesis

1.1 Publications and Conference Proceedings

JOURNAL ARTICLES

O'Brien, W.R., Issartel, J & Belton, S. (*in press*). Evidence for the efficacy of the Youth-Physical Activity Towards Health (Y-PATH) intervention. *Advances in Physical Education*.

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REVISE AND RESUBMIT

O'Brien, W.R., Belton, S., & Issartel, J. Fundamental movement skill proficiency amongst adolescent youth. *Physical Education and Sport Pedagogy*.

O'Brien, W.R., Belton, S., & Issartel, J. Deciphering the adolescent obesity epidemic – Interaction effect between physical activity, fundamental movement skills and weight status. *European Physical Education Review*.

UNDER REVIEW

O'Brien, W.R., Issartel, J & Belton, S. The relationship between physical activity, screen time and weight status among adolescents. *Research Quarterly for Exercise and Sport*.

Belton, S., Issartel, J., Meegan, S., Woods, C., **O'Brien, W.R.** Y-PATH: Youth-Physical Activity Towards Health. Evidence and background to the development of a physical activity intervention for adolescents. *BMC Public Health*.

CONFERENCE PROCEEDINGS

O'Brien, W.R., & Hegarty, D. Current directions in physical activity research in Ireland. *PEPAYS Conference Proceedings.*

POSTER PRESENTATIONS

O'Brien, W.R., Belton, S., & Issartel, J. (2013). The effectiveness of the “Y-PATH” intervention in promoting adolescent fundamental movement skill proficiency. *Learning to Move, Moving to Learn conference, Cork (Ireland).*

O'Brien, W.R., Belton, S., & Issartel, J. (2013). A whole school approach in the implementation of the “Youth-Physical Activity Towards Health” intervention. *ISBNPA conference, Ghent (Belgium).*

O'Brien, W.R., Belton, S., & Issartel, J. (2013). A disturbing childhood trend towards high daily screen time can be interrupted through the effective implementation of the Youth Physical Activity Towards Health (Y-PATH) intervention. *European Child Health Conference, Dublin (Ireland).*

O'Brien, W.R., Belton, S., & Issartel, J. (2012). The “Health Benefits” of the relationship between physical activity, fundamental movement skills and body mass index in adolescent youth. *HEPA conference, Cardiff (UK).*

O'Brien, W.R., Duff, C., Belton, S., & Issartel, J. (2011). Y-PATH - Youth Physical Activity Towards Health. *AIESEP conference, Limerick (Ireland).*

Belton, S., **O'Brien, W.R.,** & Issartel, J. (2011). Subject compliance in field based motion sensor research. *ICAMPAM conference, Glasgow (UK).*

ORAL PRESENTATIONS

O' Brien, W.R. (2013). The evaluation of the Youth-Physical Activity Towards Health (Y-PATH) intervention. *PEPAYS Research Forum*, Dublin (Ireland).

O' Brien, W.R., Belton, S., & Issartel, J. (2012). Gender and school type differences in objectively measured physical activity in early adolescent youth. *European Youth Heart Symposium*, Madeira (Portugal).

O' Brien, W.R., Belton, S., & Issartel, J. (2012). "Health Related Activity" and "Fundamental Movement Skills" for physical activity promotion in Irish second level education. *European Youth Heart Symposium*, Madeira (Portugal).

O' Brien, W.R. (2012). Youth Physical Activity Towards Health (Y-PATH). *PEPAYS Research Forum*, Limerick (Ireland).

Belton, S., **O'Brien, W.R.,** Issartel, J. (2011). Physical activity level and motor skill mastery of Irish youth: Influence of gender. *AIESEP conference*, Limerick (Ireland).

INVITED SPEAKER – RESEARCH WORKSHOP

O'Brien, W.R., & Kirwan, K. (2013). Engaging Teenagers. *Learning to Move, Moving to Learn conference*, Cork (Ireland).

1.2 Introduction

1.2.1 Progressive Development as a Researcher

In September 2006, upon commencing a Bachelor of Education Degree in Physical Education, a question was posed during day one of the university's induction programme; why do you want to pursue the career of Physical Education (PE) teaching? Albeit, I was naive, my immediate response was:

“I want to make a positive contribution to the health and wellbeing of Irish post-primary youth.”

Four years later in September 2010, another thought provoking question was asked of me during an interview for the ‘Youth-Physical Activity Towards Health’ (Y-PATH) PhD research study; why have you applied for this full-time position in Irish adolescent Physical Activity (PA) promotion? Despite my limited research experience prior to the interview, my response was based on the most recent evidence-based literature and specific to the Irish environmental context:

“Recent Irish research amongst 12 to 18 year old adolescent youth suggests that 1 in 4 are now overweight, obese and/or have high blood pressure.”

“I will embrace this challenge in helping to combat obesity levels amongst young people in Ireland.”

In recent weeks a postgraduate student asked me; why do you want to increase adolescent PA levels? As this question absorbed, I seamlessly constructed my response, heavily grounded within the most relevant Irish research:

“In Ireland, evidence suggests that only 12% of Irish post-primary youth are meeting the PA guidelines for current and future health benefits and only 10% of post-primary youth receive the recommended minimum number of minutes for PE per week. These are just two of the many culturally relevant yet alarming statistics in the field of youth PA in Ireland.

Now more so than ever, it is time for change; it is time to map the importance of innovation within PA intervention research; it is time to provide an evidence-base for PA intervention effectiveness amongst this critically important population in Ireland.”

1.2.2 Setting the Scene in Ireland - Why Physical Activity?

A recent report published for the ‘Lancet PA Series Working Group’ (Lee et al., 2012) highlighted that the incidence of non-communicable disease in Ireland which can be attributed to physical inactivity include: 8.8% Coronary Heart Disease, 10.9% Type II Diabetes, 15.2% Breast Cancer, 15.7% Colon Cancer and 14.2% all cause mortality. This evidence-based article relating to physical inactivity is not a new ‘phenomenon’ and supports many other pieces of scholarly work, particularly amongst young people (BHF National Centre for Physical Activity and Health, 2013a; Lee et al., 2012; Moore et al., 2012; Woods et al., 2010).

In Ireland the most recent cross-sectional data, from the “Children’s Sport Participation and Physical Activity Study” (CSPPA) (Woods et al., 2010), found that only 14% of 10 to 18 year olds were meeting the national recommended PA guidelines of at least 60 minutes moderate to vigorous physical activity (MVPA) everyday (Department of Health and Children, 2009). In terms of age, the CSPPA study found that 13% of females aged 12-13 years old and 24% of males the same age self-reported at least 60 minutes MVPA daily. By ages 14 to 15 years old, there was a decline in those meeting the PA guidelines with 8% and 16%, of females and males, respectively accumulating 60 minutes MVPA daily. These low levels of PA, the associated age-related decline in PA, and the evident gender differences amongst Irish adolescents are in line with the World Health Organization’s (WHO) report entitled the ‘Health Behaviour in School-Aged Children’ (HBSC) study (Currie et al., 2012). When we consider the global rise in the incidence of obesity (Al-Nakeeb et al., 2007; Centers for Disease Control and Prevention, 2011; Mitchell et al., 2013; Wang and Lobstein, 2006) and ‘sedentariness’ (Biddle, Cavill, et al., 2010; De Bourdeaudhuij et al., 2012; Rey-López et al., 2008) amongst youth, the Irish statistics for young people’s weight status and screen time pursuits are again consistent. There is now evidence to suggest that one in four Irish children (N= 1215; 13.4 ± 2.1 yrs) are unfit, overweight, obese and/or have high blood pressure (Woods et al., 2010). Furthermore, Canadian Sedentary Behaviour Guidelines (Tremblay et al., 2011) recommend ‘limiting recreational screen time to no more than two hours per day’, in an Irish context less than 1% of children and youth self-reported to meet this minimum sedentary behaviour guideline (Woods et al., 2010). Worldwide evidence indicates that time spent in sedentary behaviour increases as children age,

paralleled by a decline in PA participation (Biddle, Pearson, et al., 2010; Jones et al., 2013; Marshall et al., 2002).

In 2010, the U.S. National PA Plan containing a comprehensive set of policies, programmes and initiatives to increase PA (Evenson et al., 2013) was disseminated to PA practitioners working in public health. In an Irish context, the outlined low levels of PA and high prevalence of overweight/obesity amongst youth may in part be attributed to the fact that Ireland, unlike the U.S., has no public health policy for PA. It is therefore particularly concerning that the young people of Ireland are no longer choosing to lead a physically active lifestyle and are continuing to develop higher levels of obesity. For these reasons, it is unsurprising why Woods et al., (2010) suggested as part of their strategic advice for PA promotion in Ireland to ‘Invest in People as the Human Resource’, particularly children. Furthermore, Woods et al., (2010) suggest that ‘Fundamental Movement Skill’ (FMS) programmes aimed to develop the overall skills and abilities of youth common to all sports and activities are warranted in Ireland.

1.2.3 Setting the Scene in Ireland – Why Fundamental Movement Skills?

Young people engage in sports and activities that develop foundation skills (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). Recent evidence from Sport New Zealand (2012) found that activities such as swimming, athletics and gymnastics aimed at developing young people’s FMS all featured in the top 10 sports and activities which young people take part in. FMS are the basic observable patterns of behaviour present from childhood to adulthood; often examples exhibited during PE and PA include running, hopping, skipping (locomotor), balancing, twisting (stability), throwing, catching and kicking (object control) (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006; Stodden et al., 2008). In terms of literature findings, researchers now argue that children and young people have the developmental potential to master many FMS by 6 years of age (Gallahue and Ozmun, 2006). For this reason, it seems logical, therefore, to suggest that these basic movement patterns should be already mastered by early Irish adolescents aged between 12 to 14 years old. Furthermore in terms of youth PA promotion, FMS are now considered a potentially viable correlate, due to their positive relationship with PA (Fisher et al., 2005; Lubans et al., 2010; Okely et al., 2001; Wrotniak et al., 2006). Interestingly, McKenzie et al. (2002) examined childhood FMS as a

predictor of PA in adolescents and found no significant association between variables. More recently, Barnett et al. (2009) conversely found that adolescent time in MVPA was positively associated with childhood object control proficiency.

From this conflicting evidence, it appears that additional research is necessary to heighten our understanding of FMS, particularly in the adolescent context. In Ireland, there is a noticeable absence of data in relation to adolescent FMS proficiency, clearly indicating a gap within the literature. Considering that the development of FMS proficiency during PE instructional periods are now positively associated with PA participation amongst young people (Kalaja et al., 2012; Mitchell, McLennan, et al., 2013; Van Beurden et al., 2003), this is an area that merits exploration in the Irish context.

1.2.4 PE Background and Overview in Ireland

A plethora of scientific research supports the role of PE in the prevention of chronic illness, increase of PA and promotion of healthy lifestyle behaviours (Le Masurier and Corbin, 2006; Sallis et al., 2012; Trudeau and Shephard, 2005; Woods et al., 2010). During childhood and adolescence, PE during school hours provides a unique opportunity to practice and reinforce skills likely to enhance lifelong fitness and good health (European Commission et al., 2013). In Ireland, the PE curricula at both primary and post-primary level developed by the National Council for Curriculum and Assessment (NCCA) consist of a number of similar strand units, namely, athletics, outdoor and adventure activities, aquatics, dance, gymnastics and games (Department of Education and Skills, 2003, 1999). With the exception of the health-related activity (HRA) strand at post-primary level (Department of Education and Skills, 2003), a large proportion of content within both of these PE curricula often overlap.

At Irish primary level, PE classes are delivered by non-specialist teachers posing challenges for effective PA intervention. A recent European report (European Commission et al., 2013) on 'Physical Education and Sport at School' found that Irish primary schools had the lowest minimum time of PE teaching per year (37 hours total) across 30 countries. Many other factors impede full implementation of the primary PE curriculum, including poor facilities, a lack of equipment, large class sizes and insufficient teacher education and ongoing professional development (Irish National Teachers Organization, 2007). Yet, with all these difficulties and

barriers, primary schools in Ireland are encouraged to adopt a flexible approach in their PE curricula delivery, and to offer a range of individual and team based choices to participants (Department of Education and Skills, 1999).

In the United States, the characteristics of quality PE at middle and secondary school level have been identified by the National Association for Sport and Physical Education (NASPE) as instructional periods totalling 225 minutes per week (NASPE, 1995). In an Irish context, the Department of Education and Skills (DES) recommends that every post-primary pupil have a minimum of 120 minutes of PE per week; yet, most recent evidence suggests that Irish post-primary PE provision is the fourth lowest in Europe (European Commission et al., 2013). In 2010, research in Ireland indicated that only 10% of post-primary schools met the DES recommended minimum minutes of PE per week (Woods et al., 2010). Most recent evidence suggests that PE policies, their implementation, and PE environmental variables can have positive implications (Lounsbery et al., 2013). In their recent policy guidelines aligned to the HBSC results, the World Health Organization (Currie et al., 2012) identifies the need for interventions to increase PA in young people; in an Irish context, the school-based PE climate appears to be a sensible intervention setting.

1.2.5 Intervention Evidence and Examples

Observations from many systematic reviews over the last decade highlight that multi-component school-based interventions can increase PA during and outside of school hours amongst youth (Kahn et al., 2002; Kriemler et al., 2011; Salmon et al., 2007; Van Sluijs et al., 2008). One of the most effective strategies accepted in the literature for youth PA promotion is to provide enhanced PE focusing on increasing lesson time, providing substantial MVPA and the delivery of programmes by well-trained specialists (Le Masurier and Corbin, 2006; McKenzie and Lounsbery, 2009; McKenzie et al., 2004, 2001; Physical Activity Guidelines Advisory Committee, 2012; Sallis et al., 2012, 1997). In the United States, a health-related PE programme ‘Sports, Play and Active Recreation for Kids’ (SPARK) (Sallis et al., 1997) is the most evaluated evidence based PE programme in the world. SPARK PE lessons consist primarily of two parts: 1) health-fitness activities (cardiovascular endurance, abdominal and upper body strength) and 2) skill fitness activities (sports units such as basketball and soccer) (Sallis et al., 1997). The

original evaluation (Sallis et al., 1997) was done with fourth and fifth grade students (mean age range 9.49 to 9.62 years) to test the effectiveness of its curriculum, led by PE specialists or trained classroom teachers, as compared to traditional PE programmes. It was found that students spent significantly more minutes per week being physically active in specialist-led (40 min) and teacher-led (33 min) PE classes than in control classes (18 min). Since its inception, the SPARK intervention has evolved to include programmes for a variety of age groups (Ward et al., 2007).

Similar to SPARK, the 'Middle School Physical Activity and Nutrition' (M-SPAN) intervention had a specific focus and awareness on health-related PE. M-SPAN consisted of an enhanced PE programme, targeting middle school students (11-14 years old), through curricular materials, staff development, and on-site follow-up (McKenzie et al., 2004). The main results, after a two-year implementation period, highlighted a significant increase of 18% in MVPA during PE class (McKenzie et al., 2004).

Another Australian school-based PE intervention, 'Move it Groove It' in New South Wales (Van Beurden et al., 2003), aimed at simultaneously improving FMS and PA amongst children aged 7 to 10 years old. This intervention delivered significant increases in movement skill proficiency for both genders and for PA levels, the intervention was associated with a non-significant increase in MVPA (Van Beurden et al., 2003). In terms of targeting FMS during class time, this is the first study to show that by modifying existing PE lessons, substantial gains in movement skill proficiency can be gained without adversely affecting children's MVPA levels. While not as prevalent in the literature amongst adolescents, most recent evidence (Kalaja et al., 2012) examined the development of early adolescents FMS and PA in a PE intervention setting. This adolescent study found significant improvements in the balance, overall movement proficiency and PA as a result of the intervention programme. In a European context for early adolescents, this is one of the first interventions to explicitly highlight the potential of simultaneously developing FMS and increasing PA through PE.

Understanding the effective components from these established interventions can inform future intervention design, development and evaluation. Yet, some unanswered questions from these evidence-based programmes remain and many future challenges in terms of developing novel approaches towards intervention innovation exist. Irish PA interventions for young people appear to be calling for new and previously untried material. A recent commentary (Narayan et al., 2013) entitled 'Beyond magic bullets: True innovation in health care' suggested that :

“Success in the evolving health-care environment will need to broaden their definition of innovation even further and move towards developing novel 'integrated solutions'.”
(Narayan et al., 2013, p.1)

1.2.6 Summary and Significance of Study

In Ireland, this PhD research study is a unique longitudinal pilot exploratory intervention trial describing the design, development, implementation, and evaluation of the Y-PATH ‘Whole-School Approach’ to PA promotion amongst Irish adolescents. Specifically, the synchronized holistic integration of the student, teacher, parent, community and efficacy of online resource utility is rich in originality and rooted within previously successful intervention evidence. With the recently documented low levels of youth PA in Ireland and the resulting threat of ill health (rising levels of obesity and sedentariness), the initiation of the Y-PATH intervention is timely, innovative and indeed novel. This feasible and cost-efficient intervention programme is the first of its kind in an Irish adolescent population, which simultaneously targets the increase of PA and FMS proficiency along side the promotion of health education through the deliverable mechanism of PE by trained qualified specialists. It is equally important to acknowledge that there is a dearth of sufficient data and literature in relation to adolescent FMS proficiency both in Ireland and worldwide; this study will address this absence by providing contextual information relating to movement skill proficiency amongst 12 to 14 year old Irish youth.

The Y-PATH study was initiated at Dublin City University in 2010, in accordance with the Medical Research Council (MRC) (2000) framework for trials of complex interventions. Specifically, this framework (as shown in Figure 1.1 below) served as a template for the phases of investigation in the evaluation of the Y-PATH programme. This PhD will address the Pre-clinical, Phase 1 (Modelling) and Phase 2 (Exploratory Trial) of this MRC framework.

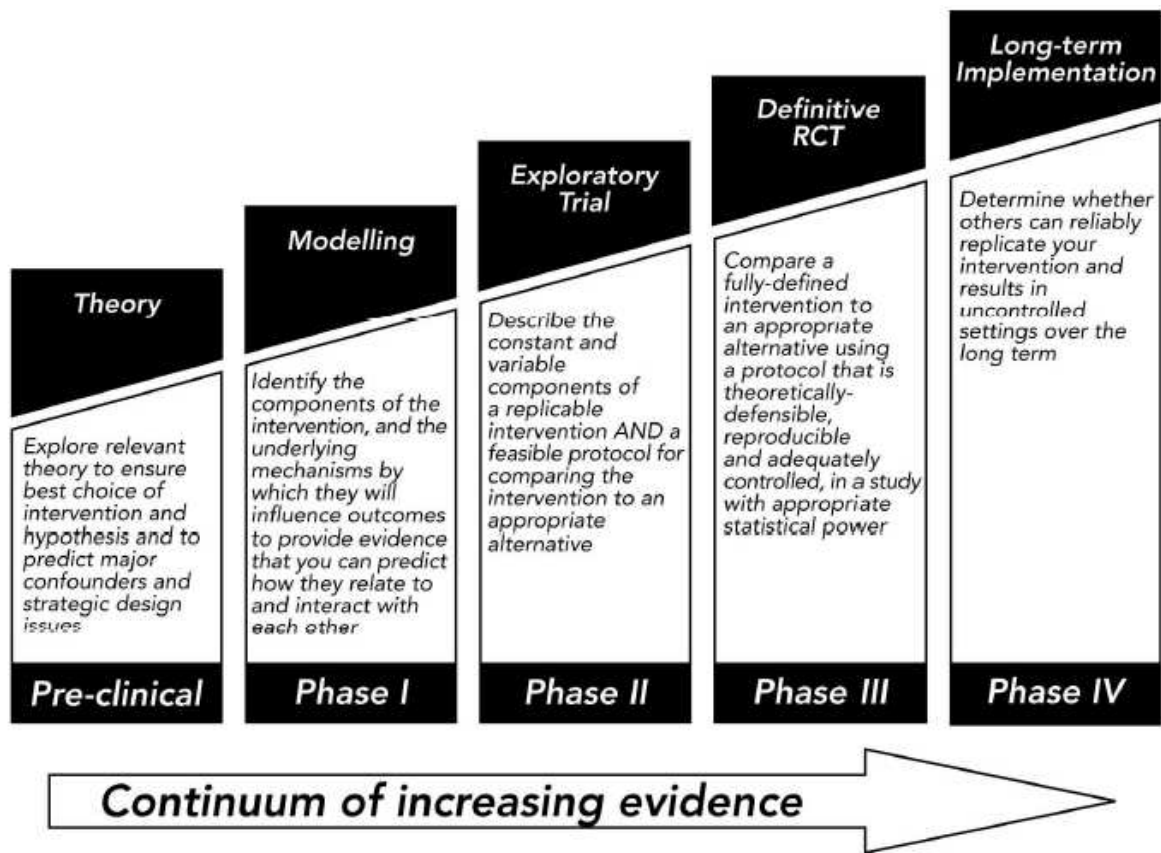


Figure 1.1: Medical Research Council - Phases of investigation in the evaluation of a complex intervention

1.3 Aim and Objectives of the study

Aim of Research

- To design, develop, implement, and evaluate a targeted school-based intervention designed to promote the quantity and quality of participation in PA within and outside of school among Irish youth.

Primary Objectives

1. To collect baseline data (2010-2011) on PA, FMS, body mass index (BMI), psychological correlates and focus groups of 12 – 14 year old Irish youth (*chapter 3*).
2. To extensively monitor levels of FMS proficiency, specifically at the behavioural component level across all skills (*chapter 4*).
3. To evaluate if involvement in the Y-PATH intervention leads to an overall increase in minutes of MVPA participation in the experimental group over time, and in comparison to a control group (*chapter 6*).
4. To assess changes in levels of FMS proficiency (pre, post and retention) of the experimental group receiving the intervention, and to make comparisons to a control group (*chapter 6*).

Secondary Objectives

1. To examine if an overall relationship between PA participation, FMS proficiency and weight status existed amongst 1st year post-primary youth at pre-test (*chapter 7*).
2. To examine possible differences in both PA participation and screen time according to the weight status of 1st year post-primary youth at pre-test (*chapter 8*).

1.4 Research Questions

1. What are the PA levels of Irish post-primary youth aged 12 to 14 years of age (at baseline, 2010-2011)?
2. What are the FMS proficiency levels amongst a large sample of rural Irish adolescent youth (again at baseline, 2010-2011)?
3. What are the essential components required for developing, designing and implementing an Irish adolescent PA promotion intervention (as guided by the literature and baseline data measurements)?
4. Is it possible to increase levels of PA and FMS proficiency over time (pre-test, post-test and retention) in 12 – 14 year old youth through the Y-PATH intervention, specifically the focus on health education and FMS (moving away from the traditional approach to PE instruction)?
5. Finally, in terms of pre-test data (prior to any intervention roll-out), is there an associated relationship between 1) PA, FMS and the weight status of Irish post-primary youth?
2) PA, screen time and the weight status of Irish post-primary youth?

1.5 Thesis Structure

Following this introduction, chapter 2 critically reviews and evaluates youth PA literature. Chapters 3 to 6 are the primary objectives of this thesis consisting of studies relating to the design, development, implementation and evaluation of the Y-PATH intervention amongst early adolescent youth aged 12 to 14 years old in Ireland. Chapters 7 and 8 are cross-sectional studies exploring the pre-test data gathered prior to the intervention roll-out and are considered secondary outcome objectives of this thesis.

Chapter 2 – *Review of Literature*: Following from Chapter 1, this first introductory chapter, the review of literature outlines the various concepts, findings and evidence upon which this thesis is based.

Chapter 3 - *Y-PATH: Youth Physical Activity Towards Health. Evidence and background to the development of a physical activity intervention for adolescents*. This third chapter examines the baseline PA and FMS data of 12 – 14 year old Irish adolescent youth, along with data on current and preferred types of PA, and various psychological correlates of PA. Focus group interviews were then used to explore barriers and motivators to PA of the cohort. Based on the data analysis, chapter 3 introduces the reader to the development of the ‘Y-PATH’ intervention specifically tailored for the needs of this age group.

Chapter 4 - *Fundamental Movement Skill Proficiency Amongst Adolescent Youth*. One of the main pillars for the Y-PATH intervention was FMS integration within PE; for this reason, the levels of FMS proficiency needed to be assessed amongst an Irish adolescent cohort in order to inform the development of the intervention. This chapter assesses the performance of nine FMS in a sample (n=223) of 12-14 year old adolescent youth during PE class prior to intervention roll-out. The findings on the prevalence of skill mastery according to gender are documented and illustrated for intervention provision considerations. The chapter further assesses the range of FMS at the component level of performance with the objective to identify common weaknesses within and between FMS. The unique FMS component analysis of this chapter has guided the research team and helped inform the development of the Y-PATH intervention, specifically the delivery of the modified PE curriculum for 1st year post-primary youth. Collectively, chapters 3

and 4 combined provided meaningful information for the overall design and development of the Y-PATH intervention.

Chapter 5 - *An overview of the Y-PATH intervention – components and content.* Chapter 5 introduces the reader to the rationale for the Y-PATH intervention and most importantly, gives an accurate and descriptive account of the intervention components. In chapter 5, the reader will be introduced to the guiding principles of the PE-based intervention, specifically the educational focus.

Chapter 6 – *Evidence for the efficacy of the Youth-Physical Activity Towards Health (Y-PATH) intervention.* The purpose of chapter 6 was to provide preliminary evidence in the evaluation of the Y-PATH intervention after 9 months (end of academic school year) and 12 months (follow-up), respectively. Chapter 6 evaluates the effect of the Y-PATH intervention on daily PA participation and levels of FMS proficiency when compared to the control condition.

Chapter 7 – *Deciphering the adolescent obesity epidemic - relationship between physical activity, fundamental movement skills and weight status.* A secondary objective of this thesis (using pre-test data) is explored in this chapter by investigating possible differences in both PA participation and FMS proficiency according to the weight status of early adolescent youth. The chapter further determines if an overall relationship between PA participation, FMS proficiency and weight status exists amongst early Irish adolescent youth aged 12 to 14 years old.

Chapter 8 - *Relationship between Physical Activity, Screen Time and Weight Status Among Adolescents.* This final chapter examines possible differences in both PA participation and screen time behaviours according to the weight status of early Irish adolescent youth prior to intervention roll-out.

1.6 Definition of Terms

Accelerometer: An accelerometer is a small device which when worn on the body can provide quantitative information relating to the vertical accelerations of the trunk and body segments at user-specified time (Dale et al., 2002; Trost, 2007; Trost et al., 2005). Accelerometers derive PA data pertaining to intensity, frequency, pattern and duration (Berlin et al., 2006).

Body Mass Index: A measure of body composition using a height-weight formula - Weight (kg) / Height (m²). High BMI values have been related to increased disease risk (Corbin et al., 2006).

Children and Young People: Used to describe those aged 5-18 years. The term children is used when specifically referring to those aged 5–12 years and the term young people when referring to those aged 13-18 years (BHF National Centre Physical Activity and Health, 2013b).

Fundamental Movement Skills: Fundamental movement skills are the basic observable patterns of behaviour present from childhood to adulthood; often examples exhibited during PE and PA include running, hopping, skipping (locomotor), balancing, twisting (stability), throwing, catching and kicking (object control) (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006; Stodden et al., 2008).

Locomotor Subtest: In the context of FMS, the locomotor subtest measures the gross motor skills that require fluid coordinated movements of the body as the child moves in one direction or the other (Ulrich, 2000).

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

Moderate Intensity Physical Activity: Activities usually equivalent to brisk walking, which might be expected to leave the participant feeling warm and slightly out of breath (Cavill et al., 2001).

Non-communicable disease: A non-communicable disease is a medical condition or disease which is not contagious and is non-transmissible among people (BHF National Centre Physical Activity and Health, 2013b).

Obesity: Excessive fat accumulation that may impair health (Corbin et al., 2006).

Object Control Subtest: In the context of FMS, the object control subtest measures gross motor skills that demonstrate efficient throwing, striking, and catching movements (Ulrich, 2000).

Physical Activity: Physical activity is described as any body movement produced by the skeletal muscles that results in a substantial increase over resting energy expenditure (Bouchard et al., 2007). Examples of physical activity include play, lifestyle activities such as walking and cycling (active transport), sport and recreational activities, household chores and gardening (BHF National Centre Physical Activity and Health, 2013b).

Physical Activity Intervention: Programmes which are defined as planned efforts to influence individuals, groups, or populations to alter, modify, and increase their physical activity or exercise levels, with the ultimate goal of producing positive health outcomes (Bouchard et al., 2007).

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

Physical Inactivity: Physical inactivity is described as doing no or very little physical activity at work, home, for transport or during discretionary time - not reaching physical activity guidelines deemed necessary to benefit public health (Bouchard et al., 2007).

Post-Primary Education: Students are required to complete between five to six years of post-primary education in Ireland (pending the students decision to undertake transition year upon completion of the junior cycle). Most often, students complete the junior cycle (lower secondary education) between the ages of 12 and 15 and then the senior cycle between the ages of 15 and 18 years old (higher secondary education) (Department of Education and Skills, 2004)

Reliability: Reliability is a determination of whether two administrations of an instrument produce a similar result (Thomas et al., 2011).

Screen Time: Mean daily hours of television, videos and computers/computer games. High screen time is considered greater than 2 hours per day (Anderson et al., 2008).

Sedentary Behaviour: Sedentary behaviour refers to activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, and watching television, and other forms of screen-based entertainment. (Pate et al., 2008). The low energy requirements distinguish sedentary behaviours from other behaviours that also occur whilst seated but require greater effort and energy expenditure, eg, using a rowing machine (BHF National Centre Physical Activity and Health, 2013b).

Static Balance: In the context of FMS, the static balance is the essential prerequisite of almost all movement skills. A static balance is defined as being able to maintain a stationary position throughout the movement. The static balance on one foot is an important non-locomotor skill that is used in gymnastics, dance, diving and many team sports (NSW Department of Education and Training, 2000).

Test of Gross Motor Development 2: Criterion- and norm-referenced instrument designed to measure the process of how children coordinate their trunk and limbs during FMS (a movement task) rather than assessing the end product result (Ulrich, 2000).

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

Vigorous Intensity Physical Activity: Activities usually equivalent to at least slow jogging which might be expected to leave the participant feeling out of breath and sweaty (Cavill et al., 2001).

1.7 List of Abbreviations

BMI = body mass index

BOT-2 = Bruininks-Oseretsky Test of Motor Proficiency-2

CI = confidence interval

CVE = cardiovascular endurance

DCU = Dublin City University

DCUREC = Dublin City University Research Ethics Committee

DLW = doubly labelled water

FMS = fundamental movement skills

H/D = hours per day

HR = heart rate

HRA = health related activity

M = mean

MIN/DAY = minutes per day

MNM = mastery and near mastery

MVPA = moderate-to-vigorous physical activity

PA = physical activity

PE = physical education

SD = standard deviation

TGMD-2 = test of gross motor development-2

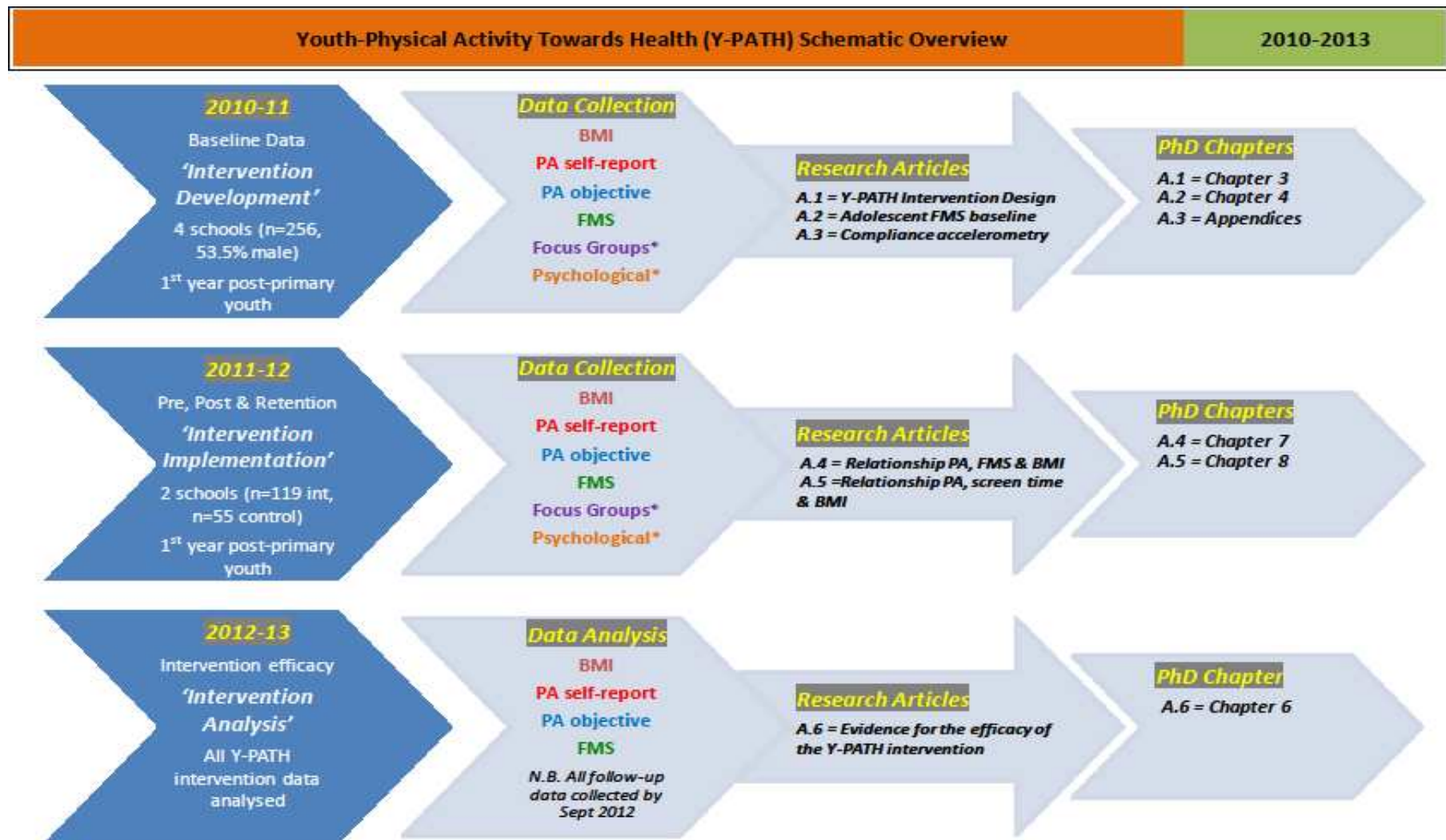
VPA = vigorous physical activity

Y-PATH = Youth-Physical Activity Towards Health

1.8 Delimitations

1. This Y-PATH study was delimited to first year post-primary youth in the age bracket of 12 to 14 years inclusive.
2. The Y-PATH PE component of the intervention was delimited to PE specialists teaching first year post-primary classes only. All PE specialists within the school not teaching first year students were excluded from the Y-PATH study.
3. This intervention study was carried out in two mixed gender-schools (1 intervention, 1 control) with 174 participants initially providing consent during the pre-testing phase of September 2011. Participants from single sex schools were not considered.
4. PA measurement amongst 12 to 14 year olds was delimited to self-report and accelerometer techniques. Other PA measurement tools such as direct observation, pedometers and heart rate monitoring were not utilised at any stages within the longitudinal phases of data collection.
5. The study was delimited to the examination of participants' fundamental gross motor skill proficiency. Fine motor skill proficiency was not considered.

1.9 Schematic Overview



Note. * = Data were collected as part of the Y-PATH programme but were not a primary PhD responsibility of Mr. Wesley O' Brien

Key Acronyms. BMI = body mass index; PA = physical activity; FMS = fundamental movement skills; Y-PATH = Youth - Physical Activity Towards Health; int = intervention school; A.1 = article 1 etc..... ;

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Chapter 2

Review of Literature

Literature Review

2.1 Physical Activity

The purpose of section 2.1 is to review the relevant literature regarding physical activity (PA) participation and assessment in children and young people. The first theme explored is the rationale for participation in PA.

2.1.1 Rationale for Participation in Physical Activity

During the last century, lifestyle changes to people in industrialised countries has resulted in the decline of people engaging in PA (Bouchard et al., 2007). As PA has diminished, sedentary pursuits such as television viewing, playing computer games and using the internet have become the preferred mode of passive entertainment in daily living, particularly amongst young people (Bickham et al., 2013; Biddle, Cavill, et al., 2010; Biddle, Pearson, et al., 2010; Oliver et al., 2012). With the rise of “sedentariness” (Rey-López et al., 2008) worldwide, people need to become aware that regular PA is an essential element of a healthy lifestyle during childhood and adulthood (Fulton et al., 2004; Lee et al., 2012; BHF National Centre Physical Activity and Health, 2013b). The meaning of PA has remained consistent amongst public health professionals over the last two decades and a standardised PA definition has become accepted as any bodily movement produced by the skeletal muscles that results in a substantial increase over resting energy expenditure (Bouchard et al., 2007; Caspersen et al., 1985; Woods et al., 2010; BHF National Centre Physical Activity and Health, 2013b). Under this broad and diverse definition, PA considers leisure time physical activity, exercise, sport, transportation, occupational work and chores (Bouchard et al., 2007).

There is now a plethora of strong research evidence demonstrating that the physical fitness and health status of children and adolescent youth are substantially enhanced by regular PA participation (Physical Activity Guidelines Advisory Committee, 2008; Dobbins et al., 2013; Rauner et al., 2013). Recent evidence also highlights that the amount of time spent being sedentary is an important risk factor for several aspects of ill health, including overweight and obesity and associated metabolic diseases (Biddle et al., 2011; Biddle, Cavill, et al., 2010; Owen et al., 2009; Troiano et al., 2012). A previous American Cancer Society study found that

increased periods of sitting significantly reduced lifespan; furthermore, this finding was independent of PA and exercise levels (Patel et al., 2010). A recent report conducted by the American PA Guidelines Advisory Committee found that, when compared to inactive young people, physically active children and youth:

“have higher levels of cardiorespiratory endurance and muscular strength, and well-documented health benefits include reduced body fatness, more favourable cardiovascular and metabolic disease profiles, enhanced bone health, and reduced symptoms of anxiety and depression.” (Physical Activity Guidelines Advisory Committee, 2008, p. A2-A3)

It has now become evident that regular PA participation decreases numerous health risks for children and youth and is associated with a reduced risk of developing chronic disease such as coronary heart disease, type II diabetes, cancers and hypertension (Cavill et al., 2001; Fulton et al., 2004; BHF National Centre for Physical Activity and Health, 2013a; Woods et al., 2010). Chronic diseases are the most serious public health burden that the world faces today (World Health Organization, 2002). Physical inactivity has been well established as one of the leading risk factors for non-communicable (not contagious and is non-transmissible) disease (Lee et al., 2012). Most recent evidence (Murray et al., 2013) highlights that two-thirds of the burden of cardiovascular diseases can be attributed to the combination of all physical inactivity and dietary components. In 2010, physical inactivity was identified as the fourth leading risk factor for global mortality causing an estimated 6% of deaths globally (World Health Organization, 2010); most recent research, indicates that physical inactivity was attributed to 5.3 of the 57 million deaths worldwide in 2008 (Lee et al., 2012).

From the evidence outlined, it is clear that many of the leading causes of ill health in today's society could be prevented if more inactive people were to become active (World Health Organization, 2010). In terms of identifying target populations, there is an escalating prevalence of youth physical inactivity (Currie et al., 2012; Eaton et al., 2012; Woods et al., 2010) and an unprecedented rise in the incidence of obesity in the last decade amongst young people (Al-Nakeeb et al., 2007; Centers for Disease Control and Prevention, 2011; Mitchell, Pate, et al., 2013; Wang and Lobstein, 2006). Naturally, children and adolescents have become the centre of attention for the promotion of PA to enhance health and reduce levels of overweight and obesity. From a European perspective, surveillance data indicates that the proportion of overweight and

obese children has dramatically increased in the last 30 years through emergent growing trends (Ledergerber and Steffen, 2011). In the UK, the prevalence of overweight children aged 7 to 11 years old rose from 8% to 20% between 1984 and 1998 (Lobstein et al., 2003). In Spain, overweight prevalence among children aged 6 to 7 years old rose from 23% to 35% in the period 1985 to 1996 (Moreno et al., 2002). Most recent Irish cross-sectional data from the “Children’s Sport Participation and Physical Activity Study” found that one in four children (N= 1215; 13.4 ± 2.1 yrs) were unfit, overweight or obese and had high blood pressure (Woods et al., 2010). There is now a platform of evidence from the literature highlighting that lower body mass index (BMI) and girth is inversely associated with greater PA levels (Andersen et al., 2006; Ekelund et al., 2012, 2004; Metcalf et al., 2011; Mitchell, Pate, et al., 2013), indicating that PA is an important mechanism in maintaining healthy body weight and preventing the chronic health conditions connected with obesity (Woods et al., 2010; BHF National Centre Physical Activity and Health, 2013b). PA levels have the potential to positively impact on life expectancy; most recent evidence suggests that individuals classified as active but overweight have an equal life expectancy as active and normal weight individuals (Moore et al., 2012).

2.1.2 Physical Activity and Sedentary Behaviour guidelines

In the previous section, physical inactivity and sedentary behaviour were recognised as important determinants for chronic disease among young people (Biddle et al., 2011; Cleland et al., 2013; Lee et al., 2012; World Health Organization, 2010; Wennberg et al., 2013). Yet documenting the scientific evidence about the importance of regular PA participation among youth is of little value if the target population cannot practically apply this behaviour to their lives. Therefore, for the past three decades, there has been gradual and progressive development in the dissemination of information relating to PA participation and sedentary behaviour among young people (Biddle et al., 2011; Strong et al., 2005; Tremblay et al., 2011; Twisk, 2001) through public health messages known as PA guidelines for health (Bouchard et al., 2007; Department of Health and Children, 2009) and sedentary behaviour guidelines and recommendations (Currie et al., 2012; Tremblay et al., 2011).

In 1988, the American College of Sports Medicine (ACSM) developed a Position Stand (American College of Sports Medicine, 1988) on the quantity of PA needed for optimal functional capacity and health by proposing that children and adolescents should obtain 20 to 30

minutes of vigorous intensity activity each day. Vigorous intensity emerged in the late 1980's as the recognition of importance for moderate-intensity PA had evolved during the early 1980's through a growing body of research evidence (Bouchard et al., 2007). Ten years later in 1998, a policy framework for young people's PA was proposed through the primary recommendation that:

“all young people should participate in physical activity of at least moderate intensity for one hour per day.” (Biddle et al., 1998, p.3)

In addition, inactive young people were to participate in physical activity of at least moderate intensity for at least half an hour per day (Biddle et al., 1998). These recommendations also flagged that young people should engage in bone strengthening exercises at least twice a week (Biddle et al., 1998). Figure 2.1 below illustrates these recommendations launched at the 1998 Health Education Authority Symposium.

<i>Recommendations for Young People and Physical Activity</i>	
<i>Primary Recommendations</i>	<i>Secondary Recommendations</i>
All young people should participate in physical activity of at least moderate intensity for one hour per day.	At least twice a week, some of these activities should help to enhance and maintain muscular strength and flexibility, and bone health.
Young people who currently do little activity should participate in physical activity of at least moderate intensity for one hour per day	

Figure 2.1: Health Education Authority Symposium ‘Young and Active’ (Biddle et al., 1998); the policy for young people and health-enhancing physical activity.

At present, the most recent and widely endorsed PA guideline in the US and UK stipulates that in order to enhance health and fitness benefits, youth should accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily (Physical Activity Guidelines Advisory Committee, 2012; BHF National Centre for Physical Activity and Health, 2013a). Consistent with the UK and US, the current Irish PA guidelines for health specify that all children and young people (2-18 years) should be active, at a moderate to vigorous level, for at

least 60 minutes everyday incorporating muscle strengthening, flexibility and bone strengthening exercises up to 3 times a week (Department of Health and Children, 2009).

Interestingly, the UK PA guidelines for children and young people were updated in 2011 (Department of Health, Physical Activity, Health Improvement and Protection, 2011). The key difference between the 2011 UK PA guidelines (Department of Health, Physical Activity, Health Improvement and Protection, 2011) and the current Irish PA guidelines (Department of Health and Children, 2009) for youth has been the addition of a new guideline relating to reducing the amount of sedentary behaviour. In 2011, these UK guidelines specified that all children and young people should minimise the amount of time spent being sedentary (sitting) for extended periods (Department of Health, Physical Activity, Health Improvement and Protection, 2011).

This sedentary behaviour guideline acknowledged by the UK in 2011 is supported by recently published recommendations from the Canadian Sedentary Behaviour Guidelines for Children (5-11 years of age) and Youth (12-17 years of age) (Tremblay et al., 2011) which state that for health benefits, recreational screen time should be limited to no more than 2 hours per day. Recent findings suggested that women are 94% more likely to die prematurely if sedentary for more than 6 hours a day (Patel et al., 2010). Evidence in Ireland and from many other countries worldwide, highlight that there is a now a need to develop specified sedentary behaviour guidelines for children and youth (Hamilton et al., 2008; Woods et al., 2010).

To summarise, many of the recent PA guidelines worldwide for children and youth have seen the inclusion of vigorous physical activity (VPA) in recognition of i) the additional health benefits, ii) the commonality of a minimum of 60 minutes PA per day and iii) the inclusion of activities to strengthen muscle and bone. Yet, to promote these guidelines effectively, it is critical that researchers and clinicians have access to precise and practical tools for PA measurement in children and adolescents (Troost, 2007).

2.1.3 Physical Activity Measurement

In the aforementioned section, the worldwide PA and sedentary behaviour guidelines for health among children and youth were outlined with the evidence suggesting that the case for PA promotion is now a public health priority (BHF National Centre Physical Activity and Health, 2013a; Sallis et al., 2012; Woods et al., 2010). In conjunction with the advocacy for PA promotion, it is critical for researchers and clinicians to access practical tools for measuring PA

among children and adolescents; previous research identifies that varying methods are available to measure and assess the complex behaviour of PA in population surveillance (Bauman et al., 2006). Evidence over the last decade identifies two types of PA measurement for young people: self report and objective techniques (Kohl et al., 2000; Trost, 2007).

The purpose of this section, therefore, is to provide an overview of the current methods for measuring PA in children and adolescents; particular attention will be given to the validity and reliability of accelerometry and self-report measurement techniques. Each type of PA measurement technique discussed carries certain strengths and weaknesses (Hands et al., 2006; Kohl et al., 2000; Trost, 2007). This further adds to the debate in identifying the most appropriate tool for measuring PA in young people (Corder et al., 2009; Ward et al., 2005) due to the multiple dimensions of PA which include frequency, duration, intensity and type (Trost, 2007).

2.1.3.1 Self-Report Physical Activity Measurement

As acknowledged above, a variety of self-report methods have been used to assess PA in children and adolescents (Trost, 2007) including self-administered recalls, interviewer administered recalls, diaries, and proxy reports completed by parents and teachers. Self report techniques are the most widely used measure of PA (Hands et al., 2006; Murphy, 2009) with the most frequently cited advantages including ease of administration, the ability to characterize activity historically, and low cost. A recent study suggests that self-report methods are important for assessing aspects of PA not easily measured objectively, namely types of activity (Corder et al., 2008). Trost (2007) highlights that self report is commonly used in epidemiological research due to the impracticality of objective measurement techniques.

Despite the convenience of self-report PA measurement, limitations include participants inability to accurately recall activities and difficulties associated with quantifying the time of activity (Hands et al., 2006; Trost, 2007). Previous evidence reviewing and synthesising the reliability and validity of PA assessment techniques among children and adolescents highlights that self-report recall methods should not be used among children younger than ten years of age (Kohl et al., 2000). In addition, young children may not fully understand the concept of PA; previous evidence from Trost et al., (2000) who investigated children's (mean age 9.8 ± 0.3 years) understanding of PA highlighted that 60% of participants had difficulty in differentiating between sedentary activities and active pursuits. Other evidence (Belton and Mac Donncha,

2010), conversely provide support for the use of a validated self-report tool designed specifically for use with younger populations in PA measurement. With this conflicting evidence, it appears that precise caution must be exercised when attempting to use self-report instruments in children aged ten years and younger.

Valid and reliable measures of PA are a necessity in studies designed to document the frequency and distribution of PA (Armstrong, 1998; Kohl et al., 2000) with a number of evidence based reviews for self-report in children and adolescents (Troost, 2007). Corder et al. (2009) investigated whether it was possible to assess free-living PA in young people (12 -13 yrs) by self-report; this study provided evidence for the concurrent validity of the Youth Physical Activity Questionnaire (YPAQ). The Y-PAQ was found to have a moderate correlation with accelerometry ($r=0.42$, $p<0.05$), suggesting that this instrument is valid at ranking MVPA. Furthermore, of the four questionnaires assessed in this study (Corder et al., 2009), Y-PAQ was the most reliable questionnaire, which showed excellent test retest reliability coefficients for MVPA (0.92^3). Chinapaw et al., (2010), in a systematic review of PA questionnaires for youth, found that correlations between self-report measures of PA and accelerometer scores are significantly strengthened in adolescent populations (mean age >12 and <18 years) compared to children (mean age >6 and <12 years). Authors of this systematic review (Chinapaw et al., 2010) recommend using accelerometry in either a full sample or subsample in conjunction with a valid self-report instrument to heighten the strength of PA accuracy.

2.1.3.2 Objective Physical Activity Measurement

The low-validity coefficients observed for self-report instruments in young children (Armstrong, 1998; Kohl et al., 2000; Trost, 2007) suggests that objective measurements of PA may be most appropriate for older children (Rowlands and Eston, 2005; Troiano et al., 2008; Trost, 2007; Ward et al., 2005). Objective PA measures are now considered most appropriate in overcoming the limitations associated with self-report in older populations (Murphy, 2009).

The following five objective techniques for PA measurement will be discussed:

1. Direct observation
2. Doubly labelled water
3. Heart rate monitoring
4. Pedometers
5. Accelerometers

1. Direct Observation: Direct (systematic) observation is the formal observation (by trained individuals) typically consisting of observing a child at home or in school for extended periods of time and recording data into either a computer or coding form providing an instantaneous rating of the child's PA level (Trost, 2007). Recent research observing PA and its contexts suggests that direct observation exceeds other PA measurement techniques by providing contextually rich data on the social and physical environment (McKenzie, 2010). PA category ratings are often recorded during direct observation on a momentary time-sampling basis at time intervals ranging from 5 seconds to 1 minute (Trost, 2007). PA has been assessed via direct observation for a number of years in a variety of naturalistic settings (McKenzie et al., 2006, 2000, 1991; Trost, 2007). Direct observation has the advantage of being able to describe what took place in the PA setting (Dale et al., 2002). For this reason, many consider direct observation as the gold standard of PA assessment in that it will provide the most accurate quantitative and qualitative information about PA, particularly for those interested in assessing group PA in open environments (Sirard and Pate, 2001; McKenzie, 2010). As with any measure, direct observation does have certain disadvantages: extensive time is required to train observers, the length of the observation period, the complexity associated with data-coding and the huge expense associated with this highly labour intensive measurement (Trost, 2007). Direct observation is therefore often confined to minor studies over brief periods of time (Dale et al., 2002; Sirard and Pate, 2001).

Over the years, many types of PA observation systems have received considerable attention for use in specific environments, for example at home and in PE classes (McKenzie, 2010), namely the 'BEACHES' (Behaviors of Eating and Activity for Children's Health: Evaluation) and 'SOFIT' (System for Observing Fitness Instruction Time) systems (McKenzie, Sallis, and Nader, 1991; McKenzie, Sallis, Nader, et al., 1991). The BEACHES evaluation

system provides data on children's PA and sedentary behaviour at home and their selected environmental variables which may influence these events (McKenzie, Sallis, Nader, et al., 1991). Another observation system requiring trained observers is SOFIT, an instrument primarily used within PE classes lessons (McKenzie, Sallis, and Nader, 1991). A recent study (McKenzie, 2010) outlines that SOFIT provides simultaneous 3-phase data on student PA levels, the lesson context and teacher interactions relative to promoting PA and fitness. In more recent years, systematic observations of youth PA levels have emerged in school play areas (SOPLAY – system for observing play and leisure in youth), community and park settings (SOPARC – system for observing play and active recreation in communities) and free-play environments (SOCARP – system for observing children's activity and relationships during play) (McKenzie et al., 2006, 2000; Ridgers et al., 2010). While each of the five observation systems (BEACHES, SOFIT, SOPLAY, SOPARC and SOCARP) use similar codes for PA, only two focus on assessing group PA in open environments (McKenzie, 2010), namely SOPLAY and SOPARC.

From this short overview of direct (systematic) observation, it appears that much research has been generated towards assessing PA in a wide variety of environmental settings (homes, schools, parks and recreation centres); for these reasons, systematic observation in PA is a unique measurement in children for which the type of activity, the place, the time and the setting is robustly observed.

2. Doubly labelled water: Doubly labelled water (DLW) is considered one of the most accurate secondary measures of PA as the technique represents an unobtrusive and non-invasive means to measure total daily energy expenditure (Troost, 2007). DLW has been acknowledged as the gold standard technique to measure energy expenditure over time (Murphy, 2009). This method uses isotope ingestion to provide a direct measure of carbon dioxide production and an accurate estimate of energy expenditure in PA (Sirard and Pate, 2001; Troost, 2007). DLW has been validated in adults and children by comparison with indirect calorimetry as this technique has proven to be accurate to within 5% to 10% of energy expenditure (Troost, 2007). Indirect calorimetry measures energy expenditure and is the most common criterion measure for laboratory-based studies (Troost, 2007). DLW is considered hugely expensive and unsuitable for PA measurement of large groups in the field however (Dale et al., 2002; Kohl et al., 2000).

3. *Heart Rate Monitoring:* Heart rate is not a direct measure of PA, but a measure of the relative stress being placed on the cardiopulmonary system by the activity (Armstrong, 1998). As an objective measure of PA, heart rate monitors are relatively inexpensive providing multiple day storage capacity for minute-by-minute heart rates (Troost, 2007). These monitors are now considered a more feasible method providing good information on intensity, frequency and duration of activity (Dale et al., 2002; Kohl et al., 2000; Sirard and Pate, 2001). Heart rate monitors are an acceptably valid and reliable measure of PA (Brage et al., 2006; Troost, 2007). There are of course disadvantages; data can be lost through signal interruptions, other factors beside PA can influence heart rate (such as stress and tiredness for example), the financial expense and participant discomfort can occur over extended periods of time (Dale et al., 2002; Sirard and Pate, 2001; Troost, 2007).

4. *Pedometers:* A cost effective alternative to direct observation, DLW and heart rate monitoring is the electronic pedometer (Troost, 2007). Pedometers are used to directly measure the number of step counts taken over a period of time (Craig et al., 2010; Duncan et al., 2008; Tudor-Locke et al., 2010). Hands et al., (2006) compared the validity of pedometer counts to ratings obtained from directly observed free play. Results from this study highlighted a strong correlation (.90) between pedometry and direct observation during free play, indicating that the pedometer may be useful in research studies to provide a simple, reliable, and valid measurement of PA in young people (Hands et al., 2006). Another study (Tudor-Locke et al., 2002) reviewing 25 articles determined pedometers to be strongly correlated with accelerometers (median $r = 0.86$) and time observed in activity (median $r = 0.82$). Pedometers however, are insensitive to some forms of movement and generally do not possess real-time data storage or downloading capabilities (Troost, 2007). Thus, accelerometers have been shown to be the most useful tools for quantifying PA amongst youth (Berlin et al., 2006; De Vries et al., 2011; De Vries et al., 2006; Troost, Pate, et al., 2000).

5. *Accelerometers:* Berlin et al., (2006) highlight that accelerometers derive PA data pertaining to intensity, frequency, pattern and duration. Activity monitors have been developed in response to the lack of reliability of self-report, the intrusiveness of direct observation, the complexity of heart rate monitoring (Puyau et al., 2002) and the lack of quantitative information

provided by the pedometers (intensity, duration, etc). Accelerometers provide quantitative information relating to the vertical accelerations of the trunk and body segments at user-specified time (Dale et al., 2002; Trost, 2007; Trost et al., 2005). Accelerometers are considered an effective PA measurement instrument for children and adolescents because of their small size, robust design and relatively modest cost (Dale et al., 2002; De Vries et al., 2006; Trost et al., 2005; Yildirim et al., 2011). Many studies report a strong correlation between accelerometer output and energy expenditure and/or exercise intensity (Freedson et al., 2005; Trost, 2007). A study comparing MVPA as measured by accelerometry and the SOFIT direct observation technique highlights that a correlation of $r = .77$ ($p \leq .01$) was demonstrated (Scruggs et al., 2005).

The most widely used accelerometer used in pediatric research is known as the ActiGraph, formerly known as the MTI and CSA 7164 (Freedson et al., 2005; Trost, 2007; Trost et al., 2002). The ActiGraph accelerometer is an extensively validated accelerometer among children and adolescents (De Vries et al., 2011; De Vries et al., 2006; Trost, 2007) which has been in existence for over 20 years (Bassett and John, 2010). These small devices are usually worn at the waist (Bassett and John, 2010) and should be as close as possible to the body's centre of mass (Trost et al., 2005). There are numerous commercial ActiGraph accelerometers on the market (Crouter et al., 2013; Sasaki et al., 2011; Trost, 2007). One of the most recent versions of the ActiGraph model is the GT3X (John et al., 2010) which measures movement in three planes. Previous studies hypothesised that that the triaxial accelerometer may be better at capturing children's activity than a uniaxial accelerometer (De Vries et al., 2006; Freedson et al., 2005). Most recent evidence (Sasaki et al., 2011), which validated and compared the ActiGraph GT1M (uniaxial) and GT3X (triaxial) found that there were no significant inter-monitor differences in vertical axis counts. This finding (Sasaki et al., 2011) further rationalises that high inter monitor agreement between ActiGraph GT1M and GT3X exists and that counts between both types of devices are comparable on the vertical axis, suggesting that both types of these ActiGraph monitors can be used during field research.

Standardizing and optimising the use of accelerometer data for free-living PA monitoring is now a core consideration (Esliger et al., 2005) for young people. Screening data is one such consideration (Esliger et al., 2005; Masse et al., 2005) with evidence now suggesting to 1) omit the first day to allow for subject reactivity and 2) screening spurious data $\geq 15,000$ counts per

minute which exceeds biological plausibility among youth (Esliger et al., 2005). The minimum number of days that youth wear the accelerometer has important implications for compliance and habitual levels of PA (Basterfield et al., 2011; Trost, Pate, et al., 2000). Research conducted by Trost (2007), indicates that the number of monitoring days required to achieve a reliability of 0.80 varies considerably between studies from 4 – 9 days amongst youth; the 7 day monitoring protocol now appears most sensible for youth (Sirard et al., 2008; Sutherland et al., 2013; Troiano et al., 2008). An accurate representation of habitual PA amongst youth requires participants to provide a minimum of 600 minutes recorded wear time per day (Anderson et al., 2005; Masse et al., 2005; Nyberg et al., 2009). Recent evidence highlights that the minimum number of valid days required for inclusion in analysis is 3 weekdays and 1 weekend day (Gorely et al., 2009; Rowlands et al., 2008). Furthermore, in order to increase participant compliance with meeting these wear time criteria, receiving an SMS reminder message each morning significantly enhances wearing the accelerometer (Belton et al., 2013) (see appendix K). Most recent evidence (Lounsbery et al., 2013) highlights that compliance was strengthened when schools offered monetary incentives for participation; similarly another recent study (Sirard and Slater, 2009), found that compensation strategies resulted in the highest participation rates and quality data for inclusion.

With the extensive use of the ActiGraph accelerometer (De Vries et al., 2011; De Vries et al., 2006; Trost, 2007), considerable controversy exists about how to covert PA output into estimates of PA intensity (Trost, 2007). The existence of numerous sets of intensity-related PA cut points for many accelerometer models has significantly hindered research efforts to quantify, understand, and intervene on youth PA behaviour (Trost, 2007). Most recent evidence suggests that at least five sets of youth specific ActiGraph cut-points have been independently developed, namely Evenson, Freedson, Mattocks, Puyau and Treuth cutpoints (Evenson et al., 2008; Freedson et al., 2005; Mattocks et al., 2007; Puyau et al., 2002; Treuth et al., 2004). When determining minutes of accelerometer derived data (e.g. minutes of MVPA per day), researchers must choose among multiple sets of cut-points that substantially vary in magnitude and consequently, report varying estimates of PA participation amongst youth (Trost et al., 2011). The recently published comparative validity of accelerometer cut-points for predicting activity intensity in youth (Trost et al., 2011) was a welcome addition to the research literature and a positive move towards a standardised approach to accelerometer data reduction. From this study

(Troost et al., 2011), the Evenson minute by minute cutpoints (Evenson et al., 2008) for sedentary, light, moderate and vigorous PA appear the most appropriate and validated amongst youth allowing researchers to reach a consensus regarding the application of intensity-related accelerometer cut points for children and adolescents.

This section summarised the key attributes for the most commonly used methods (self-report, direct observation, DLW, heart rate monitoring, pedometers and accelerometers) of free living PA measurement among children and adolescents. A descriptive overview for each type of measurement was outlined by addressing the key concepts of validity, reliability, gold standards, feasibility and practicality. Furthermore, all methods were assessed on ability to measure frequency, intensity, type or time of activity.

It must be noted that no single measurement is appropriate for all purposes as most recent evidence suggests that objective and subjective measures may reflect different constructs and contexts of PA and sedentary behaviour (Syväoja et al., 2013). The outlined evidence suggests that for early adolescents aged between 12 to 14 years old, a combination of self-report and accelerometry may be a sensible approach (Chinapaw et al., 2010). Specifically, the recently validated and reliable YPAQ questionnaire (Corder et al., 2009) and the extensively validated ActiGraph accelerometer (De Vries et al., 2011; De Vries et al., 2006; Trost, 2007) may be most appropriate for youth of this age. With such a questionnaire and stringent accelerometer inclusion criteria, an accurate assessment of youth PA and sedentary behaviour levels can be made.

2.1.4 Physical Activity Levels

The evidence to date highlights that regular PA in children and adolescents promotes health and fitness (Physical Activity Guidelines Advisory Committee, 2008; Dobbins et al., 2013; Rauner et al., 2013). In the past, the development of chronic diseases and illnesses have been rare in children (Physical Activity Guidelines Advisory Committee, 2012) but a growing body of literature is now showing 1) that the prevalence of these risk factors is increasing during adolescence (May et al., 2012; Woods et al., 2010) and 2) that levels of PA decline dramatically during adolescence (Kimm et al., 2000; O'Donovan et al., 2010; Ortega et al., 2013). Despite the known importance and associated benefits of regular PA in promoting lifelong health and well-being, lack of measurement precision has made it difficult for researchers to truthfully determine

the proportion of children and adolescents meeting the recommended PA guidelines for health (Riddoch et al., 2004; Sisson and Katzmarzyk, 2008). The principal barrier to progress in this field has been the lack of a valid measurement instrument that can capture the full complexity of PA behaviour in youth (Riddoch et al., 2004). Yet recent evidence worldwide resulting from both self-report and objective PA measurements (Aibar et al., 2012; Currie et al., 2012; Eaton et al., 2012; Riddoch et al., 2004; Troiano et al., 2008; Woods et al., 2010) found that the majority of youth are not meeting the recommended guideline of 60 minutes of PA everyday (Physical Activity Guidelines Advisory Committee, 2012).

The most recent Health Behaviour in School-Aged Children (HBSC) study (Currie et al., 2012) found that in Ireland, 31% of females aged 11 years old and 43% of males the same age self-reported accumulating at least 60 minutes of MVPA daily. By age 13, a substantially lower 20% of females and 36% of males report to be meeting this PA guideline (Currie et al., 2012). The low levels of PA, the associated age related decline in PA, and the apparent gender differences reported in this HBSC study for Ireland was consistent with almost all countries surveyed in the Currie et al. (2012) study. Similarly, many other international studies acknowledge age related differences in PA levels, with a noticeable decline occurring during adolescence and into adulthood (Kimm et al., 2000; O'Donovan et al., 2010; Riddoch et al., 2004; Trost et al., 2002; Twisk, 2001). A recent systematic review (Dumith et al., 2011) further observed PA changes during adolescence, with the majority of studies assessed by questionnaire; findings indicated that although the decline among girls was higher in younger ages (9–12 years), it was higher in older ages (13–16 years) among boys. Acknowledging this age-related decline, many international studies also demonstrate clear gender differences in PA engagement, with males appearing to be significantly more active than females in the majority of cases (Currie et al., 2012; Eaton et al., 2012; Riddoch et al., 2004; Sisson and Katzmarzyk, 2008; Woods et al., 2010). The Riddoch et al., (2004) study is one of the first to report objectively measured accelerometer PA data in a representative sample (n = 2185) of European children aged 9 to 15 years old; this study confirmed that significant gender differences in PA exist with boys 21% and 26% more active than girls respectively, at 9 and 15 years of age. More recent updated evidence (Kaczynski et al., 2013) examined gender differences in the directly observed (SOPARC) MVPA of children and adolescent youth in diverse areas of 4 parks in Kansas City, Missouri. Results from this recently published study further complement the existing evidence

with male adolescent youth more active on playgrounds and pools or splashpads than female youth.

Most recent nationally representative Irish data (n=5397; mean age=13.8 ± 2 years) from the 'Children's Sport Participation and Physical Activity Study' (CSPPA) (Woods et al., 2010) found that only 18% of adolescents aged 12 to 13 years old self-reported meeting the recommended 60 minute MVPA guideline everyday. The CSPPA findings are similar to previous studies in recent years on youth PA levels in Ireland (Fahey et al., 2005; Woods et al., 2007). Compared to Irish adolescents, recent research in the US (Eaton et al., 2012) found that a higher percentage of adolescents (29%) self-reported achieving the recommended 60 minute MVPA guideline. Similarly, a recent systematic review of PA levels in Canada and the United States observed between 26.5% (self-report) to 45.7% (pedometry/accelerometry) of youth (<18 years) meeting the recommended guidelines (Foulds et al., 2013). The prevalence of PA amongst Irish adolescents is also very low when compared in a European context with 35.9% of adolescents (14.45 ± 0.67 years) in France and Spain meeting the 60 minute guideline (Aibar et al., 2012) when measured by ActiGraph GT3X accelerometry.

Examining the sedentary behaviours of children and youth has also emerged in recent years (Biddle, Pearson, et al., 2010; Marshall et al., 2002). Many studies now provide evidence that a high proportion of children and adolescent youth engage in high amounts of daily television viewing, video games, with screen time recreation (defined as two or more hours of television, computer and/or video game usage) being the most common (Eaton et al., 2012; Hardy, King, Espinel, et al., 2010; Oliver et al., 2012). The recent HBSC report (Currie et al., 2012) found that between 63% to 65% of adolescents (13 to 15 years old) worldwide watch television for more than 2 hours per day on weekdays; it is likely that if time spent playing computers or video games been added to this value in the HBSC report, this statistic for sedentary behaviour would be much higher. From an Irish perspective, this concerning trend towards sedentary behaviour seems most apparent, with less than 1% of children and youth (Woods et al., 2010) meeting the Australian Government health recommendations of no more than 2 hours of screen time during daylight hours (Department of Health and Ageing, 2004). The evidence now suggests that the daily sedentary behaviours of young people are increasing (Basterfield et al., 2012; Biddle et al., 2011; Ekelund et al., 2012; Ortega et al., 2013).

It has been documented that PA is a preventive measure and strategy against health problems such as obesity and other related chronic diseases (Bouchard et al., 2007; Lee et al., 2012; Organization, 2010). The literature suggests that there is a clear need to increase the current PA levels and decrease sedentary behaviours among children and adolescents (Biddle, Pearson, et al., 2010; Currie et al., 2012; Woods et al., 2010). In order to address low PA levels and high sedentary behaviour engagement amongst youth, additional attention is warranted to examine the factors that predict PA amongst youth, including individual and environmental correlates (Giles-Corti and Donovan, 2002).

2.1.5 Correlates of Physical Activity

Correlates of PA amongst youth have been identified as including biological, psychological, social/cultural, and physical environmental (Sallis et al., 2000; Van Der Horst et al., 2007). Based on the existing low levels of youth PA worldwide (Currie et al., 2012; Oliver et al., 2012; Troiano et al., 2008), researchers and practitioners are particularly interested in identifying which factors are the most modifiable and responsive to intervention to increase PA (Kenyon et al., 2012). Understanding the factors that influence PA among children and adolescents can aid in the design of more long-term effective interventions for increasing PA and decreasing time spent in sedentary behaviours (Bauman et al., 2012; Leggett et al., 2012; Sallis et al., 2000; Uijtdewilligen et al., 2011).

There are many variables that have an effect on youth PA participation, with substantial evidence documenting how children and young people are influenced by their parents, peers, and siblings (Fitzgibbon et al., 2012; Kahn et al., 2002; Salmon et al., 2007; Trost et al., 2003; Van Sluijs et al., 2008), as well as their environment (Bouchard et al., 2007; Sallis et al., 2000; Van Der Horst et al., 2007). These different variables are often associated with the terms ‘correlates’ and/or ‘determinants’ which are used interchangeably throughout various review articles in young people (Sallis et al., 2000; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007); in this literature review, the term ‘correlates’ will be used primarily. Evidence from a quality synthesis of prospective studies (Uijtdewilligen et al., 2011), examining the factors that influence PA and sedentary behaviour in young people, highlight that more attention should be paid to the different types of correlates of behaviour, such as the psychological and social influences of PA during the development of interventions.

2.1.5.1 Psychosocial Influences (Predisposing Factors) on Physical Activity

In the literature, the terms ‘psychological’ (Uijtdewilligen et al., 2011) and ‘psychosocial’ are often used interchangeably when examining the PA correlates amongst youth; for the purpose of this literature review, the specific terms as used in each of the individual research papers will be referenced. A recent study (Crimi et al., 2009) examining the psychosocial correlates of PA in children and adolescents suggests that the factors for young people’s engagement in regular PA include attitudes towards PA, perceived physical competence, and parental support. The Youth Physical Activity Promotion (YPAP) model (Welk and Schaben, 2004; Welk, 1999) is a theoretical model developed in order to gain a greater insight and understanding of the factors that influence youth PA behaviours. Some research suggests that the YPAP model (shown in Figure 2.2 below) is one of the few that have been designed specifically to explain the influences on youth PA (Crimi et al., 2009).

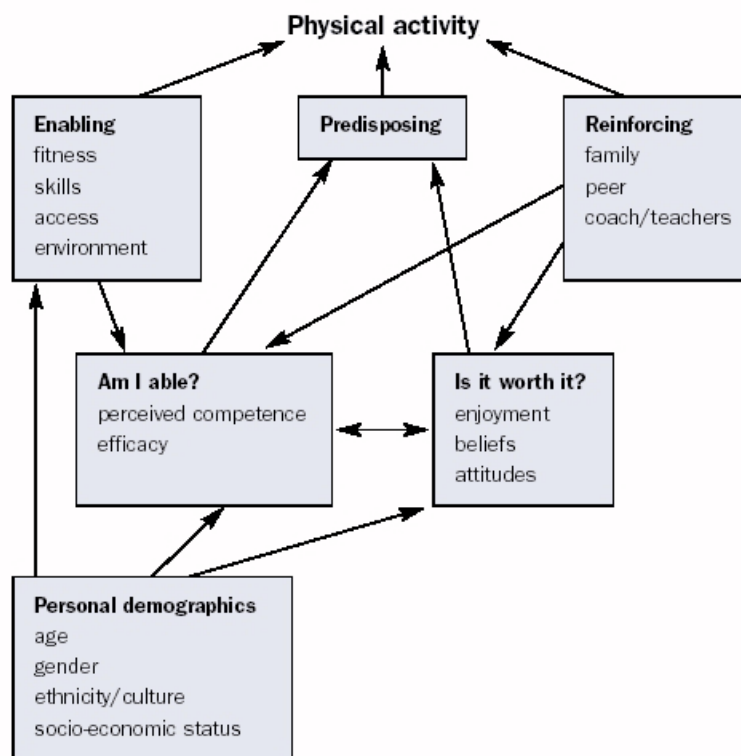


Figure 2.2: A conceptual diagram of the Youth Physical Activity Promotion Model highlighting the different variables that lead to physical activity (taken from Australian Sports Commission adapted from Welk, 1999)

The YPAP model suggests that different predisposing (the likelihood that youth will participate in PA), reinforcing (the influences that encourage participation), and enabling factors (child's physical skills, access to facilities, and physical fitness) can directly influence youth PA participation (Welk and Schaben, 2004; Welk, 1999). The model was constructed based on a variety of studies that found significant correlations between these broad areas of influence (Crimi et al., 2009). A previous study conducted on 296 children (mean age= 12.4 ± 1.3 years) provides good internal validity evidence and acceptable external validity evidence for a brief set of questionnaire items to investigate the theoretical basis for the YPAP model (Rowe et al., 2007). In light of this evidence, the YPAP model serves as an effective theoretical basis for intervention design; more research, however, is warranted in order to evaluate this model on youth, particularly regarding the predisposing and reinforcing factors (Crimi et al., 2009).

The predisposing factors of the YPAP model are the variables that have a strong influence on the likelihood that a child will engage in regular PA, examples include self-efficacy, attitudes and beliefs (Crimi et al., 2009). A comprehensive review which examined the correlates of PA in the literature from 1970 to 1998 (Sallis et al., 2000) found significant positive associations between PA and self-efficacy, and PA and attitudes in adolescents aged between 13-18 years of age. A more recent review by Van Der Horst et al., (2007) examined the correlates of PA and included studies published between January 1999 and January 2005; of the 40 included adolescent related studies, 28 examined psychological correlates with attitude, self efficacy and goal orientation found to be most positively associated with PA. Specifically, this review (Van Der Horst et al., 2007) found a positive association between PA and self-efficacy in 14 studies. No association was found between PA and perceived benefits, self perception, fun/enjoyment and depression. Evidence linking PA and intention, perceived barriers and sport competence was also found to be inconclusive (Van Der Horst et al., 2007).

Over the past decade social-cognitive research has specifically identified self-efficacy for PA as a strong correlate of PA among children, youth and adults (Davidson et al., 2010; Dishman et al., 2004; Pan et al., 2009; Trost et al., 1999). Perceived self efficacy is defined as the belief in ones capabilities to organise and execute the courses of action required to manage prospective situations (Bandura, 1994). A recent study examining the neighbourhood influences of PA and body weights among Canadian children reinforces that self efficacy is the confidence to participate in PA (Davidson et al., 2010). A previous study (Allison et al., 1999) examining

the relationship between self-efficacy and participation in vigorous PA amongst youth highlighted that self-efficacy is predictive of PA. The Dishman et al. (2004) study provides additional evidence that targeting self efficacy increases PA among black and white adolescent girls. As a strategy for youth PA promotion, there is now sound evidence to suggest that the use of self-efficacy as a targeted, mediator variable in interventions seems appropriate (Sallis et al., 2000; Trost et al., 1999; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007). While the importance of self-efficacy is outlined above for youth PA promotion, most recent evidence suggest that mechanisms other than self-efficacy may be more important for increasing PA among adults (Olander et al., 2013).

2.1.5.2 Social Influences (Reinforcing Factors) on Physical Activity

The reinforcing factors of the YPAP theoretical model are different to the predisposing factors, since they are conditions that support a child's physical activity behaviours (Crimi et al., 2009). These include supportive influences and variables such as family, peers, teachers and coaches. Social support can be defined as a 'system by which an individual receives assistance, reinforcement and or stimuli in daily living' (Trial of Activity for Adolescent Girls, 2004). Some recent evidence would suggest that social support is a potentially important mediator of increased PA in young people (Morgan et al., 2008; Oliver et al., 2010; Van Lippevelde et al., 2012) and has been targeted by several intervention programmes (Fitzgibbon et al., 2012; Haerens et al., 2006). A systematic review of literature examining the correlates of PA participation for adolescent girls (Biddle et al., 2005) found that peer support had an indeterminate effect on PA, with three studies reporting a positive effect and three studies reporting no effect. However, family support was found to have a small to moderate effect on PA levels in seven of the eight studies reviewed (Biddle et al., 2005). Thirteen studies included in the Van Der Horst et al., (2007) review examined social variables as correlates of activity. Family influences and friend support were found to be positively associated with PA. Craggs et al., (2011) reviewed prospective quantitative studies investigating change in PA and determinants of change in children and adolescents. A total of 46 studies were included in the analysis, 31 of these used self-reported PA measurements. Higher scores on social support measures were found to be consistently associated with smaller declines in adolescent PA levels,

further supporting the importance of social support in promoting and maintaining youth PA engagement.

During the last decade, a detailed study of the leisure time pursuits of Irish adolescents (12-18 years old) was conducted by Connor (2003). A total of 312 adolescents were interviewed and completed a questionnaire as part of this study protocol. A common theme which emerged from the interviews (Connor, 2003) was the influence exerted by the family unit on adolescent PA levels.

“It was a tradition, it was in the family. Everyone in my family and area either played hurling or camogie.” (Female aged 14)

Similarly, Vu et al., (2006) used focus groups in the ‘Trial of Activity for Adolescent Girls’ (TAAG), and found that the majority of adolescent girls identified the family to be the most positive influential factor in their decisions to be physically active. Davison et al. (2011) examines the supporting influences on US adolescents PA levels. Results highlighted that both boys and girls in the high activity group reported significantly higher levels of paternal logistic support, peer support and sibling support than adolescents in the low activity group. A recent study conducted by the British Association of Sport and Exercise Sciences (O’Donovan et al., 2010) examining the ABC of PA for health highlights that it is critical for beginners to find activities they enjoy and gain support in becoming more active from family and friends.

From the outlined studies and research relating to the reinforcing factors of the YPAP model, there appears to be robust evidence that parental and peer support, whilst also coming from a ‘sporty family’ can positively contribute towards youth PA participation. Strategic advice by Woods et al. (2010) on increasing the PA participation levels of Irish children and youth indicates that family and teacher support are crucial influences for developing PA opportunities. Interestingly, the CSPPA report (Woods et al., 2010) also suggests that fundamental movement skill (FMS) programmes aiming to develop the overall skills and abilities of youth common to all sports and activities is warranted in Ireland. In more recent years, movement science has become overlooked due to the perception that movement will occur naturally as part of life (Cools et al., 2009); however, evidence now suggests otherwise, indicating that FMS may be a potentially viable correlate of youth PA participation.

2.1.5.3 Fundamental Movement Skills Influences on Physical Activity

Fundamental movement skills are the basic observable patterns of behaviour present from childhood to adulthood; often examples, exhibited during physical education (PE) and PA, include running, hopping, skipping (locomotor), balancing, twisting, dodging (stability), throwing, catching and kicking (object control) (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006; Stodden et al., 2008). Recent research, underpinning the necessity of a physically active lifestyle, suggests that FMS are the building blocks for movement as they provide the foundation for the acquisition of more complex skills in the specialised sport specific movement stage (Gallahue and Ozmun, 2006; Hardy, King, Espinel, et al., 2010). Research commissioned by the Victorian Department of Education (1996) states that all FMS can be mastered by 10-11 years. Okely et al. (2001) have argued that the mastery of FMS in relation to their transfer to sport specific skills is an important contributing factor to PA participation amongst youth. A recent systematic review by Lubans et al. (2010) found strong positive relationships between FMS and PA in both children and adolescents.

Overall, the influencing factors of PA among young people are often not well understood due to the complexity and undetermined nature of results (Van Der Horst et al., 2007). One particular correlate which requires additional examination in the literature is the levels of FMS proficiency amongst young people, specifically adolescents, and this association with PA (see section 2.2 for a complete discussion of FMS). It seems logical to hypothesise that:

“Since fundamental movement skills are considered a prerequisite to, or foundation of, the specific skills used in popular forms of adult physical activity, it is reasonable to assume that there may be a relationship between an individual's participation in physical activity and his/her mastery of fundamental movement skills.” (Okely et al., 2001, p.1899)

2.1.6 Discussion

In the introductory section to this literature review, PA for youth was contextualised and rationalised under specific sub-headings. In section 2.1.1, the rationale for PA amongst children and adolescents was evaluated using empirical literature and evidence to highlight the importance of this behaviour. To summarise, the findings strongly indicate that participation in regular PA by those aged 2-18 years of age is associated with the following; improved

cardiovascular health, improved bone health, reduced body fat and healthy weight maintenance, improved cardiorespiratory fitness, stronger muscles, improved self confidence, improved social skills and reduced symptoms of anxiety and depression (Cavill et al., 2001; Fulton et al., 2004; BHF National Centre for Physical Activity and Health, 2013a; Woods et al., 2010). Indeed, PA can prevent chronic disease and premature mortality; furthermore, most recent findings now illustrate that if 88 million physically inactive Americans increased their participation in moderate PA, direct medical healthcare costs could be reduced by \$76.6 billion dollars (Schneider et al., 2013).

In section 2.1.2, the guidelines for PA and sedentary behaviour over time were outlined for children and adolescents. In terms of the recommended PA guidelines for health, it has become widely accepted in the literature and across many countries that all children and young people should engage in moderate to vigorous intensity PA for at least 60 minutes every day. (Department of Health and Children, 2009; Physical Activity Guidelines Advisory Committee, 2012; BHF National Centre for Physical Activity and Health, 2013a). Yet, guidelines for sedentary behaviour amongst youth are not well defined worldwide, with a significant gap in an Irish context. Of the countries (e.g. Canada) which have developed specific sedentary behaviour guidelines (Tremblay et al., 2011), it is suggested that recreational screen time should be limited to no more than 2 hours per day.

In section 2.1.3, the various measurement techniques of PA were evaluated in terms of ability to assess frequency, intensity, type and time of activity (Troost, 2007). Many measurement techniques were discussed including direct observation, doubly labelled water, heart rate monitoring and pedometers etc. Yet in terms of reliability and validity, no single measurement is appropriate to accurately assess all conditions associated with frequency, intensity, type and time of activity (Hands et al., 2006; Kohl et al., 2000; Troost, 2007). While acknowledging this limitation between measurement techniques, a recent systematic review of PA questionnaires (Chinapaw et al., 2010) for youth found that correlations between self-report measures of PA and accelerometer scores are significantly strengthened in adolescent populations compared to young children. Guided by the literature, Corder et al., (2009) provide evidence for using the YPAQ self-report instrument having validated this measure against accelerometry among early adolescents aged 12 to 13 years of age.

In section 2.1.4, the review progressed on to assessing the current levels of PA and sedentary behaviour among youth. Despite the importance of regular PA in promoting lifelong health and well-being, evidence from this section suggests that levels of PA among youth remain low (Currie et al., 2012; Eaton et al., 2012; Physical Activity Guidelines Advisory Committee, 2012; Troiano et al., 2008). Furthermore, evidence over the past decade suggests that levels of PA decline dramatically during adolescence (Kimm et al., 2000; O'Donovan et al., 2010), with a noticeable gender divide emerging in many international studies of males appearing to be significantly more active than females (Currie et al., 2012; Eaton et al., 2012; Riddoch et al., 2004; Sisson and Katzmarzyk, 2008; Woods et al., 2010). In the case of sedentary behaviour, evidence now acknowledges that a high proportion of children and adolescent youth engage in high amounts of daily screen time (Bickham et al., 2013; Eaton et al., 2012; Hardy, King, Espinel, et al., 2010; Oliver et al., 2012). In an Irish context, the cause for action seems most urgent. Recent evidence (Woods et al., 2010) suggests that only 12% of adolescents (12 to 18 years old) meet the recommended 60 minute MVPA guideline and less than 1% meet the screen time health recommendations. Most recent evidence highlights that the decline in MVPA and increased sedentary time observed from childhood to adolescence are of concern and might increase the risk of developing obesity and other chronic diseases later in life (Ortega et al., 2013).

Finally, section 2.1.5, examined the correlates of PA, in particular the psychological (psychosocial), social support and FMS influences on PA participation. In line with the YPAP theoretical model (Rowe et al., 2007; Welk, 1999), the identification of self-efficacy, parental and family influence and perceived skill competence are considered to be the potentially important mechanisms promoting PA. Welk's (1999) YPAP model suggests that physical skills and fitness promote PA, with increased fitness and skilfulness leading to increased persistence in PA and enhancement of perceived competence and self-efficacy (Stodden et al., 2008). In this section, self-efficacy was the only psychological correlate which was consistently associated with youth PA participation in many of the most recent reviews over the last decade (Sallis et al., 2000; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007). Similarly, when the results of the Sallis et al., (2000) and the Van der Horst et al., (2007) reviews of PA correlates are compiled, positive associations between social support and levels of adolescent PA are prevalent.

Finally, this literature review briefly described FMS as an important and viable correlate for youth PA engagement with positive associations found in the literature (Lubans et al., 2010). FMS development is the equivalent of the ABCs in the world of PA (Stodden et al., 2008). There is now an undeniable plethora of research examining the relationship between PA levels and FMS proficiency in youth. Yet without further examining the literature on the importance of FMS (see next section), researchers may be ignoring the hypothesis that FMS are the stepping-stones to motor development and ultimately, lifelong PA (Stodden et al., 2008). There is evidence emerging that developing FMS during childhood may be a significant step towards establishing a lifelong commitment to PA (Barnett et al., 2009) and, importantly, that mastery of FMS among children and adolescents is associated with a number of health benefits such as higher levels of PA, cardiorespiratory fitness level, self-esteem, and lower levels of overweight/obesity (Lubans et al., 2010).

2.2. Fundamental Movement Skills

The purpose of section 2.2 is to review the relevant literature regarding the development of FMS proficiency and assessment in children and young people. The first theme explored is an overall introduction and description to FMS.

2.2.1 Introduction and Description of Fundamental Movement Skills:

In the previous section, FMS were defined as basic observable patterns of movement (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). The hourglass model as proposed by Gallahue and Ozmun (2006) is a helpful heuristic device outlining the sequential progression of motor development across the lifespan; this model, conceptualises, describes and explains the rate of movement skill acquisition from infancy throughout life (see Figure 2.3 below).

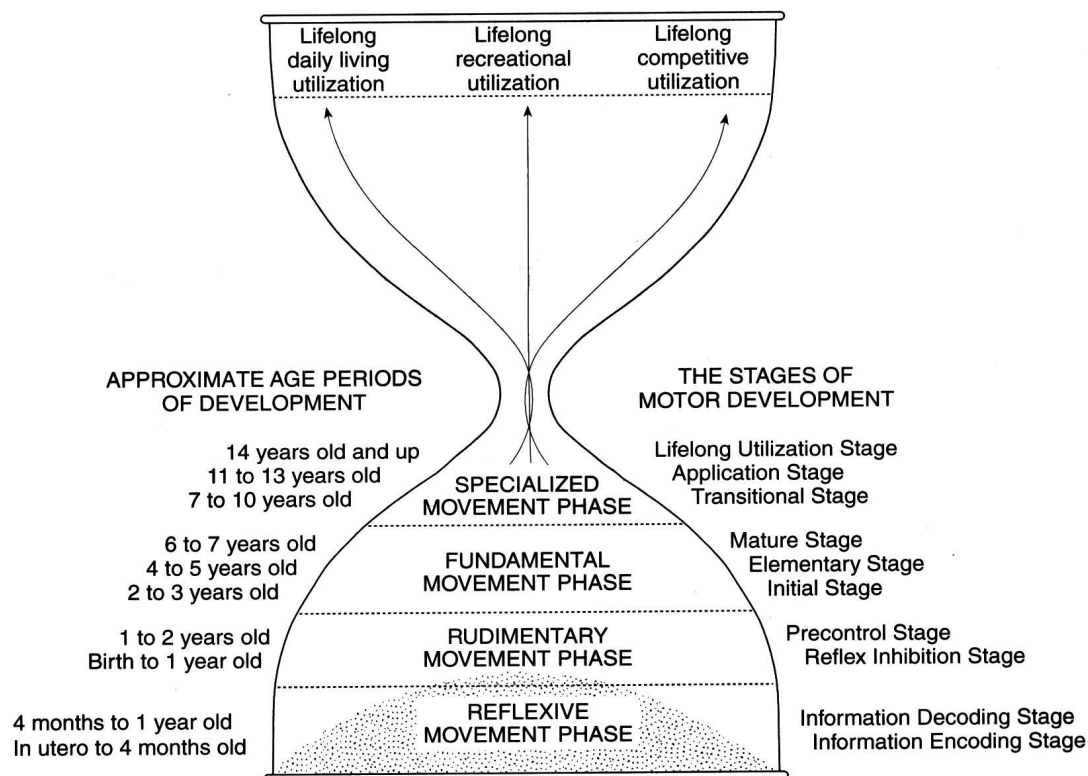


Figure 2.3: The phases and stages of motor development (taken from Gallahue and Ozmun, 2006)

Children at the FMS stage (3-10 years) are building upon previously learned movements from the reflexive and rudimentary movement phases and are preparing for the acquisition of more advanced skills within the sport specific stage (Gallahue and Ozmun 2006; Department of Education Victoria 1996). Figure 2.3 inadvertently highlights that children have the developmental potential to master most of the FMS by the ages of 6 to 7 years old (Gallahue and Ozmun 2006). While this outlined model shows the chronological age related process and maturation of movement skill acquisition, Clark (2007) denotes that FMS are not naturally acquired, therefore needing to be learned, practiced and continuously reinforced. Clark (2007) examines the problem of motor skill development and concludes that:

“Motor skills do not just come as birthday presents. They must be nurtured, promoted, and practiced. If we recognize the cultural misconception that motor skills just mature, then we must be proactive in dispelling that misconception.” (Clark, 2007, p.43)

Evidence over the past decade suggests that it takes approximately 10 hours of instruction for most children aged 3 to 10 years old to master one FMS (Booth et al., 1999). In more recent years, it has become accepted in the literature (Gallahue and Ozmun, 2006; Hardy, King, Espinel, et al., 2010; Okely et al., 2001; Stodden et al., 2008) that FMS are the building blocks for movement as they form the foundation for many of the specific motor skills required in popular sports and leisure activities.

It has been suggested that many of the performance related skills used in sports and movement activities are advanced versions of FMS (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006; Haywood and Getchell, 2009). This hypothesis has been trialled and examined in a recent study (O’Keeffe et al., 2007), whereby authors investigated the relationship between fundamental overarm throwing and related sport specific skills in an Irish adolescent cohort. The investigation verified the transferability between FMS and sport specific skills; in this case, the results indicated that the learning of the overhand throw is positively related with the sport specific skills of the badminton overhead clear and the javelin throw (O’Keeffe et al., 2007). Evidence now suggests that children and youth should learn generalisable movement skills, specifically during PE, to ensure a successful transfer into diverse activities, sports and games occurring later in life (McKenzie and Lounsbery, 2009).

Yet, the importance of movement is sometimes overlooked with a common misconception emerging in the literature that FMS are ‘naturally’ acquired during childhood (Cools et al., 2009; Stodden et al., 2008). A growing body of literature however, illustrates that children and adolescent youth do not obtain proficiency in FMS development (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Mitchell et al., 2013; Okely and Booth, 2004). Most recent evidence from the Australian New South Wales Schools Physical Activity and Nutrition Study (SPANS) highlights that the majority of children should have mastered the key FMS by ages 9 to 10 years (Hardy, King, Espinel, et al., 2010) prior to the transition of more advanced skills within the sport specific stage (Department of Education Victoria, 1996). With this age related association to motor learning, it seems logical that the early elementary years are identified as critical periods in a child’s development and mastery of FMS (Hardy, King, Farrell, et al., 2010). A recent meta-analysis of the effectiveness of motor skill interventions in children (Logan et al., 2011) highlights that early learning centres are now deemed effective environments to instigate change in FMS competence through instructional movement programmes. FMS skills need to be learned, practiced and reinforced (Robinson and Goodway, 2009). Based on the outlined evidence, it is reasonable to expect, therefore, that adolescent youth (12-14 years) should demonstrate competency in FMS during PE at second level school. A recent study suggests that school-based PE programmes have the potential to teach generalisable movement and behavioural skills to children and youth;

“If exercise is medicine, physical education is the pill not taken.” (McKenzie and Lounsbery, 2009, p.219)

2.2.2 Importance of Fundamental Movement Skills during the School Setting and during Physical Education

Data from the aforementioned CSPPA report (Woods et al., 2010) acknowledges that FMS programmes, with the overall objective of developing skills amongst youth are warranted in an Irish context. The school based PE setting is now considered (McKenzie and Lounsbery, 2009) as one of the key settings where young people, can accumulate vigorous PA and learn important generalisable FMS.

Strong et al. (2005) acknowledge the importance of basic movement skills being taught through the guided instruction of qualified professionals (teachers, coaches and mentors).

Despite this evidence, the aims and objectives of the current Irish second level PE curriculum for qualified PE teachers do not specify the importance of developing FMS for youth aged 12 to 16 years of age (years 1 to 3). This may not be so surprising as evidence from the last decade examining PA for school-age youth (Strong et al., 2005) acknowledges less emphasis has been placed on the development of FMS during adolescence. Yet, the authors of this paper argue that FMS is a central component for adolescent PA promotion:

“refinement of those skills (FMS) is important and new movement skills can be learned and can contribute to a physically active lifestyle.” (Strong et al., 2005, p.736)

School is however perceived as a particularly salient environment for primary (elementary) school children (Lounsbery et al., 2013) with PE being identified as an important contributor for active behaviours. Contrary to the Irish second level PE curriculum, there is a focus in the Irish Primary School PE Curriculum on the:

“Childs holistic development, stressing personal and social development, physical growth, and motor development.” (Department of Education and Skills, 1999, p.6)

In the Irish education context, there appears to be a lack of continuity on the importance of motor skill proficiency as children make the transition from the primary PE to the post-primary PE environment. While motor skill development is a specific focus for the Irish Primary School PE Curriculum, no such recommendation or guideline exists in an Irish post-primary PE context. It is possible that Irish PE practitioners assume that children will ‘naturally’ (Cools et al., 2009; Stodden et al., 2008) acquire FMS during primary school years. In the past, the development of FMS during childhood was not a concern but a growing body of evidence suggests that adolescent levels of FMS proficiency are low (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hardy et al., 2013; Mitchell, McLennan, et al., 2013). For these reasons, policy changes at Irish post-primary PE level may be warranted; at the very least, an examination of Irish adolescent FMS levels is needed.

In countries such as the United States, the rationale for the promotion of motor skills during school based PE (elementary to high school) is more apparent within the literature (McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009; McKenzie et al., 2009; Sallis et al., 2012). Dating as far back as 1995, the National Association for Sport and Physical Education (NASPE) defined that the physically educated individual should be able to demonstrate

competency in many movement forms for the development of motor skills (NASPE, 1995). Furthermore, in 2006, the American Heart Association (AHA) released a scientific document entitled “Promoting Physical Activity in Children and Youth: A Leadership Role for Schools”; in this document, the importance of teaching children motor skills was attributed to lifelong PA engagement (Pate et al., 2006). One of the primary objectives in this document was to improve the quality of PE programmes in the US by recommending that:

“Schools should deliver evidence-based health-related PE programs that meet national standards to students at all school levels. These programs should provide substantial amounts of moderate-to-vigorous physical activity (50% of class time) and should teach students the motor and behavioral skills needed to engage in lifelong physical activity.”
(Pate et al., 2006, p.1220)

The Sports, Play, and Active Recreation for Kids (SPARK) PE programme is one of the most evaluated evidence based PE programmes in the world (Dowda et al., 2005; McKenzie et al., 2009; Sallis et al., 1997). SPARK was originally initiated in 1989 as a strategy to combat the low levels of children’s PA and physical fitness (Sallis et al., 1997) . Since SPARK’s original inception, a specific focus of the programme has been the development of a variety of basic movement and manipulative skills for youth through the mechanism of PE (SPARK, 2013). Motor skills are specifically addressed within SPARK during the instructional units through the age-appropriate prescription of skills used in many sports (McKenzie et al., 2009). A more specific Australian teaching aid with established validity and reliability amongst children and adolescents is ‘Get Skilled: Get Active’ (NSW Department of Education and Training, 2000). Originally designed for Australian primary school PE teachers, this tool outlines general considerations which teachers should keep in mind when incorporating FMS in their Personal Development, Health and Physical Education (PDHPE) and sport programmes (NSW Department of Education and Training, 2000). The resource informs the teacher about the skill (description, breakdown and key points) and how to develop the skill (teaching cues, common errors, suggested activities and lesson planning) (NSW Department of Education and Training, 2000).

A recent study by Tsangaridou (2012) investigating the importance of teaching PE emphasised the positive contribution of FMS in supporting students development of social,

cognitive and affective skills in order to develop lifetime PA engagement. When measuring FMS proficiency during PE through an outcome approach, the teacher will need to make a judgement about students' performance and achievement; these judgements are made on the basis of assessment evidence (NSW Department of Education and Training, 2000). FMS proficiency can be assessed using a variety of assessment tools depending on the context in which the assessment is planned (Gallahue and Ozmun, 2006; Hands, 2002; Haywood and Getchell, 2009; Ulrich, 2000). Many of these assessment tools discussed in the next section are often implemented in a European or worldwide context (Cools et al., 2009). The subsequent section will outline the convenience of four existing FMS assessment tools amongst general population samples.

2.2.3 Fundamental Movement Skills Measurement

A multitude of clinical motor skill assessments have been designed and integrated, with the primary focus on the outcome of what the individual can achieve, but seldom on the process of performance within specific movements. For example, in the skill of running, the product of assessment is concerned with the individual(s) velocity of movement. Conversely, the process of assessment is concerned with examining the components of how the individual(s) execute the run. Teachers can use FMS assessment to evaluate the process of performance which have been identified as critical for all children to learn. Within each skill, the teacher can identify the specific component(s) for which the teaching should be organised (Department of Education Victoria, 1996). The aim of regularly assessing children and youth, apart from establishing basic movement skill patterns, is to plan and carry out an intervention (Gard and Rösblad, 2009).

“The planning of an intervention requires that also the movement’s execution, or quality, be analysed and described, and this analyse together with the analyse of functional level will then form the basis of an understanding of the child’s test performance.” (Gard and Rösblad, 2009, p.51).

Emerging evidence in previous literature suggests that too often, the focus of FMS assessment is on the product, rather than on the process (Cools et al., 2009; Ulrich, 2000), particularly amongst older children. Stodden et al., (2009) examine the relationship between FMS competency and measures of health related physical fitness in young adults aged 18 – 25 years of age (mean age= 20.4 years old). All 3 FMS skills (jumping, throwing and kicking) were

measured based on the product mode of assessment – maximum ball speed and maximum jumping distance. The assessment of movement skills is a critical component of many disciplines and professions (Hands, 2002). In order to implement effective movement programmes, it is imperative to gather quantitative information about the FMS level of the child (Hands, 2002). Moving away from the outcome or product, criterion referenced tests compare the participant's performance to predetermined criteria.

“A criterion-referenced test takes into account the qualitative aspects of the movements required to perform the movement skill item.” (Cools et al., 2009, p.154).

Unlike the product mode of assessment, process-oriented assessments of FMS are more accurate in identifying specific topographical aspects of the movement (Hands, 2002). In other words, qualitative process-orientated measures surpass the product outcome by identifying specific gross motor skill strengths and weaknesses, allow specifically designed instruction for those experiencing gross motor skill delays and annual goals can be easily developed from test results (Ulrich, 2000).

Many different tools to assess FMS proficiency during childhood are available with many aimed at a specific target group and hence, have specific content. Cools et al., (2009) review article of seven movement skill assessment tools, defines these measurement instruments as either norm- or criterion referenced.

“A norm-referenced test compares the child's performance to that of a normative group, and quantifies the child's movement skill competence. A criterion referenced test compares the child's performance to predetermined criteria. A criterion-referenced test takes into account the qualitative aspects of the movements required to perform the movement skill item.” (Cools et al., 2009, p.154)

The Movement Assessment Battery for Children (ABC)–2 identifies and describes children with movement difficulties. The Movement ABC –2 Test is a standardised assessment tool that requires children and adolescents to perform a range of motor tasks in order to acquire an objective measurement of motor impairment (Henderson et al., 2007). The Movement ABC – 2 is a revision of the Movement Assessment Battery for Children, originally named the Test of Motor Impairment (TOMI) (Cools et al., 2009). The components of the Movement ABC –2 within each age band, include 8 tasks that are grouped in three categories: manual dexterity,

aiming and catching, and balance skills (Henderson et al., 2007). This assessment tool is available in several countries and has cross cultural validity based on the comparison of local sample data (Smits-Engelsman et al., 1998; Van Waelvelde et al., 2004). Furthermore, the test has simple administration and facilitates large sample screening over a short period (Cools et al., 2009). The major disadvantage as outlined by Johnston and Watter (2006) is that the Movement ABC only reveals that a child cannot perform and as a result, a more qualitative interpretation on impact of the score is recommended. The instrument is considered an effective screening tool (Johnston and Watter, 2006) but not yet representing the gold standard measurement for gross motor skill proficiency.

The Movement ABC-2 as described identifies motor impairments; the Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) is used to assess fine and gross movement skill abilities (Cools et al., 2009). Similar to the Movement ABC-2, the BOT-2 also identifies participants (4-21 years of age) with mild to moderate motor coordination deficits. The BOT-2 is targeted by practitioners and researchers as a discriminative and evaluative measure to describe motor performance, with particular emphasis on fine manual control, manual coordination, body coordination, and strength and agility (Deitz et al., 2007). There are many advantages associated with BOT-2 including ease of administration, construct validation, the face validity of the items representing daily childhood movement skills and the moderate to strong inter-rater and test-retest reliability (Deitz et al., 2007). While the test has been normed on a representative US sample of children (N=1520) (Cools et al., 2009), reliability limitations regarding some subtests and composites for some age groups have led therapists to be sceptical in using this test to determine a child's skill level in specific areas of motor development (Deitz et al., 2007). Authors conclude that until further research is completed, caution is recommended.

Another Australian FMS measurement tool 'Get Skilled: Get Active' has been developed to help support teachers with the increase of primary school students levels of gross motor skill proficiency (NSW Department of Education and Training, 2000). This process-orientated FMS instrument consists of 12 FMS; a unique strength of the 'Get Skilled: Get Active' resource is that all categories of FMS are included within this assessment protocol (locomotor, object-control and stability) (Gallahue and Ozmun, 2006; Haywood and Getchell, 2009). These 12 skills (run, balance, vertical jump, catch, hop, side gallop, skip, overarm throw, leap, kick, two-handed strike and dodge) were selected because collectively, they represent a platform for the development of

specialised skills, enabling students to participate in a wide range of physical activities (NSW Department of Education and Training, 2000). All 12 FMS are composed of observable, behavioural components that together constitute a mature performance of the skill (Okely and Booth, 2004). Each individual FMS has been broken down into individual components which are developed at different stages of learning; checklists for teachers also exist to help identify student performance (NSW Department of Education and Training, 2000). A substantial amount of evidence in Australia highlights that the 'Get Skilled: Get Active' FMS assessment protocol is an appropriate, reliable, culturally acceptable and valid instrument for measuring levels of gross motor skill proficiency amongst children and adolescents (Barnett et al., 2010, 2009; Hardy, King, Espinel, et al., 2010; Hardy et al., 2013; Okely and Booth, 2004; Okely et al., 2001a).

Finally, the Test of Gross Motor Development -2 (TGMD-2) (Ulrich, 2000) has been recently considered in a meta analysis of FMS interventions (Logan et al., 2011) as the only measurement instrument satisfying all the inclusion criteria. The TGMD-2 is designed to measure gross motor skill proficiency through a process orientated qualitative protocol (Ulrich, 2000). The TGMD-2 was normed on a sample of 1,208 participants in the United States, with gender normative tables created for the object control subtest (Ulrich, 2000). The TGMD-2 is composed of two subtests (locomotor and object control) that measure the gross motor abilities which develop early in life. Participants perform each of the 12 FMS with each gross motor skill including several behavioural components presented as performance criteria (Ulrich, 2000). The TGMD-2 is designed to assess the FMS in children and has been used in many studies (Cliff et al., 2011; Hardy, King, Farrell, et al., 2010; Mitchell et al., 2013), due to its empirically determined reliability and established validity (Evaggelinou et al., 2002; Houwen et al., 2010; Wong and Yin Cheung, 2010).

Evaggelinou's et al., (2002) study investigated the construct validity of the earlier version Test of Gross Motor Development (TGMD) (Ulrich, 1985) employing confirmatory factor analysis as the evaluation tool. Results from this study provide strong support for the construct validity of the TGMD with correlations between the object control and locomotor factors yielding a high positive value (0.82). More recently, Wong & Cheung's (2010) study investigated the validity of the updated TGMD-2 (Ulrich, 2000) version amongst 626 children (mean age= 6.45 ± 2.10 years) from Hong Kong. The composite reliability of locomotor (.82) and object control (.81) factors highlights that the TGMD-2 is a usable process orientated gross

motor assessment. Finally, Houwen et al., (2010) further evaluated the reliability and validity of the TGMD-2 in primary school school-age children (n=75, 6-12 years old) with visual impairments; all factor loadings were again statistically significant with construct validity evident.

To summarise, the TGMD-2 is a process and product-orientated test which refers to a criterion and a norm (Cools et al., 2009). A shortcoming of TGMD-2 may be the absence of a stability subtest with some evidence (Gallahue and Ozmun, 2006; Haywood and Getchell, 2009) suggesting that locomotor, manipulative and stability skills be incorporated in the overall assessment process. Of the 3 assessment tools discussed, the rationale for selecting the TGMD-2 seems apparent and most convincing.

The TGMD-2 is designed to assess the gross motor functioning in children 3 through 10 years of age and has empirically determined reliability and validity for this age cohort (Ulrich, 2000). Although the instrument is not specifically designed for youth over the age of 10 years, other studies (Frey and Chow, 2006; Houwen et al., 2009, 2007) have obtained a measure of motor proficiency (raw scores only) using the TGMD-2 in adolescent populations, not making normative comparisons (i.e. regardless of their age). For these reasons, the TGMD-2 seems to be the only assessment tool that can be used reliably in mainstream settings (Cools et al., 2009).

There are a great variety of assessment tools available for measuring FMS competency, particularly during childhood (Cools et al., 2009). Yet, these tests do not prevent the relatively low levels of FMS proficiency emerging worldwide in the literature, amongst children aged 5 to 12 years old (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Mitchell et al., 2013; Okely and Booth, 2004).

2.2.4 Fundamental Movement Skill Levels

One of the first studies to highlight low levels of youth FMS proficiency was Okely and Booth's (2004) study which presented findings on the proportion of children's (n=1288, school years 1 – 3) FMS mastery (n=6) from New South Wales (NSW). Results from this study confirm that no skill exceeded 35% mastery level, suggesting that the prevalence of FMS proficiency is low to moderate across a cohort of NSW primary school children. This finding is supported by more recent studies amongst Australian primary school children (Hardy, King, Espinel, et al., 2010; Hardy et al., 2013) which indicate that children's FMS proficiency is consistently low.

While the evidence from the above two studies highlight discrepancies in FMS proficiency between children, recent research highlights that adolescent youth are not performing FMS to their expected developmental capability (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hardy et al., 2013; Hume et al., 2008; Mitchell et al., 2013). For example, the Australian New South Wales School Nutrition and Physical Activity Study (Hardy, King, Espinel, et al., 2010) documented the low percentage of early adolescent youth (11–12 years) achieving skill mastery across a range of seven FMS. Research by Booth et al., (1999) reported that skill mastery did not exceed 40% for five of the six FMS amongst children and adolescent youth aged 9 to 15 years old. Mitchell, et al. (2013) in their examination of school based FMS proficiency indicated that at baseline measurements, less than half of the children and early adolescents (aged 5-13 years old) exhibited proficiency in kicking (21%), throwing (31%) and striking (40%). In other countries similar trends have been observed, for example, in an Irish context results from a PE study (O’Keeffe, Harrison, and Smyth 2007) indicated that fundamental over arm throwing amongst adolescent youth (15-16 years) was low. The evidence would suggest that while levels of FMS vary from country to country, performance levels remain consistently low across the spectrum with the majority of children and adolescents failing to surpass 50% mastery in most skills. Globally, there appears a need to improve the skill proficiency levels of both children and adolescents (Hardy, King, Espinel, et al., 2010; Lubans et al., 2010; Stodden et al., 2008; Van Beurden et al., 2002); furthermore a multitude of studies have found gender differences across the age spectrum between males and females in their associated levels of FMS proficiency (Barnett et al., 2010; Breslin et al., 2012; Hume et al., 2008; Wrotniak et al., 2006).

2.2.4.1 Gender Differences in Fundamental Movement Skills

Breslin et al., (2012) in their assessment of children's (n=170; 7-8 years old) motor competence from the effect of teachers trained in a FMS programme found that significant gender differences existed between males and females in specific subtests. In this study, authors observed that males were scored more proficient than females on all object control related skills except the locomotor log roll skill, where females outperformed males. Evidence over the last decade (Hardy, King, Farrell, et al., 2010; Ulrich, 2000) defines locomotor skills as those that measure the coordinated movement of the centre of gravity from one point to another and object control related skills as those that measure the projecting and receiving of objects. Recent studies

would suggest that gender differences in FMS performance are emergent from an early preschool age (Cliff et al., 2009; Hardy, King, Farrell, et al., 2010) with findings reporting that males are more proficient in object control related skills, and females reporting greater proficiency in locomotor movements. Cliff et al., (2009) examine the relationship between FMS and objectively measured PA in preschool children (3-5 yrs) with findings indicating that males having a stronger correlation with object related skills such as kicking and striking.

In accordance with the above finding, Okely and Booth (2004) examine primary school FMS performance in NSW with males again performing significantly better in all four object control related skills (throw, catch, kick and strike) compared to females; yet female proficiency in the skip significantly outweighed male performance. Van Beurden et al. (2002) examination of primary school children's FMS performance similarly observed that males perform object control related skills more proficiently with females performing locomotor skills more proficiently. This FMS finding relating to gender division at pre and primary school level is consistent within the literature from an early stage; Raudsepp and Paasuke (1995) provide statistical evidence that a gender divide between FMS proficiency amongst 8 year old pre-pubertal children was evident with males significantly surpassing females in overhand throwing kinematics, motor performances and muscular strength.

Differences in FMS proficiency between genders during childhood can be attributable to and explained by the environmental influences and biological factors, and their overall interaction (Thomas and French, 1985).

“At puberty, gender differences in motor performance appear to be influenced by both biological and environmental factors. Although we must acknowledge the importance of biological changes as being closely associated with increasingly larger gender differences in many motor performance tasks, environmental factors may assume even greater importance at and following puberty.” (Thomas and French, 1985, p.261)

More recent evidence suggests that the social norms associated with gender participation in sports and games also contribute to gender differences during childhood (Wrotniak et al., 2006). Evidence now argues that greater female movement skill proficiency is positively associated with cooperative and shared play time as opposed to the male egocentric dominated competitive skill environments (Hardy, King, Farrell, et al., 2010). Booth et al., (1999) further suggest that gender differences may be associated with the sports and games participated in; males may

receive greater attention from parents and teachers in skill development such as kicking, throwing, striking, coordination and rhythm. With FMS studies during early childhood showing consistent gender differences, evidence from the last decade suggests that these skill differences typically increase over time into later childhood (McKenzie et al., 2002).

As noted the gender differences in FMS proficiency are prevalent in the literature amongst children (Cliff et al., 2009; Hardy, King, Farrell, et al., 2010; Okely and Booth, 2004; Raudsepp and Paasuke, 1995; Thomas and French, 1985). While there is a absence in the literature relating to adolescent FMS proficiency, some studies acknowledge that gender differences do occur from ages the ages of 10 to 16 years old (Barnett et al., 2010; Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hardy et al., 2013; Hume et al., 2008; Wrotniak et al., 2006). Booth et al., (1999) present data from the 1997 NSW Schools Fitness and Physical Activity Survey relating to the skill mastery and near mastery prevalence across 6 FMS (mean age range: 9.3 years to 15.3 years). Results from this study revealed that substantially fewer females displayed mastery in the object control related skills compared to males. More recent evidence amongst adolescents, Barnett et al., (2010) examine gender differences in FMS proficiency, indicating that male adolescents are more object control proficient than girls. It is important to note from this study however, that the gender divide is not as clear within the locomotor subtest (Barnett et al., 2010), which supports other early adolescent findings (Hume et al., 2008). Hume et al., (2008) illustrate 9 to 12 year old male superiority within the kick, overhand throw and two-handed strike; poor performances however, in the vertical jump and run were equally observed amongst both genders.

Based on the existing adolescent literature from both cross-sectional and longitudinal studies (Barnett et al., 2010; Booth et al., 1999; Hume et al., 2008), it seems evident that adolescent males possess significantly higher object control related skills than females with the gender divide not as apparent within the locomotor subtest. Recent research illustrates that maturation factors, such as sex hormones and growth spurts may be the cause of gender differences in motor skill proficiency occurring during adolescent puberty (Haywood and Getchell 2009). A previous study from Hands and Larkin (1997) proposed to develop supportive gender-specific social environments for learning FMS in order to substantially diminish differences in performance of males and females. This gender differentiation within adolescent FMS proficiency highlights that additional support through evidence-based PE interventions

(Lounsbery et al., 2013; McKenzie and Kahan, 2008; Sallis et al., 2012) are warranted in order to facilitate females' development of object control related skills. In order for this transition to occur:

“Physical education should be an enjoyable experience during which students learn generalizable movement skills that will transfer into diverse activities, sports, and games.” (McKenzie and Lounsbery, 2009, p.222)

2.2.5 Advancing Towards Specialised Movement Skills

Advancing towards specialised movement skills during the stages of motor development depends on the maturity level of FMS development (Department of Education Victoria, 1996; Hardy, King, Espinel, et al., 2010). Specialised movement skills have been previously defined as:

“fundamental movement patterns that have been refined and combined to form sport skills and other specific and complex movement skills.” (Gallahue and Ozmun, 2006, p.313).

With specialised movement skills, the task is specific, with FMS the task is unspecific (Gallahue and Ozmun, 2006). Adolescent motor skill proficiency is a decisive factor in the subsequent outgrowth of the FMS phase (Hardy, King, Espinel, et al., 2010; Okely et al., 2001).

Older children, adolescents and adults have the developmental potential to master most of the FMS yet recent evidence would suggest otherwise (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Stodden et al., 2009). Failure to execute proficient mature patterns of FMS proficiency has direct consequences on the individual's ability to perform task-specific skills during the specialised movement phase (O'Keeffe et al., 2007). This research investigation hypothesises that an adolescent will be unable to participate successfully in sport specific scenarios such as Gaelic Games or Rugby if his or her fundamental striking, kicking, catching and running skills are poor. Examining FMS in adolescence will therefore provide meaningful data assessing participants' ability to make the transition to complex movement activities in the lifelong utilization stage (Gallahue and Ozmun, 2006). Mitchell et al., (2013) study illustrates at baseline (prior to intervention) that children aged 5 to 12 years have low levels of FMS proficiency. This study recognises that skill proficiency increases with age (early adolescents 11 to 12) but overall inadequate for sufficient engagement within sport specific scenarios. As

previously outlined, results from an Irish PE intervention (O' Keeffe et al., 2007) indicate that there is a direct transfer of learning between FMS and sport specific skills amongst adolescent youth (mean age 15.8 ± 0.60 years).

The evidence indicates that children may be making the transition to adolescence without acquiring FMS proficiency (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hume et al., 2008; Mitchell et al., 2013), though this has yet to be confirmed in an Irish context. Therefore, encouraging and monitoring the use of a mature pattern of movement will enhance FMS proficiency over time (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013), increasing the participant's likelihood of making a successful transition to the specialised movement phases associated with specific sporting tasks. Yet, the mastery of FMS is not just associated with the benefit of acquiring and shifting towards specialised movement skills (Gallahue and Ozmun, 2006). In recent years, there has been considerable research carried out examining the health status and associated benefits of movement skill execution amongst children and adolescents internationally (Barnett et al., 2008; Fisher et al., 2005; Lubans et al., 2010; Morano et al., 2011; Okely et al., 2004, 2001a; Wrotniak et al., 2006).

2.2.6 Benefits of Fundamental Movement Skills

Lubans et al., (2010) review systematically examined the psychological, physiological and behavioural public health benefits associated with FMS competency in children and adolescents by identifying eligible studies on a 6-point scale. Of the 21 studies satisfying the inclusion criteria, 4 studies found a positive relationship between FMS and physical fitness level, and 11 found strong positive relationships between FMS and PA components. There is now substantial evidence to suggest that FMS proficiency is positively associated with habitual PA levels in children and adolescents (Barnett et al., 2009; Fisher et al., 2005; Harten et al., 2008; Jaakkola and Washington, 2012; Okely et al., 2001; Wrotniak et al., 2006). These consistent literature findings are in line with a previous position statement from NASPE who emphasised the need to demonstrate FMS proficiently to perform a variety of physical activities necessary for the health benefits of cardiovascular endurance and muscular strength (NASPE, 1995).

Cross-sectional evidence now highlights the importance of FMS proficiency in children and adolescents, showing that it is positively associated with many forms of PA including; total PA (Fisher et al., 2005), MVPA (Wrotniak et al., 2006), skill-specific PA (Raudsepp and Päll,

2006) and organised PA (Okely, 2001). Okely et al., (2001) examine the relationship of PA to FMS among adolescents, with findings highlighting that the ability to perform FMS was significantly related to participation in organized PA. Barnett et al., (2011) explore the direction of relationship between FMS proficiency and PA engagement amongst adolescents; findings indicated a significant reciprocal relationship between MVPA and object-control skill execution and a one-way relationship between MVPA and locomotor skill execution. Similarly, Barnett et al., (2009) investigated the relationship between childhood FMS proficiency and subsequent adolescent PA behaviour in a longitudinal cohort study in New South Wales, Australia. The final model, adjusting for school grade and gender, highlighted that the proficiency of object control skills at childhood was associated with time spent in organised activities accounting for 18.2% of the variation. From these studies, it appears specifically that the object control skills are a significant contributor for subsequent adolescent PA participation. Further longitudinal studies are however, warranted to complement the recent evidence that FMS proficiency is significantly attached to youth PA (Hume et al., 2008; Jaakkola and Washington, 2012; Kalaja et al., 2012; Okely et al., 2001). In an Irish context, the strategic advice outlined in the CSPPA study (Woods et al. 2010) promoting FMS for subsequent PA levels amongst youth is well supported from the literature findings.

Independent of PA, there is now some additional evidence to suggest that FMS proficiency is positively associated with physical fitness (cardio-respiratory fitness and cardiorespiratory endurance) in children and adolescents (Barnett et al., 2008; Lubans et al., 2010; Okely et al., 2001b). For example, Barnett et al., (2008) observe the relationship between childhood FMS proficiency and subsequent adolescent cardio-respiratory fitness (CRF) as part of a longitudinal study known as the Physical Activity and Skills Study (PASS). The final model, adjusting for gender revealed that object control proficiency in childhood was significantly associated with adolescent CRF, accounting for 25.9% of the variation in fitness. Children of either gender with good object control skills achieved on average, more than 6 additional laps on the Multistage Fitness Test during adolescence (Barnett et al., 2008). Okely et al., (2001b) examine the relationship between cardiorespiratory endurance and FMS proficiency among high school New South Wales Australian adolescents; results from this study further illustrate across both genders that FMS proficiency explains between 12 to 26% of the variance in cardiorespiratory endurance. A recent review of the associated health benefits of FMS in children

and adolescents concluded that the relationship between FMS proficiency and physical fitness (CRF and cardiorespiratory endurance) is now positively related (Lubans et al., 2010). Furthermore, most recent evidence by Haapala (2013), found that higher CRF and FMS proficiency have been associated with better academic performance in early adolescents. In terms of lifelong PA engagement, Stodden et al., (2009) examined the relationship between FMS competency and measures of health related physical fitness in young adults aged 18 – 25 years of age. Results from the regression analyses found that FMS accounted for 79% of the variance in the overall physical fitness of participants (Stodden et al., 2009). Yet, the evidence on children and adolescents relies mainly on cross-sectional data. Further studies are recommended to fully determine if the improvement of movement skills, particularly in adolescents, positively promote physical fitness (Lubans et al., 2010; Okely et al., 2001b).

Based on the outlined evidence, there is now a very strong rationale for promoting the development of FMS in children and adolescents as a means of acquiring the behavioural benefit of increased PA (Barnett et al., 2011; Hume et al., 2008; Kalaja et al., 2012; Lubans et al., 2010; Wrotniak et al., 2006); also, whilst not as prevalent in the literature, FMS proficiency appears in some few studies to be positively associated with the physiological benefit of increased physical fitness amongst young people (Barnett et al., 2008; Okely et al., 2001b). Recent evidence, however, from the aforementioned review study suggests that weight status is the most commonly assessed physiological benefit of FMS proficiency (Lubans et al., 2010). From this systematic review, weight status, primarily BMI, was examined in nine studies (Castelli and Valley, 2007; Cliff et al., 2009; D'Hondt et al., 2009; Graf et al., 2004; Hume et al., 2008; McKenzie et al., 2002; Okely et al., 2004; Southall et al., 2004; Williams et al., 2008); six of these found an inverse relationship between FMS proficiency and weight status (Lubans et al., 2010). In other words, those classified as overweight or obese demonstrate significantly lower motor skill proficiency than their normal weight counterparts. Other studies have also examined the relationship between motor coordination and weight status in children and adolescents (D'Hondt et al., 2011; Lopes et al., 2012). This recent shift towards the examination of FMS proficiency and weight status may be attached to escalating rise in childhood obesity worldwide (Lobstein and Jackson-Leach, 2007; Lopes et al., 2012; Wang and Lobstein, 2006)

There is now reputable literature and evidence from numerous international studies, from a variety of populations and ethnic diversities, that a significant inverse association between

FMS proficiency and weight status exists (Cliff et al., 2011; Hume et al., 2008; Morano et al., 2011; Siahkoughian et al., 2011). Cliff et al., (2011) investigated the prevalence of FMS mastery using the TGMD-2 amongst a clinical sample of overweight/obese children (n=134) compared to a normative US sample. This study provides strong evidence that children with a higher BMI (overweight/obese) perform all FMS (n=12) markedly lower ($p<0.05$) across all age groups. Evidence suggests that poor gross motor coordination in relation to weight status is as a result of the increased mass of body segments, ultimately hindering coordinated skill execution during complex body movements (D'Hondt et al., 2011). Despite the emerging evidence illustrating an inverse association between both variables, few studies have thoroughly investigated the relationship between motor skill proficiency and weight status amongst early adolescent youth (Hardy, King, Espinel, et al., 2010; Hume et al., 2008; Lopes et al., 2012). Of these existing studies, many found a consistently significant inverse relationship between weight status and motor skill proficiency and/or motor coordination (Hardy, King, Espinel, et al., 2010; Hume et al., 2008; Lopes et al., 2012). It was interesting that Hume et al., (2008) observed a significantly higher proportion of normal weight young people achieving significantly higher mastery scores in the run only. Recent studies (Hardy, King, Espinel, et al., 2010; Siahkoughian et al., 2011) speculate that overweight and obese participants execute significantly lower locomotor skill performance due to the discomfort of engaging in locomotion which require greater movement of body mass against gravity. Evidence outlined to this point strongly rationalises the inverse relationship between FMS proficiency and weight status in children and adolescents (Cliff et al., 2011; Hardy, King, Espinel, et al., 2010; Hume et al., 2008; Morano et al., 2011; Siahkoughian et al., 2011). In order to determine the causal nature of these inverse relationships between FMS and BMI, further longitudinal studies are warranted (Lubans et al., 2010).

To conclude, the rationale for promoting the development of FMS in childhood relies on the existence of substantial evidence on the current benefits associated with the acquisition of FMS proficiency (Lubans et al., 2010), namely the strong evidence for a positive association between FMS competency and both PA and CRF in children and adolescents. Furthermore, the inverse link between weight status and FMS execution needs further exploration (Hume et al., 2008) particularly due to the noticeable absence in the literature with regard to the adolescent context. Nonetheless, recent research (Logan et al., 2011) signals that there is a pressing and

immediate call to implement effective FMS interventions to strategically reduce the existing obesity “epidemic” through the promotion of these movement skills at childhood.

2.2.7 Discussion

In the overview to this section of the literature, the rationale for FMS amongst children and adolescents was explored under a variety of sub-headings. The literature and research evidence strongly insinuate that FMS proficiency have a significantly positive role to play in the development of sport specific skills (Gallahue and Ozmun, 2006; Haywood and Getchell, 2009; O’Keeffe et al., 2007), and increasing habitual PA level amongst adolescent youth (Hume et al., 2008; Jaakkola and Washington, 2012; Kalaja et al., 2012; Okely et al., 2001a). In section 2.2.1, the topic of FMS was contextualised as specific observable patterns of movement consisting of running, hopping, skipping (locomotor), balancing, twisting, dodging (stability), throwing, catching and kicking (object control) (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). These basic patterns of movement need to be learned, practiced and reinforced (Robinson and Goodway, 2009) with school based PE programmes (section 2.2.2) now providing a window of opportunity to teach generalisable and behavioural skills to children and youth (Fahimi et al., 2013; McKenzie and Lounsbery, 2009). The importance of FMS promotion within the PE class is not well outlined for adolescent youth in an Irish education context; yet, as was more apparent within the literature, there seems to be a strong association in the United States PE curriculum for the promotion of youth motor skill proficiency (McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009; McKenzie et al., 2009; Sallis et al., 2012).

Assessing FMS proficiency is a core component specific to the environmental context as was highlighted in section 2.2.3. Assessing one’s degree of movement skill proficiency has traditionally involved measuring the product or outcome of performance with the comparison of results against a normative representative sample (Cools et al., 2009; Hands, 2002). FMS assessment in the manner of product outcome does not inform the assessor about the quality of movement (Gard and Rösblad, 2009), hence process orientated FMS assessment tools are now encouraged for implementation (Cools et al., 2009; Johnston and Watter, 2006; Ulrich, 2000). Of the four assessment tools critically observed in section 2.2.3, the TGMD-2 (Ulrich, 2000) appears the most efficient measurement tool worldwide for assessing the gross motor abilities of

children, further supported by its reliability and established validity (Evaggelinou et al., 2002; Houwen et al., 2010; Wong and Yin Cheung, 2010).

While numerous assessment tools for FMS exist, a poor trend of skill execution amongst children and young people has become evident worldwide (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Mitchell et al., 2013; Okely and Booth, 2004). In section 2.2.4, the FMS levels of children and adolescents were discussed. With a particularly noticeable absence in the literature relating to adolescent FMS proficiency, further research is truly warranted. Of the few adolescent studies in existence, evidence strongly indicates that FMS proficiency levels are consistently low (Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hardy et al., 2013; Hume et al., 2008; Mitchell et al., 2011). From a gender perspective, section 2.2.4.1, found that significant FMS differences existed between males and females in specific subtests. Specifically, in adolescent context, gender differences do occur from ages the ages of 10 to 16 years old (Barnett et al., 2010; Booth et al., 1999; Hardy, King, Espinel, et al., 2010; Hume et al., 2008; Wrotniak et al., 2006). Consistent findings indicated that fewer females displayed mastery in the object control related skills compared to males; yet, the gender divide is not as apparent within the locomotor subtest. With these low levels of FMS proficiency and further gender differences evident across the age spectrum, there is a pressing call to teach and build proficient FMS execution amongst youth. This may in turn allow for later learning of adaptive, skilled actions within specific movement contexts, as outlined in Gallahue and Ozmun's (2006) hourglass model of motor development.

Section 2.2.5 identifies that failure to execute proficient mature patterns of FMS proficiency will have direct consequences on the individual's ability to perform task-specific skills during the specialised movement phase (O'Keeffe et al., 2007). In other words, there is a compelling argument that adolescents will be limited in their participation to successfully engage in sport specific environments without the pre-requisite of basic observable patterns of movement. To the best of the author's knowledge, no study in an Irish context has previously examined FMS proficiency in an adolescent cohort; this type of data would provide meaningful data assessing participants' ability to make the transition to complex movement activities in the lifelong utilization stage (Gallahue and Ozmun, 2006).

The final section 2.2.6 examined the associated benefits of FMS proficiency amongst children and adolescents. Of the benefits examined, substantial evidence suggests that FMS

proficiency is positively associated with habitual PA levels in children and adolescents (Barnett et al., 2009; Fisher et al., 2005; Harten et al., 2008; Jaakkola and Washington, 2012; Okely et al., 2001a; Wrotniak et al., 2006). Furthermore, while not as prevalent in the literature, some studies found a positive association between FMS proficiency and physical fitness (cardio-respiratory fitness and cardiorespiratory endurance) in children and adolescents (Barnett et al., 2008; Lubans et al., 2010; Okely et al., 2001b). Finally, there was undeniable plethora of research indicating that that a significant inverse association between FMS proficiency/motor coordination and weight status exists (Cliff et al., 2011; Graf et al., 2005; Hume et al., 2008; Lopes et al., 2012; Morano et al., 2011; Siahkoughian et al., 2011). This physiological benefit associated with weight status is timely in the combat of the escalating rise in worldwide childhood obesity (Lobstein and Jackson-Leach, 2007; Lopes et al., 2012; Wang and Lobstein, 2006).

2.3 The Road to Intervention

At this stage of the literature review, the evidence has strongly emphasised and illustrated that PA is a cornerstone in the development of infants, young and older children, and adolescents approaching adulthood (Fulton et al., 2004; Lee et al., 2012; BHF National Centre Physical Activity and Health, 2013b). Refuting this compelling evidence for PA promotion across the lifespan would seem senseless, yet, the 21st century has seen an ‘unprecedented’ rise in sedentary pursuits, particularly amongst young people (Biddle et al., 2011, 2004; Biddle, Cavill, et al., 2010; Currie et al., 2012; Hardy, King, Espinel, et al., 2010; Mitchell et al., 2009). The short term health impact of sedentary lifestyles amongst youth is low energy expenditure and a risk of developing obesity (Biddle, Cavill, et al., 2010; Booth et al., 2003; Wang and Lobstein, 2006). Alarming, the long term effect of youth inactivity is risk of obesity (Biddle, Pearson, et al., 2010; Cleland et al., 2013; Nelson et al., 2006), inadequate movement skill development (Gallahue and Ozmun, 2006; Haywood and Getchell, 2009; Stodden et al., 2008), lack of competence to engage in sport or exercise (Uijtdewilligen et al., 2011; Van Der Horst et al., 2007; Welk, 1999; Woods et al., 2010) and an overall risk of premature mortality (Bouchard et al., 2007; Cavill et al., 2001; Moore et al., 2012; Murray et al., 2013).

PA is clearly important to young people for health (McKenzie and Kahan, 2008; Sallis et al., 2012; Woods et al., 2007, 2010) and for this reason intervention programmes have been designed, developed, implemented and evaluated with the purpose of increasing PA and/or FMS (Van Beurden et al., 2003; Haerens et al., 2007; Lubans et al., 2012; McKenzie et al., 2009; Mostafavi et al., 2013; Sutherland et al., 2013). With the age related decline in PA most prevalent amongst adolescents (Dumith et al., 2011; Kimm et al., 2000; O’Donovan et al., 2010), it is imperative to stimulate interest and preferences towards PA participation during development within this crucial age window (Ward et al., 2007). To conclude, the design, development, implementation and evaluation of the most appropriate intervention that suits the interests and goals of adolescent youth is simply ‘critical’ (Murillo Pardo et al., 2013; Trudeau and Shephard, 2008).

2.3.1 Call for School-Based Physical Activity Interventions

Considering that PA has important health benefits in youth (Cavill et al., 2001; Fulton et al., 2004; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007), it is concerning that a large

majority of young people are not meeting the recommended guidelines for PA and sedentary behaviour (Currie et al., 2012; Eaton et al., 2012; Troiano et al., 2008; Woods et al., 2010). In line with these low levels of PA, it seems appropriate that the World Health Organization (2003) emphasised the need for research to generate sound knowledge on models of successful intervention in PA. Improving the PA levels of youth has been recognised as an important public health challenge (Sallis et al., 2012, 2000; Ward et al., 2007). Most recently, in their policy guidelines aligned to the HBSC results, the World Health Organization (Currie et al., 2012) identifies the need for interventions to increase PA in youth.

In recent years, PA and/or exercise interventions have been defined as planned efforts to influence individuals, groups, or populations to alter, modify, and increase their PA or exercise levels, with the ultimate goal of producing positive health outcomes (Bouchard et al., 2007). Many PA interventions for youth (e.g. ‘SPARK’, ‘Move It Groove It’) have been subject to rigorous scientific evaluation assessing their impact on a range of health and other outcomes (McKenzie et al., 2009; Sallis et al., 1997; Van Beurden et al., 2002). The primary purpose of PA intervention evaluation is to:

“To assess a program’s effectiveness and to monitor and document program activities.”
(Ward et al., 2007, p. 168)

A recent review article (Murillo Pardo et al., 2013) highlights that numerous studies have targeted adolescent PA and health promotion, including many intervention programmes addressing specifically the design, development, implementation and/or evaluation of promising school-based intervention strategies (De Bourdeaudhuij et al., 2010; Ericsson, 2011; Haerens et al., 2007, 2006; Jamner et al., 2004; McKenzie et al., 2004; Pate et al., 2005; Stevens et al., 2005; Sutherland et al., 2013). In the next section of this literature review, school-based strategies and effective intervention guidelines will illustrate a number of opportunities to intervene with adolescents for the purpose of increasing PA (McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009; Strong et al., 2005; Trudeau and Shephard, 2005; Ward et al., 2007). There is now a plethora of sufficient reputable evidence supporting multi-component school-based interventions for increasing PA among children and adolescents (Dobbins et al., 2013; Kriemler et al., 2011; Salmon et al., 2007; Van Sluijs et al., 2008). Among adolescents in particular, a recent systematic review of the effectiveness of interventions (Van Sluijs et al.,

2008) highlighted that additional supporting family networks positively influence PA as part of school-based interventions. Although multi-component school-based interventions appear effective in increasing PA during school hours (Physical Activity Guidelines Advisory Committee, 2012), an absence of evidence exists for school-based intervention programmes aiming to ‘spill over’ to outside PA. A recent review of school-based PA interventions (Physical Activity Guidelines Advisory Committee, 2012) highlighted that sufficient evidence now exists showing that not only can PE increase PA time during class, but that PE can also increase overall PA among youth. Health education delivered through the mechanism of PE is identified as a potential influencing factor for developing behavioural skills such as PA goal setting, preventing barriers and seeking support (Ward et al., 2007).

The most effective strategies for PE based PA interventions include a well-designed and implemented curriculum, enhanced instructional strategies for PE and the provision of sufficient teacher training (Physical Activity Guidelines Advisory Committee, 2012). Despite the importance of PE as an effective strategy for youth PA promotion, the well-informed opinion of Sallis et al. (2012) outlines that:

“The failure of public health and education groups to work together sufficiently to implement increased physical activity within physical education is hurting children’s health.” (Sallis et al., 2012, p.132)

In a European context, the recent ‘Physical Education and Sport School’ report from the European Union (EU) Eurydice service (European Commission et al., 2013) found large discrepancies between countries in the amount of taught time earmarked to PE per annum; in Irish primary schools, PE is given 37 hours per annum, the lowest of 30 countries. At post-primary level, PE is given 45 hours per annum, which is the 4th lowest country in the EU. (European Commission et al., 2013). These findings for Ireland are not surprising with recent research (Woods et al., 2010) indicating that only 35% of primary pupils and 10% of post-primary pupils received the Irish Department of Education and Skills recommended minimum minutes of PE per week (60 minutes per week at primary level, and 120 minutes per week at post-primary level).

Despite the low provision for the quantity of PE in Ireland, the school-based setting offers a realistic and evidence-based opportunity to increase PA among youth (Kahn et al., 2002; Murillo Pardo et al., 2013; Physical Activity Guidelines Advisory Committee, 2012; Salmon et

al., 2007; Van Sluijs et al., 2008). Specific studies highlight that school-based PE programmes can positively increase PA among youth if well designed and regularly monitored (Physical Activity Guidelines Advisory Committee, 2012; McKenzie and Lounsbery, 2009; Sallis et al., 2012; Strong et al., 2005; Ward et al., 2007). As a viable change agent to increase PA in the school-aged population, PE is considered a very important provider of PA (Payne and Morrow, 2009; Scheerder et al., 2008; Ward et al., 2007). PE also gives children and adolescent youth an opportunity to learn physical and behavioural movement skills (Haerens et al., 2007; McKenzie and Lounsbery, 2009; Pate et al., 2006; Van Beurden et al., 2003). It is important to note that school-based PE programmes represent just one element of intervention however, and the importance of multi-component approaches to such complex problems as affecting PA behaviour must be recognised, with findings from a systematic review reporting that whole-of-school approaches including curriculum, policy and environmental strategies appear more effective with adolescents than those that incorporated curriculum-only approaches (Timperio et al., 2004).

2.3.2 The Importance of Multi-Component School-Based Physical Education Interventions for Youth

The research is now substantially favourable that the school environment has the potential to make important differences to PA participation and presents a number of opportunities for intervention (Lavelle et al., 2012; Van Sluijs et al., 2008; Vasques et al., 2013; Ward et al., 2007). Effective school environments present opportunities to embody a culture of care, and to be fully inclusive of the individual regardless of the existing racial or socio economic background differences (Cavanagh et al., 2012). Most recent evidence (Lounsbery et al., 2013) highlights that the school is a particularly salient environment for the provision and promotion of PA because it is the only setting that reaches nearly all young people, most of whom spend almost half their waking day at school for about 36 weeks a year for 12 years. A recent report by Sallis et al., (2012) highlighted that in the past two decades, evidence-based school curricula have shown significant differences in MVPA during and outside of school hours. While the school environment presents many opportunities for targeting the individual, it is important to highlight the importance of targeting ecological domains beyond the individual in adolescent PA interventions (Perry et al., 2012). From this Perry et al. (2012) review, promising strategies for increasing adolescent PA were outlined, namely the teaching of behavioural skills

(intrapersonal), the provision of additional opportunities for PA and the delivery of non-traditional PE classes (environmental) (Perry et al., 2012).

Recent findings from a systematic review (Metcalf et al., 2012) assessing the efficacy of PA interventions (many school-based) suggest that interventions have a low overall effect on increasing minutes of objectively measured whole day total PA and time spent in MVPA amongst children and adolescents (<16 years). This paper (Metcalf et al., 2012) reviewed 30 studies, yet eliminated many previously successful evidence-based PA interventions amongst children and adolescents, namely TAAG (Stevens et al., 2005), LEAP (Pate et al., 2005), and KISS (Kriemler et al., 2010) from their data analysis due to failure to comply with the selected inclusion criteria (e.g. measuring MVPA during intervention specific periods of the day and using self-report baseline PA measurement instruments). Evidence from the last decade across many other comprehensive systematic reviews has consistently highlighted the importance of school-based interventions for PA promotion (Kahn et al., 2002; Salmon et al., 2007; Strong et al., 2005; Van Sluijs et al., 2008). For example, Kahn et al. (2002) systematically reviewed 94 studies examining the effectiveness of PA interventions. They concluded that the school setting is likely to be effective across diverse settings and population groups. Similarly, Salmon et al. (2007) reviewed 76 interventions worldwide aimed at promoting PA participation in children and adolescents. They also found that for children (defined as 4 – 12 years) school-based interventions with a focus on PE and involving school break times were the most effective. For adolescent youth (defined as 13 – 17 years), motivationally tailored advice sessions were in addition found to show promise (Salmon et al., 2007). Van Sluijs et al. (2008) in a similar review found that there was strong evidence showing that school-based interventions with a family or community component can increase PA in adolescents (defined as ≥ 10 years).

Evidence from these reviews makes a compelling case for the implementation of multi-component interventions with educational, curricular, and environmental components amongst youth (Kriemler et al., 2011; Salmon et al., 2007; Van Sluijs et al., 2008); these reviews further outline many successful strategies including year long interventions, addressing the school curriculum, family involvement, and offering enhanced PE lesson time by trained specialists. Most recent evidence (Bassett et al., 2013) which quantified the estimation of PA for school-based policies and active living, found that mandatory PE provided the highest number of minutes of MVPA (23 minutes) per school day across 85 screened articles published between

1995 and 2011; this study further concluded that policymakers could use this information to identify the best options for increasing PA in youth. Since 1995, PE in the United States has been identified as the primary resource for providing students with the opportunity to obtain the knowledge and skills required in the pursuit of lifelong PA (NASPE, 1995). Since then, it is clear that PE has been revitalised through many evidence based interventions such as CATCH (McKenzie et al., 1996), M-SPAN (McKenzie et al., 2004), SPARK (McKenzie et al., 2009; Sallis et al., 1997), LEAP (Pate et al., 2005), KISS (Kriemler et al., 2010) and 'Move It Groove It' (Van Beurden et al., 2003) for children and adolescents.

In the United States, PE's role in public health of youth has made significant strides forward in the past 20 years, (Sallis et al., 2012), particularly in the development of the aforementioned evidence-based PA interventions namely SPARK, CATCH, M-SPAN and TAAG. A recent review from the US describes the future of the 'Health Optimizing Physical Education' (HOPE) public health and education initiative in further improving PA and academic outcomes amongst children and adolescent youth (Sallis et al., 2012). The goal of HOPE is to integrate curriculum and PE lessons through the medium of health-related PA, to keep students active for at least 50% of class time, to engage all students (regardless of physical ability) and to increase students overall PA participation and health. Yet, unfortunately the future for PE in an Irish adolescent context is not as radiant as the HOPE agenda; since 2004, the allocated time scheduled for PE in post-primary schools has increased on average by 5 minutes a week, but this still results in just 10% of students receiving the recommended 120 minutes of PE per week (Woods et al., 2010).

With these worrying statistics, it seems timely to call for strategies enhancing PA promotion, specifically within Irish post-primary PE. From this section, the implementation of multi-component school-based PE interventions seems sensible.

2.3.3 The Framework for Physical Activity Interventions

Research is now sufficient to suggest that multi-component school-based PE interventions can increase PA during and outside of school hours amongst children and adolescents (Kahn et al., 2002; Kriemler et al., 2011; Physical Activity Guidelines Advisory Committee, 2012; Salmon et al., 2007; Van Sluijs et al., 2008). These recent findings indicate that multi-component interventions with educational, curricular, and environmental components

are more effective than isolated education or curricular components only (Physical Activity Guidelines Advisory Committee, 2012)., There is strong research evidence emphasising the importance of including school, familial and/or community components in adolescent interventions (Perry et al., 2012; Van Sluijs et al., 2008).

The behavioural and social approach to increasing youth PA shows strong evidence that school-based PE is one of the most effective mechanisms for improving PA and physical fitness (McKenzie and Lounsbery, 2009; McKenzie et al., 2001, 1996; Pate et al., 2005; Sallis et al., 2012, 1997) amongst young people. PE provides students with the opportunities to obtain the knowledge and movement skills needed to establish and maintain a physically active lifestyle across the lifespan (Physical Activity Guidelines Advisory Committee, 2012; Sallis et al., 2012). In section 2.3 on FMS, evidence was strong to suggest that the PA levels of children and adolescents are positively associated with motor skill proficiency (Hume et al., 2008; Jaakkola and Washington, 2012; Kalaja et al., 2012; Okely et al., 2001). For these reasons, PE should provide young people with the opportunities to run, skip, balance, kick and throw and further develop these building blocks of movement (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006; Martin et al., 2009; Stodden et al., 2008). Most recent evidence (Hardy et al., 2013) suggests that the delivery of FMS programmes requires stronger positioning within the school curriculum. Evidence from thirteen-year trends in child and adolescent FMS (Hardy et al., 2013) concludes that strategies to improve youth PA should consider teaching FMS to competency level as a mechanism for enjoying being physically active. The overarching PE strategies for effectiveness include a well designed PE curriculum describing what the students should be able to do, a specific focus on behaviour modification and intrinsic motivation, keeping participants active for the majority of instructional time, and incorporating a fitness component to the lesson plans (Physical Activity Guidelines Advisory Committee, 2012). School-based PE interventions that balance skill acquisition with health – related PA is an effective strategy for PA promotion, as has been exemplified through the “Move It Groove It” and “SPARK” programmes (Van Beurden et al., 2003; Dowda et al., 2005). PE holds promise and should be considered an efficacious instructional resource for intervention (Trudeau and Shephard, 2008), specifically considering the subject’s successful position in public health in recent years (Sallis et al., 2012).

In a European context, a recent systematic review of interventions for promoting PA among teenagers outlines some important observations relating to the effectiveness of school-based interventions (De Meester et al., 2009):

1. School-based interventions generally lead to short term improvements in PA levels.
2. Improvements in PA levels by school-based interventions were limited to school related PA with no conclusive transfer to leisure time PA.
3. Including parents appeared to enhance school-based interventions.
4. The support of peers and the influence of direct environmental changes increased the PA level of secondary school children.
5. When interventions aimed to affect more than one health behaviour the intervention appeared to be less effective in favour of PA.

A more recent review article (Murillo Pardo et al., 2013), outlines 5 promising school-based strategies and intervention guidelines to increase PA among adolescents:

1. Design multi-component interventions that foster the empowerment of members of the school community.
2. Develop improvements to PE curricula as a strategy to promote PA to adolescents.
3. Design and implement non-curricular programmes and activities to promote PA.
4. Include computer-tailored interventions during the implementation and monitoring of physical activity promotion programmes.
5. Design and implement specific strategies that respond to the interests and needs of girls.

From these review articles amongst the adolescent population, it appears that multi-component school-based PA interventions provide short-term effectiveness with the evidence for intervention effectiveness in other settings not as well documented. In line with this, it is appropriate at this stage to critically review and summarise some published youth PA intervention studies. By presenting information on these specific intervention programmes, a comprehensive aggregation of commonality between studies can be used as an effective resource for programme development and implementation.

2.3.4 Intervention Evidence – Physical Activity Promotion and Other Components Amongst Youth

Over the past two decades, many evidence-based school programmes and PE curricula specifically designed to achieve multiple goals (consisting of PA, student-acquired fitness, knowledge, motor skills etc) have been developed and rigorously evaluated in primary and second level education settings (Sallis et al., 2012). Morgan et al., (2007) found that PE can provide up to 18% of a child's recommended daily PA with PA interventions such as SPARK, M-SPAN and CATCH (McKenzie et al., 2004, 1996; Sallis et al., 1997), showing significant increases in MVPA and energy expenditure during elementary and middle school PE.

Sports, Play, and Active Recreation for Kids (SPARK) was originally evaluated with fourth- and fifth grade students, with the programme being led by either PE specialists or trained classroom teachers (Ward et al., 2007). SPARK is concerned not only with increasing PA during PE, but also with promoting the generalisation of PA beyond classes (McKenzie et al., 2009). One of the earliest studies (Sallis et al., 1997) established that following the two year SPARK intervention (Sallis et al., 1997), students (mean age range = 9.49 to 9.62 years) within the control conditions had significantly fewer mins of PE class per week (18 mins) and spent less time in MVPA per week compared to the specialist led conditions ($p < 0.001$). While no effects for PA gains outside of school were found, this study highlights that health – related PE curricula can increase the PA levels of children specifically during PE class time (Ward et al., 2007). A more recent study undertaken by Dowda et al. (2005) evaluated the sustainability of SPARK PE; results indicated that up to 80% of the 111 schools whom initially adopted the programme reported sustained use up to 4 years later. Results further indicated that programme sustainability was similar in both advantaged and disadvantaged communities highlighting that the evidence-based SPARK PE programme is highly sustainable. Most recent evidence (Mostafavi et al., 2013) investigated the effect of SPARK PE on FMS in 4 to 6 year old children. Results from this study found that the SPARK programme had a higher efficacy on the promotion of the FMS compared to the routine PE programme group or gymnastics PE group. From the outlined evidence, there now appears to be a plethora of compelling evidence to suggest that SPARK PE programmes are an appropriate alternative that can promote children's PA, FMS and lifelong wellness. SPARK is applicable across the age spectrum as the intervention strives to:

“Improve the health of children, adolescents, and adults by disseminating evidence-based Physical Education, After School, Early Childhood, and Coordinated School Health programs to teachers and recreation leaders serving Pre-K through 12th grade students.” (SPARK, 2013)

Expanding from the previous successes of SPARK PE (Sallis et al., 1997), the Middle School Physical Activity and Nutrition (M-SPAN) project at San Diego State University was the first scientific effort to assess and evaluate middle school students PA levels during PE classes (Mc Kenzie et al., 2004). The core component of the M-SPAN intervention was enhanced PE programmes (McKenzie et al., 2004) with the aim of the intervention to provide simple curricular materials through the increase of student MVPA. Some unique strengths of this intervention have been the teacher training focus on the awareness and need for active and health-related PE programmes, the implementation of an active curriculum, and ongoing teacher support (Ward et al., 2007). Results from M-SPAN (McKenzie et al., 2004) indicated that the intervention significantly improved students MVPA in PE, by approximately 3 minutes per lesson (18% increases after two year implementation). Differences in overall daily MVPA participation between groups were not reported in this study. These positive gains were obtained without any increases in PE frequency or duration highlighting that health related M-SPAN education lessons appear most beneficial within school-based PE intervention strategies. SPARK PE for elementary schools provided PE teachers with structured curricula, M-SPAN conversely provides sample curricular materials to help educators revise their existing programmes and instructional strategies to increase student MVPA (McKenzie et al., 2009). Overall, M-SPAN shows much promise for increasing PA during PE (McKenzie et al., 2004; Ward et al., 2007).

Some school-based PA programmes facilitate the intervention to leverage a number of aspects to increase PA behaviour or to focus on a physiological health outcome (Ward et al., 2007). Many interventions over the last two decades have attempted to improve the cardiovascular health of children at elementary (primary) school level, such is the example of the ‘Coordinated Approach to Child Health’ (CATCH) (McKenzie et al., 2001, 1996). CATCH was originally targeted at third to fifth grade children under the name ‘Child and Adolescent Trial for Cardiovascular Health’. CATCH consisted of multilevel school-based and family-based

components that work together to decrease the consumption of fatty/salty foods and increase regular PA (McKenzie et al., 1996). McKenzie et al., (1996) documented the materials and methods associated with the CATCH intervention by highlighting a new health related curriculum, methodological approach, teacher training and follow-up teacher consultations. Some primary results from this study found that intervention children reported 12 more minutes of daily VPA than control children, and furthermore, intervention schools engaged in significantly more MVPA during PE lessons compared to control schools (McKenzie et al., 1996). This study provided important information relating to the effect of the intervention in terms of habitual PA participation and MVPA levels during PE. Other evidence by Perry et al. (1997) found that CATCH intervention children were less likely to consume high-fat foods and were more likely to be physically active. McKenzie et al., (2001) investigated the effect of CATCH PE by teacher type and lesson location based on student activity levels and PE lesson context. Results from this study indicated that the intervention school PE classes were 1.5 minutes longer and provided significantly more MVPA and VPA during PE time compared to control schools (McKenzie et al., 2001). Overall evidence indicates that this multilevel intervention helps promote PA within and outside of school among elementary (primary) school children (Ward et al., 2007).

Other school-based intervention programmes have targeted PA promotion amongst specific high school populations, including the Lifestyle Education for Activity Project (LEAP) (Pate et al., 2005; Saunders et al., 2006). Pate et al., (2005) evaluated the effectiveness and contribution of the LEAP school-based intervention programme on the PA levels of adolescent girls (mean age = 13.6 ± 0.6 years) in South Carolina. LEAP was a PA promotion intervention targeting high school girls using six of the eight components of the Coordinated School Health Programme for regular PA promotion (Ward et al., 2007); health education, PE, health services, staff wellness, family/community involvement and the healthy school environment (Pate et al., 2005). The health education component, which was integrated within a variety of classes through health, PE and science aimed to provide girls with the behavioural skills to remain physically active throughout the lifespan (Ward et al., 2007). Results indicated that participation rates amongst girls in VPA were significantly greater in the LEAP intervention schools ($p < 0.05$) compared to the control schools (Pate et al., 2005). Other interventions, similar to LEAP, have in recent years incorporated the component of family involvement for PA promotion amongst

adolescents (Araújo-Soares et al., 2009; Haerens et al., 2007, 2006); all 3 studies interestingly reported significantly positive PA increases amongst those in the intervention group compared to control groups.

The TAAG intervention (Trial of Activity for Adolescent Girls, 2004) was designed with the aim of promoting PA in middle school by preventing the decline in PA levels among adolescent girls; a study by Stevens et al. (2005) highlights that the primary aim of TAAG is to reduce in half the age-related decline in MVPA amongst middle school girls. Similar to LEAP, the TAAG intervention had community and school linkages, specifically the components of health education, PE and programmes for PA promotion (Ward et al., 2007). The PA programmes designed were tailored to link girls to PA opportunities in the community, particularly during the after school period (Stevens et al., 2005). Some recent evidence (Webber et al., 2008) found that upon completion of the TAAG intervention, girls in the intervention schools were significantly more physically active than girls in the control schools by accumulating approximately 1.6 minutes more of daily MVPA. This evidence suggests that the school-based, community-linked TAAG intervention modestly improved PA in adolescent girls. In line with these positive results, explanations may in part be attributed to the underlying rationale of the intervention.

“The TAAG Programs for Physical Activity draws from Organizational Change Theory and direct action community organizing in developing a process by which schools, communities, and the TAAG intervention staff form partnerships to accomplish a common goal of increasing girls’ participation in physical activity at school and outside of the regular school day.” (Trial of Activity for Adolescent Girls, 2004, p.48)

Recent evidence from a meta-analysis of the effectiveness of motor skill interventions in children (Logan et al., 2011) found that the development of FMS is associated with positive health-related outcomes. Many recent school-based interventions found a significant positive effect of motor skill interventions on the improvement of FMS in children and early adolescents (Van Beurden et al., 2003; Martin et al., 2009; Mitchell et al., 2013; Salmon et al., 2008). Van Beurden et al., (2003) evaluated the “Move It Groove It” (MIGI) PE intervention in relation to children’s PA and FMS proficiency over time. This quasi – experimental design consisted of 9 control and 9 intervention schools stratified by the New South Wales Department of Education

and Training (n=1045, age range 7 to 10 years old). At follow-up, there was a highly significant 16.8% increase in FMS proficiency amongst intervention schools ($p < 0.0001$); also follow – up data revealed a significant 3.3% increase in VPA for intervention schools compared to control schools ($P = 0.008$). This is one of the first interventions from the past decade to show that the modification of PE lessons can result in significant improvements in FMS mastery proficiency amongst children. Martin et al., (2009) examined the influence of a mastery motivational climate intervention on young children’s FMS proficiency in a PE setting. Results indicate that the mastery intervention group improved significantly in FMS proficiency from pre- to post-intervention compared to their control counterparts. This recent study (Martin et al., 2009) provides evidence that a mastery motivational climate can have a positive impact on children’s FMS performance during PE and further suggests that young children who are in the initial stages of motor skill development can benefit from a self-directed climate. Salmon et al., (2008) evaluated the effectiveness of the ‘Switch-Play’ intervention designed to prevent weight gain, decrease the time spent within sedentary screen behaviour, improve FMS proficiency and promote PA participation among 10-year old children. The FMS component of this intervention consisted of taught lessons at the PA facilities at each school through games and activities; these intervention lessons emphasised the importance of FMS mastery through enjoyment, fun and maximum participation. Results from this study found a significant group by gender interaction effect for FMS proficiency over time; when compared with girls in the control group, girls in the FMS intervention group recorded significantly higher FMS proficiency.

Mitchell et al., (2013) evaluated the effectiveness of ‘Project Energize’, a school-based teacher led FMS intervention for children and early adolescents aged between 5 to 12 years old. Project Energize of New Zealand was launched in 2005 and by 2011, 250 schools, 39,598 children and 1725 teachers were actively involved. All 12 FMS significantly improved following completion of the intervention, with the greatest percentage increases occurring in kicking (28.8%), throwing (32.5%) and striking (36.3%) over the course of this tailored led FMS programme within PE. The positive effects for FMS proficiency in this intervention amongst children and early adolescents may have implications for the long term PA participation and fitness with subsequent health benefits (Mitchell et al., 2013).

More recent evidence from Kalaja et al. (2012) examined the development of early adolescents (13 years old) FMS and PA in a PE setting. This school-based PE FMS intervention

lasted 33 weeks (academic year), and was specifically dedicated to a focus on locomotor, object-related and stability skills. Results from this intervention study found significant improvements (standardized by using Z-scores and summed together) in the balance skills sum score ($p=0.04$), overall movement skills sum score ($p=0.02$) and PA ($p=0.01$). Specifically, at follow-up, the intervention group recorded significantly more days (4.17 ± 1.68) where they accumulated 60 minutes MVPA compared to the control group (3.83 ± 1.59). In a European context for early adolescents aged 13 years old, this is one of the first interventions to explicitly highlight the potential of simultaneously developing FMS and increasing PA through PE. With the recent age related decline in adolescent PA (Aibar et al., 2012; Kimm et al., 2000; O'Donovan et al., 2010), this FMS intervention (Kalaja et al., 2012) provides preliminary evidence for addressing FMS to help combat the existing low levels of early adolescent PA (Currie et al., 2012; Eaton et al., 2012; Woods et al., 2010).

2.3.5 Physical Activity Intervention Evidence for Successful Implementation

From the outlined school-based programmes specifically targeting PA and FMS (Kalaja et al., 2012; McKenzie et al., 2009, 2004, 2001; Mitchell et al., 2013; Pate et al., 2005; Sallis et al., 1997; Saunders et al., 2006; Stevens et al., 2005), it would be fair to acknowledge that there are many ways for appraising intervention effectiveness (Bouchard et al., 2007). As researchers, this poses difficult challenges as there is an abundance of conflicting evidence on recommended approaches for youth PA promotion interventions. From this literature overview, there is a strong rationale for multi-component school based interventions in the pursuit of increasing PA amongst youth (De Meester et al., 2009; Kahn et al., 2002; Salmon et al., 2007; Van Sluijs et al., 2008). Providing enhanced PE objectives, including motor skills (McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009; Pate et al., 2006; Sallis et al., 2012) taught by well-trained specialists emphasising instructional practices that provide substantial MVPA seem effective (Physical Activity Guidelines Advisory Committee, 2012). In the past two decades, school-based PE programmes with multiple goals (SPARK, M-SPAN, CATCH, LEAP, TAAG, Move It Groove It, Project Energize etc) have yielded consistently positive findings for PA and FMS promotion amongst children and early adolescents.

Consistently, it has been shown that enhanced PE can increase time spent in MVPA during class, and further increase participants PA and physical fitness levels (Physical Activity

Guidelines Advisory Committee, 2012). Yet, in terms of identifying gaps within the literature, there appears a dearth of sufficient intervention data available on adolescent PA promotion, specifically the simultaneous contribution of health education and opportunities for providing FMS during PE class. Quality PE according to Le Masurier and Corbin (2006):

1. Can Help Promote Lifelong Physical Fitness.
2. Provides Unique Opportunities for Activity.
3. Teaches Self-Management and Motor Skills.
4. Helps Educate the Total Child (Le Masurier and Corbin, 2006).

From the empirical intervention evidence outlined, it is important to note that increasing the amount of time children and adolescents spend in MVPA during a school-based PE programme is not the only way for youth to obtain regular PA (Kahn et al., 2002; Strong et al., 2005). Young people accumulate the majority of their PA outside of school, therefore, PA instructors must encourage increased PA outside of the intervention by providing children and adolescents with the skills, knowledge and motivation needed to adopt a physically active lifestyle (Ward et al., 2007). Social and physical environments can also be altered to provide additional support for PA (Physical Activity Guidelines Advisory Committee, 2012; Woods et al., 2010). Yet, from this literature review it seems evident that youth who acquire components such as FMS and learn new information about PA during PE appear more likely to increase their activity patterns (Kalaja et al., 2012; McKenzie et al., 2009, 2004; Mitchell et al., 2013; Sallis et al., 1997; Van Beurden et al., 2003). In an adolescent context, these findings need to be examined further to verify the following statement by Ward et al. (2007):

“Focusing on the development of motor and behavioral skills, as well as on the dissemination of information about physical activity, is the key technique that influences the time youth spend in physical activity outside of school and in other programs.” (Ward et al., 2007, p.54)

Crucial to a successful PA intervention design, is the importance of taking care to use the intervention time effectively, motivating youth to pursue activities at home or in their community, and providing supportive environments (Ward et al., 2007). Supporting these mechanisms (family, home, community) with multi-component school-based interventions

appear to be the most effective strategies to increase PA during school time and most importantly, outside of school (Physical Activity Guidelines Advisory Committee, 2012; Sallis et al., 2012; Sutherland et al., 2013; Van Sluijs et al., 2008) for young people, specifically adolescent youth.

With this outlined PA intervention evidence, additional details regarding the most effective methods for PA intervention evaluation are needed to:

“Enhance understanding about what has been achieved and the processes that have taken place during the intervention.” (Cavill et al., 2012, p.4).

2.3.6 Research Considerations for Designing and Evaluating Adolescent Physical Activity Intervention Studies

In 2000, the Medical Research Council (MRC) produced a framework for the development and evaluation of randomised controlled trials (RCTs) for complex interventions aiming to improve health (MRC, 2000). In this document, the MRC acknowledge that it is generally unacceptable to modify an intervention during the course of an RCT, yet an exploratory or pilot trial can be developed to explicitly address these goals:

“variations of the intervention can be tested, to see which seem to be the most appropriate for a full scale trial.” (MRC, 2000, p.10)

In 2008, the MRC produced a further document providing additional guidance on the development, implementation and evaluation of complex interventions to improve health (MRC, 2008). In this new document (MRC, 2008) it is acknowledged that the development and implementation of health interventions can be a lengthy process. This document further states that the general neglect of sufficient intervention development and pilot work will result in weaker interventions, which are more difficult to evaluate and ultimately less likely to be worth implementing (MRC, 2008).

Upon considering these MRC framework documents, it seems unsurprising that the evaluation of many public health interventions are often inaccurately designed, use unsuitable outcome measures, fail to report on health outcomes, and primarily focus on the intervention process measures such as attendance and participant contentment (Katikireddi et al., 2011).

According to the MRC (2008), there are some fundamentally important considerations for developing an intervention:

- *Are you clear about what you are trying to do?*
- *What outcome you are aiming for?*
- *How will you bring about change?*
- *Can you describe the intervention fully, so that it can be implemented properly for the purposes of your evaluation, and replicated by others?*
- *Does the existing evidence – ideally collated in a systematic review – suggest that it is likely to be effective or cost effective? (MRC, 2008, p.4)*

In terms of selecting the research setting, it is evident from the literature discussed previously, that multi-component, school-based PE programmes appear to be an effective strategy for increasing adolescent PA levels (McKenzie and Lounsbery, 2009; Murillo Pardo et al., 2013; Perry et al., 2012; Sallis et al., 2012; Strong et al., 2005; Trudeau and Shephard, 2005; Van Sluijs et al., 2008). Yet, in order to evaluate the most appropriate PA intervention for adolescents, researchers must extract information pertaining to study design, randomisation procedures, description of intervention and control conditions and PA measures (Van Sluijs et al., 2008).

A previously published systematic review undertaken by Van Sluijs et al. (2008) thoroughly evaluated the effectiveness of interventions to promote PA in children and adolescents. For this reason, integrating their methodological study inclusion criteria may be considered an important consideration in the evaluation of an adolescent PA intervention. From this systematic review, inclusion criteria consisted of the following:

1. Comparison of the PA intervention with a controlled trial
2. Participants younger than 18 years
3. Report statistical analysis of PA outcome measure (Van Sluijs et al., 2008)

This Van Sluijs et al. (2008) inclusion criteria is supported by a more recently published systematic review among European teenagers (De Meester et al., 2009). De Meester et al., (2009) similarly reviewed effective adolescent PA interventions against a set of pre-determined inclusion criteria with 75% of the identified PA interventions delivered through the school

setting. The inclusion criteria within this review (De Meester et al., 2009) are generally consistent with the Van Sluijs et al. (2008) review.

1. The effect of primary interventions to promote PA is evaluated
2. A comparison or control group is used
3. The participants were teenagers with a mean age between 10 and 19 years
4. The main outcome measure is PA
5. An effect of the outcome measure is available on at least one follow-up measurement (De Meester et al., 2009)

Both of these articles (De Meester et al., 2009; Van Sluijs et al., 2008) are accepted in the literature as scientifically rigorous systematic reviews for youth PA interventions. For these reasons, the previously outlined inclusion criteria appear suitable methodological considerations for the evaluation of an Irish PA intervention aiming to increase youth PA levels. The acquisition of a research framework as guided by recent systematic review inclusion criteria is a sensible strategy for implementing and evaluating the effectiveness of adolescent PA interventions.

2.3.7 Summary

Understanding the psychological, social, and environmental factors that influence the behaviour of children and adolescents is a crucial component in designing any PA intervention (Sallis et al., 2000; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007). In this literature review, the author has predominantly examined the significance of PA and FMS amongst young people as potentially successful contributors to school-based PE programmes (Barnett et al., 2009; Currie et al., 2012; Hardy et al., 2013; Lubans et al., 2010; Troiano et al., 2008; Woods et al., 2010; Wrotniak et al., 2006). Youth PA interventions have been designed to increase regular PA participation, improve FMS proficiency and decrease sedentary behaviours (Van Beurden et al., 2003; Kalaja et al., 2012; McKenzie et al., 2009, 2004; Sallis et al., 1997; Salmon et al., 2008; Stevens et al., 2005). PA interventions have been defined as:

“Specific purposive efforts to engage with individuals or populations to increase defined and measurable elements of PA and to attribute changes to participation in such programs.” (Bouchard et al., 2007, p.333)

In this final stage of the literature review, specifically section 2.3.1, the evidence highlighted the need for policy interventions to increase youth PA (Currie et al., 2012) as an important public health challenge (Sallis et al., 2012; Woods et al., 2010). Many types of documented interventions (school-based, community, and family-based etc) for adolescent PA promotion are in existence across a variety of settings (Kahn et al., 2002; Metcalf et al., 2012; Perry et al., 2012; Salmon et al., 2007; Van Sluijs et al., 2008; Ward et al., 2007). From the abundance of research examined, it is evident that the school setting presents a number of opportunities to intervene with children and adolescents for the purpose of increasing PA (Ward et al., 2007). From this evidence, it seems unsurprising that in recent years many studies have addressed adolescent PA and health promotion through the development and evaluation of specific school-based intervention strategies (Murillo Pardo et al., 2013). The process of developing such interventions must be given sufficient attention, however, the recent MRC document (MRC, 2008) acknowledges a general neglect towards pilot work during intervention development, resulting in weaker interventions.

In sections 2.3.2 and 2.3.3, the effectiveness of the school-based intervention setting for youth was examined more precisely. Most recent evidence (Murillo Pardo et al., 2013) highlights the importance of identifying promising school-based strategies to increase the regular PA of adolescents. In line with the theme of school-based interventions, Sallis et al., (2012) noted that in the past two decades, evidence-based school curricula have shown significant differences in youth MVPA during and outside of school hours. Further supporting this intervention setting, Salmon et al., (2007) reviewed 76 interventions worldwide and found that school-based interventions with a focus on PE and involving school break times were the most effective. The scientific evidence supporting the role of PA in health and well-being has been extensively documented (Le Masurier and Corbin, 2006), with unquestionable evidence for PE playing an important role in public health because it reaches most children (Lounsbery et al., 2013; McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009; Sallis et al., 2012). Applying motor skills in a variety of game and sport settings within PE class is important for youth in transition; these opportunities during PE must be creative and adequate provision devoted to practice skill development (Le Masurier and Corbin, 2006; McKenzie and Lounsbery, 2009; Pate et al., 2006). A pool of evidence regarding previously successful school-based PE interventions is essential, and was critically discussed in the closing sections of this literature review.

Recent findings from many comprehensive review articles have found that the school setting provides an ideal opportunity to increase PA among youth; sufficient evidence is now available to recommend global implementation of multi-component school-based programmes (Physical Activity Guidelines Advisory Committee, 2012; Salmon et al., 2007; Strong et al., 2005; Van Sluijs et al., 2008). Furthermore, enhanced PE programmes can increase PA among youth and should be widely implemented in schools (Le Masurier and Corbin, 2006; McKenzie and Lounsbery, 2009; Sallis et al., 2012; Trudeau and Shephard, 2008). Interventions such as SPARK, M-SPAN, CATCH, LEAP, TAAG, Move It Groove It, Switch-Play and Project Energize have been rigorously evaluated, providing sufficient evidence for multi-component school-based PE interventions. Physical educators who further incorporate the key components of quality PE (i.e., learning opportunities, meaningful instruction, and appropriate instruction) (Le Masurier and Corbin, 2006) significantly improve the chances for children and adolescents to increase PA participation and FMS development as evident from recent school-based interventions (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013; Mostafavi et al., 2013; Van Beurden et al., 2003).

Intervention evaluation, determines the extent to which a programme has achieved its objectives, and will assess how different processes have contributed to this (Cavill et al., 2012). In section 2.3.6, findings of a systematic review (De Meester et al., 2009) on the effectiveness of interventions to promote PA among European adolescents was reported. Studies were considered for inclusion in this systematic review if the effect of primary interventions to promote PA were evaluated, a comparison or control group was used, participants were adolescents with a mean age between 10 to 19 years, the main outcome or one of the outcomes was an objective or self reported measure of PA and finally, the effect of the outcome measure was available on at least one follow-up measurement. In an Irish context, the use of these inclusion criteria as methodological considerations may ultimately allow for more rigorous PA intervention evaluation over time.

From this review of literature it is evident that the scientific knowledge of what works is still evolving, and this author agrees it is critical that:

“We continue to evaluate the impact of physical activity programs in schools and ensure that effective programs are translated for a variety of audiences and widely disseminated.” (Physical Activity Guidelines Advisory Committee, 2012, p.2)

2.4 References

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Chapter 3

Y-PATH: Youth-Physical Activity Towards Health. Evidence and background to the development of a physical activity intervention for adolescents.

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Chapter 3: Independent contribution to this chapter

Title: Y-PATH: Youth-Physical Activity Towards Health. Evidence and background to the development of a physical activity intervention for adolescents.

My Role: My role in the completion of this chapter included:

- Wrote 50% of the first draft of the introduction and contributed significantly to the subsequent redrafts until submission
- Alongside the leading author Dr. Sarahjane Belton, I was the principal investigator responsible for all of the data collected (2010/11) in this chapter. Data consisted of physical activity, fundamental movement skills, body mass index, psychosocial correlates and focus groups.
- I organised all stages of data collection consisting of timetabling undergraduate students, contacting all post-primary schools (principals, teachers and students), equipment preparation, data storage, data cleaning and data inputting. A significant component of this baseline study was the rigorous training and protocol for field staff assistants; for this, I organised each training session and associated workshop.
- In terms of data analysis, I contributed strongly to the physical activity, fundamental movement skills and body mass index data as presented in this chapter. I was actively involved in the psychosocial and focus group data analysis which were the primary responsibilities of other Y-PATH team members.
- Regarding the methods section, I wrote 40% of the first draft (specifically the FMS and focus group section) and contributed significantly to the subsequent redrafts until submission.
- Co-wrote and co-completed the results section with leading author Dr. Sarahjane Belton, specifically the sections relating to the preferred and current types of PA, FMS and focus groups.
- Regarding the design of the Y-PATH intervention, I was responsible for developing all the content and resources which are outlined in the discussion section. For this chapter, I designed figure 3.2 (Y-PATH intervention structure).
- Overall, it has been agreed by all authors, that my independent contribution was 40% to this entire chapter, specifically drafting, editing and writing the manuscript.

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3.1 Abstract

Introduction: Despite the known benefits of regular physical activity (PA) for health and well-being, many studies suggest that levels of PA decline dramatically during adolescence.

Purpose: To develop a targeted physical education (PE) based PA intervention for post-primary youth, based on the youth physical activity promotion model.

Methods: Cross-sectional data on PA levels (using self-report), correlates of PA, and the fundamental movement skill (FMS) proficiency of 256 youth were collected. A sub sample (n = 59) participated in focus group interviews to explore their perceptions of health and identify barriers and motives to participation in PA.

Results: Most (67%) were not meeting the recommended minimum PA guidelines for health, and 99.5% did not achieve the FMS proficiency expected for their age. Self-Efficacy and PA Attitude scores were significantly different ($p < 0.05$) between low, moderate and high active participants. Active and inactive youth reported differences in their perceived understanding of health as well as their identified barriers to PA participation.

Conclusions: Data show a need for targeting low levels of PA in youth through addressing poor health related activity knowledge and low FMS proficiency. The Youth-Physical Activity Towards Health (Y-PATH) intervention was developed in accordance with these findings; details of the intervention format are presented.

3.2 Introduction

Physical activity (PA) as a preventive measure is widely recognised as key to effective management of overweight and obesity problems (Department of Health and Children, 2005), and for children it is seen as an important factor in reducing the risk of chronic disease in adulthood (Centers for Disease Control and Prevention, 2011; BHF National Centre Physical Activity and Health, 2013). Evidence suggests that habitual physical activity (PA) amongst young people is declining with a rise in incidence of overweight and obesity (Centers for Disease Control and Prevention, 2011). Consequently, children and adolescents are a target population for the promotion of PA to enhance health. A critical consideration for children, adolescents, parents, professionals, and scientists is the implementation and adherence to regular PA guidelines (Ward et al., 2007). The most widely endorsed PA guideline stipulates that in order to enhance health, youth should accumulate at least 60 minutes of moderate-to-vigorous PA (≥ 60 min. MVPA) daily (Physical Activity Guidelines Advisory Committee, 2008; Department of Health and Children and Health Service Executive, 2009).

Despite the known importance and associated benefits of regular PA in promoting lifelong health and well-being, studies suggest that levels of PA decline dramatically during adolescence (Kimm et al., 2000; O'Donovan et al., 2010), with males significantly more active than females (Currie et al., 2012; Riddoch et al., 2004; Sisson and Katzmarzyk, 2008; Woods et al., 2010). The Health Behaviour in School-Aged Children study (Currie et al., 2012) found that in Ireland, among 11-year olds 31% of females, and 43% of males reported accumulating ≥ 60 min. MVPA daily, this figure drops to 20% of females, 36% of males by age 13. The level of PA, the age related decline in PA, and the gender differences reported in the HBSC study for Ireland was relatively consistent with almost all countries surveyed (Currie et al., 2012). The 'Children's Sport Participation and Physical Activity' study (CSPPA, N=5397, age range 10-18 years, mean age 13.8 ± 2 , 52% female) (Woods et al., 2010) reported lower participation levels than the HBSC (Currie et al., 2012), with only 18% of adolescents of their 12 to 13 year olds meeting the recommended ≥ 60 min. MVPA daily. The social ecological approach suggests that intervention design for health promotion should cover different levels such as policy, organisational, interpersonal and individual (Stokols, 1992). Evidence now emphasizes the need for research to generate sound knowledge on models of successful intervention in PA (Ward et al., 2007). In their policy guidelines aligned to the HBSC results, the World Health Organization (WHO) (Currie et al., 2012) supported the need for policy interventions to increase PA. They state that policy-makers and

practitioners should seek to identify what prevents and what motivates participation. Some of the factors listed as ensuring equitable access in this report include *“providing a range of activities that appeal specifically to girls, ensuring activities are free or affordable, with provision of free or low-cost transportation to the venue, and involving young people in programme design to identify barriers to participation.”* (Currie et al., 2012, p.137).

The Center for Disease Control’s (CDC) Task Force on Community Preventive Services (Centers for Disease Control and Prevention, 2001) in a systematic review of community interventions designed to increase PA, recommended six different types of intervention as having good evidence for achieving sustainable behaviour change in PA. Consistent with recent findings (Payne and Morrow, 2009; Sallis et al., 2012), the organisation level or school-based physical education (PE) was highly recommended as one of these intervention types (Centers for Disease Control and Prevention, 2001). PE has the opportunity to reach nearly all school-aged children (Rosenkranz et al., 2012), and has been associated with improved mental health, dietary choices and academic achievement (Simms et al., 2013). For an increasing number of children PE may be the only opportunity they have during the week to engage in MVPA (Trudeau and Shephard, 2005) due to the high prevalence of total sedentary behaviour among the current generation of children. PE is now widely accepted as a public health resource (Sallis et al., 2012). Increasingly, studies are reporting the positive effect school-based PE interventions have on PA participation (McKenzie et al., 2004; Payne and Morrow, 2009; Ward et al., 2006). However, it is less apparent in the literature how young people’s knowledge of (or beliefs and attitudes towards) the role of PA, in ensuring optimal health, affects their PA participation. A large number of PA intervention programmes have reported some element of health education (related to PA) as part of the intervention structure (Van Sluijs et al., 2008).

At the individual level, the CDC (Centers for Disease Control and Prevention, 2011) recognises that for young people perceived competence, and perceptions of their ability to perform a PA (self-efficacy), will affect their participation in an activity. A systematic review (Salmon et al., 2007) of 76 interventions worldwide aimed at promoting PA participation in children and adolescents found that for children (defined as 4 – 12 years), school-based interventions with a focus on PE and involving school break times were the most effective. For youth (defined as 13 – 17 years old), tailored advice sessions were found to be more effective. This is supported by other evidence-based PA (Strong et al., 2005) who found that at approximately 10 years of age PA priorities start to change from general PA with an emphasis on motor skill development to prescriptive PA with an emphasis on health, fitness

and behavioural outcomes. A similar review on the effectiveness of PA interventions (Van Sluijs et al., 2008) found that there was strong evidence showing that school-based interventions with a family or community component can increase PA in adolescents (defined as ≥ 10 years).

The strategic advice outlined in the CSPPA study (Woods et al., 2010) in order to achieve the overall recommendation of increasing PA levels of youth include the development and promotion of fundamental movement skills (FMS). Cross-sectional evidence has grown regarding the importance of fundamental movement skill proficiency, showing that it is positively associated with total PA (Fisher et al., 2005), MVPA (Wrotniak et al., 2006), skill-specific PA (Raudsepp and Päll, 2006) and organised PA (Okely et al., 2001) in youth. Mastery of motor skills in childhood is likely to be a key determinant of later adolescent PA (Barnett et al., 2009). Findings of a recent study (Barnett et al., 2011) advocate for the simultaneous targeting of increasing PA and fundamental movement skills in PA interventions; such is the evidence of a school-based programme (Van Beurden et al., 2003) which found positive effects in FMS and PA levels following a 5 month respective PE intervention. The CSPPA study (Woods et al., 2010) found that 'lack of competence' was the most commonly reason cited for non-participation in sport and PA by children and youth. This finding is supported by the Self-Determination Theory (Standage et al., 2005). The link between poor FMS levels and low levels of PA have been described above, however what is less apparent in an Irish context is the current levels of FMS of youth, particularly at the critical period of transition from primary to post primary education. No published studies reporting this information were available in the preparation of this article. Children have the developmental potential to master most of the FMS by 6 years of age (Gallahue and Ozmun, 2006), yet recent evidence outside of Ireland suggests adolescent youth are not performing FMS to their expected developmental capability (Booth et al., 1999; Hardy et al., 2010; Mitchell et al., 2013). This emerging evidence indicates that children are likely making the transition to adolescence without acquiring basic movement skill proficiency, though this has yet to be confirmed in an Irish context.

In order to counteract the attraction of sedentary pursuits, and to promote lifelong engagement in PA, intervention programmes need to be developed focusing on the unique needs of young people (Ward et al., 2007). To design personally meaningful and socially relevant PA interventions for youth, their views and opinions and insight into motivations and barriers they experience in relation to participation both within and beyond school must be sought. This improved understanding of the factors that influence young people's PA

behaviours will allow for the planning of more appropriate interventions to promote PA within this cohort (Crimi et al., 2009). To simplify this process the Youth Physical Activity Promotion (YPAP) Model (Welk, 1999) guided the development of the Y-PATH intervention. This model was designed to provide an insight into the psychosocial correlates of PA for youth. It has two major components; ‘predisposing’ factors (which increase the likelihood that youth will participate in PA) and the ‘reinforcing’ factors (the influences that encourage participation) (see figure. 3.1 below). This proposed intervention hypothesises that youth engaged in Y-PATH will more positively re-evaluate their predisposing ‘Am I able’ (e.g. skill level and self-efficacy) and their reinforcing factors ‘Is it worth it’ (e.g. enjoyment, lack of embarrassment, perceived competence and physical self-concept) for PA post intervention in comparison to youth who were not exposed to the intervention.

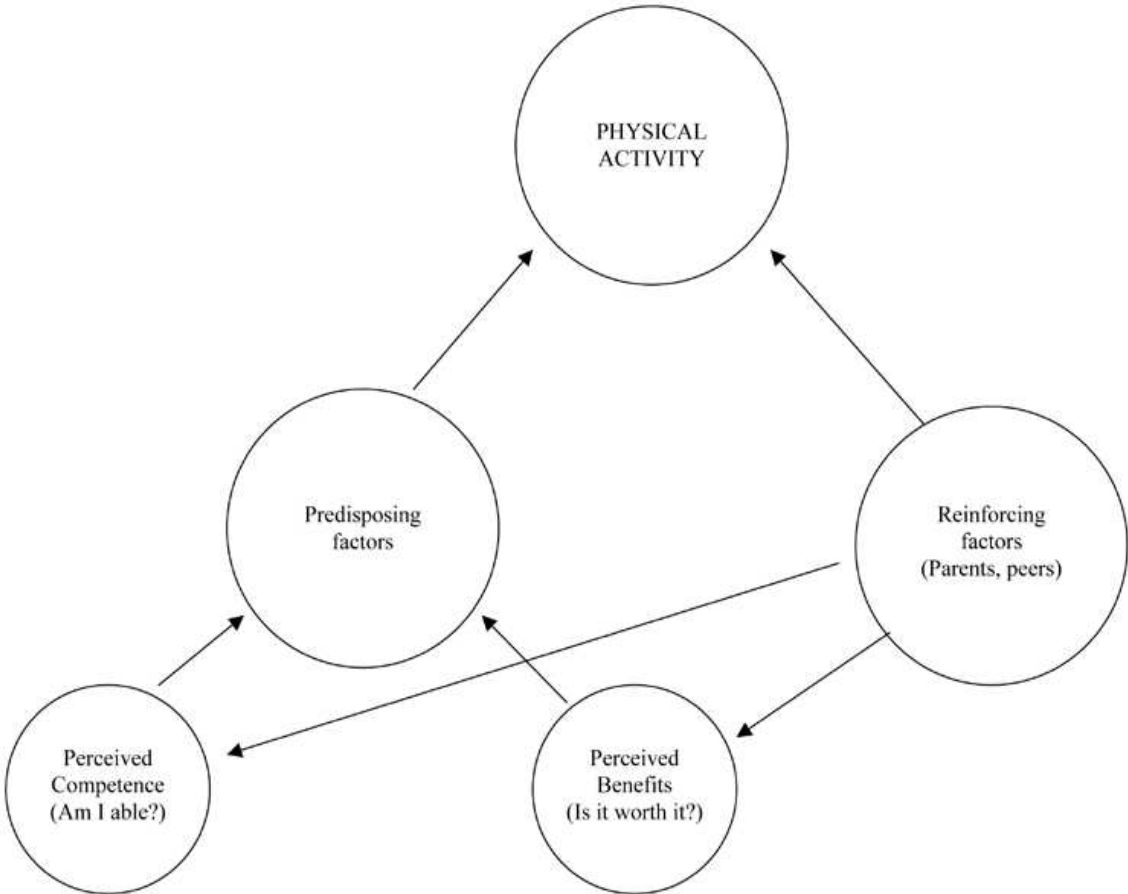


Figure 3.1 The YPAP model as presented in Rowe et al. (2007)

A recent study (Martínez-Andrés et al., 2012) advocate for the use of mixed methods in studies aiming to develop effective interventions for youth, using qualitative methods to better understand young peoples points of view in relation to barriers and motivators for PA, and using quantitative data to get a more objective picture of the amount of PA youth

participate in. The purpose of the current study (Y-PATH: Youth Physical Activity Towards Health) was to collect such data in an Irish context so that a meaningful and relevant intervention could be developed. Data on current levels of PA and FMS of 12 – 14 year old adolescent youth was collected, along with data on current and preferred types of PA participated in, and various psychological correlates of PA. Focus group interviews were then used to explore barriers and motivators to PA of the cohort. Based on the information gathered an intervention programme ‘Y-PATH’ specifically tailored for the needs of this age group was developed.

3.3 Methods

3.3.1 Participants and recruitment

A cross-sectional research design was employed. All second level schools in a rural Irish town (two mixed schools, one all male school, and one all female school) were targeted and provided consent. All first year students (aged 12 – 14 years) within these four schools were invited to be involved in the study; 256 participants from a possible total of 288 agreed to participate. Informed consent for participation was granted by each participant and their parent/guardian; all participants were free to withdraw from the research at any stage. Full approval for this study was given by the institutional research ethics committee (DCUREC/2010/081).

3.3.2 Procedures and data management

Body mass (kg) and height (m) were directly measured using a SECA Leicester Portable Height Measure and SECA heavy duty scales. Level of PA participation, current and preferred modes of PA participation, and psychological correlates of PA were assessed via self-report (Corder et al., 2009; Rowe and Murtagh, 2012). A sub sample of participants (one class group from each school, total n=117) also wore an Actigraph GT1M or GT3X accelerometer for a period of 9 days in order to provide an objective measure of habitual PA participation; due to a firmware malfunction with the software, collected accelerometer data was omitted from the analysis. Each FMS was assessed in conjunction with the behavioural components from three established instruments: Test of Gross Motor Development (TGMD) (Ulrich, 1985), Test of Gross Motor Development 2 (TGMD-2) (Ulrich, 2000) and the Victorian Fundamental Motor Skills manual (Department of Education Victoria, 1996). Focus group (FG) interviews were used to explore students' perceptions of what it means to be healthy and to identify their motivators and barriers to PA participation.

The questionnaire developed for the Y-PATH study was a combination of well-known, valid, and reliable self-report measures (Corder et al., 2009; Rowe and Murtagh, 2012). The measures used were developmentally suitable for adolescents of this age group and addressed the key areas of research interest. Habitual PA was assessed using two questions (Woods et al., 2009) - the number of days during the past week, and for a typical week, that participants accumulated 60 minutes or more of MVPA. A composite mean of the 2 items provided a score of days per week that the adolescents had accumulated 60 minutes of MVPA, this

method has recently shown moderate to high correlations with objective accelerometer data (0.20-0.51) amongst adolescents (Ridgers et al., 2012). Current modes of PA were assessed using the YPAQ questionnaire (Corder et al., 2009). Questions on preferred types of PA, and psychological correlates of PA (self-efficacy, physical self-worth, perceived benefits and barriers to participation, PA attitudes, subjective norms, behavioural control and intentions) were all taken from the FifeActive survey (Rowe and Murtagh, 2012).

Data was collected on participants in their class groups (maximum n = 30) during a 2-hour school visit, with a ratio of 1 researcher to 10 students for questionnaire completion, and 1 researcher to 5 students for all other measures. The study was briefly explained and instructions provided on how to complete the questionnaire. Participants were encouraged to take their time, reflect on their answers, and to be as honest as possible. All questionnaires were completed online through 'Survey Monkey' in class, with an ID number assigned. In cases where computer networks failed, participants completed hardcopies of the questionnaire. Reliability among a sample of 35 participants (11-12 years of age) was carried out to ensure comparability of the two administration protocols (computer versus hardcopy); reliability coefficients ranged from 0.81 to 0.94, showing the scores across both formats of the questionnaires to be very stable over time.

FMS data were collected during PE classes; again, participants were assigned ID numbers for anonymity purposes. The following 9 FMS were assessed (along with height and weight) during a timetabled 80 minute PE lesson: run, skip, horizontal jump and vertical jump (locomotor; maximum score = 34); kick, catch, overhand throw, strike and stationary dribble (object control; maximum score = 40). Prior to FMS data analysis, researchers were required to reach a minimum of 95% inter-observer agreement for all 9 skills on pre-coded data. FMS analysis focused exclusively on the raw scores across the selected 9 FMS. The number of FMS performance criteria varied from 3 to 6 across the range of selected FMS; all participants were given a '1' for correct execution of criteria, and a '0' for a failed attempt. Participants performed the skill on 3 occasions including 1 familiarisation practice and 2 performance trials. For each FMS, the two performance trials were added together to get the total for each skill score. There were a total of 74 performance criteria for all 9 gross motor skills. A total score for all 9 skills was calculated for each participant, along with an Object Control score, and a Locomotor score.

Once FMS data were collected, participants in the selected class groups were then given an accelerometer to wear for the following nine days. Participants were shown how to wear the accelerometer above the iliac crest of the right hip (Troost et al., 2006), and were

asked to wear the accelerometer during all waking hours unless showering, swimming or taking part in a contact activity for which an adult deemed it unsafe to wear. A member of the research team met with the students each school morning of the nine days to ensure students were complying with accelerometer wear instructions. In order to try boost participant compliance with the wear protocol, participants that provided their mobile phone numbers received an SMS each morning of the 9 days to remind them to wear the monitor, and all participants were informed that if they complied with the wear protocol they would be entered in a draw for a €50 sports voucher (Belton et al.,2013) (see appendix K).

FG interviews that explored student perceptions of what it means to be healthy and their views on the important factors that influenced their involvement in, or avoidance of, PA were also conducted. A semi-structured interview guide, using questions designed by the research team whom had specific expertise in qualitative design and PA intervention development were developed. Questions were piloted on a sample of 16 students from the target group. Following the pilot work and associated data collected, 8 FG interviews were conducted in the 4 schools post self-report and FMS data collection. Each school had 2 focus group interviews, 1 with an 'active' group and 1 with an 'inactive' group. A subsample of students (n=59) randomly selected from the 4 schools were selected into either 'active' or 'inactive' categories based on the previously collected self-report data at baseline (0-2 days 60 minutes MVPA = inactive; 6-7 days 60 minutes MVPA = active) (Woods et al., 2010). Prior to FG commencement, all participants received and signed a consent form and a plain language statement providing details of the research. Focus groups occurred in a school classroom and lasted an average of 45 minutes. Participants were reminded that they could withdraw from the interview at any stage and that all recordings would remain confidential. The FG interviews were recorded by Dictaphone and were transcribed verbatim. Each of the eight FG interviews were conducted by two researchers; a facilitator and a note taker. The facilitator's role was to guide the FG, stimulate interaction among students toward the theme, oversee group discussion and encourage all students to respond. The note taker kept a record of the discussion as it evolved to add details for instances where the recording was not audible (Tannehill et al., 2013).

3.3.3 Data analysis

Where participants had incomplete data for a given variable, participants were excluded from analysis of this variable specifically. Current and preferred modes of PA and the number of self-reported days meeting the 60 minutes PA guideline were analysed

descriptively using means, standard deviations and proportions. Similar to the CSPPA study (Woods et al., 2010), students were categorised as low active (meeting guidelines on 0, 1, 2 or 3 days a week), moderate active (meeting on 4 or 5 days), or high active (meeting on 6 or 7 days). Chi square tests for independence explored the relationship between PA category (low, moderate and high active) and preferred types of activities. A summative score was calculated for each psychological correlate (scoring system detailed in FifeActive (Rowe and Murtagh, 2012)). Descriptive statistics and frequencies for all FMS were calculated. “Mastery” was defined as correct performance of all skill components on both trials, “Near Mastery” was defined as correct performance of all components but one on both trials (Van Beurden et al., 2002). Two-way between groups ANOVA’s were used to explore the impact of gender and PA grouping (low, moderate or high active) on Total FMS score, Locomotor score, Object Control score, BMI, and on all psychological correlates.

The FG data was analysed using the constant comparative method (Merriam, 1998). This process involved highlighting and comparing the emergent themes from the associated data collected in the FG interviews. Similar themes from the active and inactive focus group participants were grouped together under several headings. Areas of significance and importance in relation to students’ perception of health and their views on the factors deemed important in motivating or preventing their participation in PA, were identified. In order to ensure data trustworthiness and credibility, various steps were taken including member checking, peer examination and independent data coding. Member checking involved the researchers discussing the main findings with the FG participants to verify accurate reflections of the discussion (Merriam, 1998). Participants were given the opportunity to make amendments or add suggestions. No participants made any changes to the research findings. Peer examination of the data occurred between the researchers to ensure individual researchers found similar trends from the data and a second reader independently coded the data. Differences in the coding were discussed between the researchers and independent coder until consensus was reached.

3.4 Results

Table 3.1 (see below) gives the gender breakdown of mean (SD), along with the sample size, for all variables, both overall and across PA grouping.

3.4.1 Descriptive and Anthropometric Characteristics

Of the 256 participants involved in this study, 53% were male and 47% were female, with a mean age of 12.40 ± 0.51 years. Just over half (52%) of participants were attending a mixed school, with 25% attending an all male school, and 23% attending an all female school. Participants had a mean BMI of 20.03 ± 3.30 kg/m², with 75% categorised as normal weight, 21% overweight, and 4% obese using the Cole et al., (2000) classification.

3.4.2 PA (self-report)

Self-report PA data showed that 20% of participants met the 60-minute guideline on 0 – 3 days a week (low active), with 31% meeting the guideline on 4 or 5 days (moderate active); the remaining 49% of participants met the guideline on 6 or 7 days (high active). The percentage of participants meeting the guideline on all 7 days was 33%. Results of the Two-way ANOVA's exploring the impact of gender and PA grouping on the different variables are given in Table 3.1 (see below). The interaction effect for gender and PA grouping was not significant for any of the variables. Statistically significant main effects for gender and/or PA grouping are shown in the main effect column in Table 3.1, along with the effect size (Partial Eta Squared) in each case.

Table 3.1 Mean (SD) of variables by gender across PA grouping with significant main effects and effect size of Two-Way ANOVA's

Variable	Gender	N	Overall	Habitual Physical Activity			Main effect	Partial Eta Squared
				Low	Moderate	High		
Body Mass Index	Male	131	19.89 (3.45)	20.60 (4.32)	19.61 (3.04)	19.93 (3.25)	None	
	Female	113	20.17 (3.13)	20.26 (2.77)	20.16 (3.28)	19.79 (3.49)		
Total FMS Score (max 74)	Male	120	61.93 (5.56)	60.81 (6.03)	62.51 (6.76)	62.18 (4.14)	None	
	Female	103	60.13 (5.33)	60.73 (5.14)	60.60 (4.90)	59.96 (5.30)		
Object Score (max 40)	Male	120	36.62 (2.62)	36.13 (2.81)	36.49 (3.17)	36.75 (1.97)	Gender, $p = 0.003$	0.044
	Female	103	35.27 (2.82)	35.30 (2.93)	35.57 (2.71)	35.04 (2.47)		
Locomotor Score (max 34)	Male	120	25.31 (4.19)	24.68 (4.61)	26.03 (4.63)	25.43 (3.39)	None	
	Female	103	24.85 (3.94)	25.43 (3.45)	25.03 (3.67)	24.93 (4.16)		
Self efficacy	Male	133	25.36 (4.04)	23.74 (4.18)	26.30 (4.17)	25.73 (3.47)	PA, $p = 0.018$	0.032
	Female	118	24.80 (4.27)	24.28 (4.58)	24.74 (4.20)	25.56 (3.90)		
Physical Self-Worth	Male	133	19.53 (3.30)	18.76 (3.32)	19.76 (3.43)	19.90 (3.12)	Gender, $p = 0.043$	0.017
	Female	118	18.53 (3.63)	17.76 (4.06)	19.32 (2.76)	18.68 (3.76)		
Perceived benefits of PA	Male	133	31.71 (4.04)	31.23 (4.80)	32.11 (3.88)	31.71 (3.55)	PA, $p = 0.031$	0.028
	Female	118	31.31 (4.24)	30.19 (4.23)	32.68 (3.40)	31.27 (4.23)		
Perceived barriers to PA	Male	133	33.86 (8.12)	32.63 (7.85)	35.07 (7.05)	33.67 (9.21)	PA, $p = 0.027$	0.029
	Female	118	33.91 (6.57)	31.76 (6.61)	34.29 (5.51)	36.38 (6.81)		
Attitudes to PA	Male	129	13.78 (2.30)	12.87 (2.43)	14.09 (2.16)	14.18 (2.17)	PA, $p = 0.000$	0.086
	Female	117	13.59 (2.32)	12.67 (2.37)	13.87 (2.15)	14.53 (2.00)		
Social Support	Male	129	16.14 (3.94)	15.89 (4.03)	15.88 (3.44)	16.55 (4.32)	None	
	Female	117	15.90 (3.12)	15.52 (2.99)	16.57 (3.32)	15.68 (3.04)		
Behavioural Control	Male	129	10.17 (1.91)	9.73 (1.85)	10.21 (1.95)	10.47 (1.89)	PA, $p = 0.012$	0.036
	Female	117	9.79 (1.99)	9.24 (2.08)	10.05 (1.87)	10.24 (1.86)		
PA intentions	Male	129	6.28 (1.54)	5.70 (1.56)	6.23 (1.52)	6.76 (1.39)	PA, $p = 0.002$	0.052
	Female	117	5.88 (1.64)	5.59 (1.60)	5.87 (1.65)	6.29 (1.62)		

3.4.3 Current and preferred activity types PA (self-report)

The three most popular types of activity participants reported taking part at least once a week were soccer (73%), cycling (53%), and rugby (42%) for males, and hockey (77%), dance (53%), and cycling (40%) for females. 'Team games' was the most popular weekly activity category for both males (94%) and females (93%). In terms of preferred modes of activity 74% of both males and females said they would like to take part in more team games if they could. The second most popular preferred mode of activity was 'outdoor recreation' (57% male, 72% female), while the third most popular was 'water based activity' for male (50%), and 'individual sports' for females (57%). Chi square tests for independence indicated no significant association between any of the PA groups (low, moderate and high) and each of the current or preferred types of activity, $p > 0.05$.

3.4.4 Psychological correlates (self-report)

Of the psychological variables only subjective social norms showed no significant main effect for either gender or PA category, while Physical Self-Worth was the only variable with a main effect for both Gender and PA category. All other psychological variables demonstrated a significant main effect for PA category only, with a small effect size in each case. Post-hoc comparisons using the Tukey HSD showed that in all cases the mean score for the low active group was significantly lower than the high active group; only in the Barriers to Self-Efficacy and the Attitudes to PA variables were the low active group mean scores also significantly lower than the moderate active groups.

3.4.5 FMS

Only one participant (0.5%) possessed complete mastery level across all 9 object related and locomotor movement skills, with 11% scoring mastery or near mastery across the 9 skills (see Table 3.2 below). The poorest performances were for the vertical and horizontal jumps (locomotor) where 13% and 29% respectively achieved mastery and 10% and 28% achieved near mastery. Results of a Two-Way ANOVA showed that male participants obtained a significantly higher object control score compared to female participants ($p < 0.01$). There was, however, no significant gender difference in the overall locomotor mean score performance.

Table 3.2 Percentage and raw score, and 95% confidence intervals (95% CI) of mastery of fundamental movement skills

	Mastery		Raw Score (SD)	
	Male	Female	Male	Female
Locomotor				
Run	95.1% (89.2, 98)	76% (66.2, 83.7)	7.92 (0.40)	7.45 (1.09)
Skip	10.6% (6, 17.7)	11% (6, 19.2)	3.67 (1.36)	4.18 (0.95)
Horizontal Jump	35.8% (27.5, 45)	20% (12.9, 29.4)	6.30 (1.64)	5.22 (1.93)
Vertical Jump	13.8% (8.5, 21.5)	12% (6.6, 20.4)	7.46 (2.68)	7.94 (2.00)
Object control				
Catch	70.7% (61.7, 78.4)	64% (53.7, 73.2)	5.57 (0.82)	5.55 (0.66)
Overhand Throw	60.2% (50.9, 68.8)	27% (18.9, 36.7)	7.08 (1.33)	6.00 (1.58)
Stationary Dribble	65.9% (56.7, 74)	55% (44.8, 64.9)	7.05 (1.62)	6.87 (1.55)
Strike	43.1% (34.3, 52.3)	55% (44.8, 64.9)	9.05 (0.94)	9.25 (0.99)
Kick	86.2% (78.5, 91.5)	78% (68.4, 85.4)	7.80 (0.52)	7.64 (0.76)

3.4.6 Focus Groups

Three key themes emerged from the FG data that were pertinent to students perception of health and what students deemed important in influencing their participation in, and barriers to, PA, PE, sport and exercise These themes were:(1) Being healthy: diet, exercise and body image, (2) Motivators: PA is fun, and (3) Barriers: lack of time, distance, PE related factors.

Being healthy: diet, exercise and body image

Active participants perceived being healthy to be related to eating and exercising. One student commented that being healthy means: ‘eating healthy and you see people jogging on the road and you know they are fit and healthy.’ Similarly, another student linked being healthy with: ‘well say if you are not doing exercise and you eat too much fattening foods, it will clog up your heart and you will get a heart attack.’

Inactive participants’ perception of health differed as they largely associated being healthy with nutrition and body image, with exercise rarely mentioned. To illustrate this, one participant associated being healthy as ‘not getting fat...eating the right food to help your body.’ When this response was probed, the same participant went on to explain that eating the

right food consists of ‘replacing junk foods with fruit and vegetables.’ Other responses from the inactive participants who associated being healthy with body image included: ‘you don’t have to worry about being fat’ and being healthy ‘kind of keeps you skinny.’

Motivators: PA is fun

The key emergent theme in relation to motivators for PA among active participants was enjoyment and fun. Examples of this include a student stating: ‘I think it’s [physical activity] fun and like if you’re at home all day, it’s great to get out for a couple of hours.’ Similarly, another student stated: ‘well I enjoy it and I know it’s very good and like healthy for you’. Perceiving physical activity as being fun was similarly attributed by inactive participants as a participation motivator, with one student stating: ‘I just find them fun, they’re good to do.’

Barriers: lack of time, distance, PE related factors

In relation to barriers to PA participation, insufficient time to participate was identified as the main barrier amongst the active group. One student indicated: ‘we don’t really have any time to do extra sport apart from like football training because you get back from school at like quarter to 5, you get the bus from here to [place name] so you just kind of get time to eat your dinner, get changed for training, go training, and go home and do your homework’. Findings illustrated that barriers to PA participation amongst the inactive participants outweighed the motivating factors of their active counterparts. Several inactive participants cited distance to activity as a barrier to PA participation with one participant stating ‘you travel for sometimes an hour, all the way just to play a match, and then you lose, and it’s a waste of time pretty much.’ Other identified barriers to participation were PE related factors and included the apparent competitive nature, and perceived lack of choice, in PE class. One such participant stated: ‘the guys played and they just got really competitive and it was not fair.’ Another student voiced concerns about the choice in PE: ‘It’s very like, only the team can play, you can’t really choose how you want to do it, and you don’t get to choose what you do.’

3.5 Discussion

Results of this study highlight that a large number of Irish youth are insufficiently active to benefit their current and future health (only 33% meeting PA guideline for health). Though higher than the 19% reported for this age group in the CSPPA study (Woods et al., 2010), this finding is relatively consistent with the range of findings reported for other European countries in the HSBC study (Currie et al., 2012). Given the consistently reported decline in activity with age (Currie et al., 2012; Woods et al., 2010), the need for intervention to address these low levels reported for young people aged 12 – 14 years old is evident.

The majority youth in this study (99.5%) failed to reach a level of mastery across key FMS, indicating that basic movement skill proficiency is low. Other research outside of Ireland examining the FMS proficiency of adolescents support this low level of FMS mastery (Hardy et al., 2010; Okely and Booth, 2004). Guided by previous findings (Salmon et al., 2007), it is important to recognise that an intervention designed around movement skill acquisition alone would probably be insufficient to change PA behaviour in youth long term. This points to the targeting of an improvement in FMS proficiency as a strategic supplement in the promotion of PA in adolescents.

Consistent with other studies (Biddle et al., 2005; Crimi et al., 2009; Reynolds et al., 1990; Sallis et al., 2000; Trost et al., 1999; Van Der Horst et al., 2007), analysis of psychological variables reveals an association with PA level. This was evident for self-efficacy, physical self-worth, perceived barriers and benefits, all of which exhibited moderate effects. Self-efficacy is consistent with recent reviews (Bauman et al., 2012; Biddle et al., 2005; Van Der Horst et al., 2007), which was found to be a consistent positive correlate of PA in children and adolescents. Attitude to PA demonstrated a significant difference between low and moderately active, and low and high active participants; with low active participants scoring significantly lower than their moderate and high active counterparts in each case. Most recent evidence (Lowry et al., 2013) found that a positive attitude towards PA was associated with increased PA and decreased sedentary behaviour among US adolescents. It is of note however, that in several articles the findings in relation to attitude varied, with the majority of papers reviewed finding it unrelated to PA, or reporting findings as inconclusive- authors conclude that attitude may not be a correlate of PA in adolescents (Bauman et al., 2012; Van Der Horst et al., 2007). These variables (attitude, self-efficacy) are categorised as predisposing factors for PA in the YPAP model (Welk, 1999), indicating they have a strong influence on the likelihood that a young person will become physically active.

From the FG findings, it was evident that the active and inactive participants had different perceptions of health, and the relative contribution of PA to that concept. Active participants cited the importance of 'exercise' which supports previous research (Wright and Burrows, 2004) who found that students' responses similarly linked practices like eating and exercise with being healthy. FG findings suggest however that inactive participants associate the term health with body images such as being skinny and avoiding becoming fat. Similar research (Macdonald et al., 2005) also found that children perceived being fit and healthy as being skinny and losing weight.

Consistent with a previous study (Wilson et al., 2005), both active and inactive participants identified PA being fun as a primary motivator for participation. Participation barriers identified by inactive participants included lack of time (Uijtdewilligen et al., 2011), distance (Nelson and Woods, 2009), the competitive nature, and lack of choice, in PE. Research examining the environmental influences on PA among adolescents (Bauer et al., 2004) similarly found that competition was one of the predominant barriers to students fully participating in PE. Other research suggests offering alternate, non-competitive forms of PE as realistic ways for change and improving the long-term participation in PE for children and youth (Allender et al., 2006; Tannehill et al., 2013).

Findings of this study clearly highlight the need for intervention to improve PA levels of young people, and provide good insight into how we can best structure the intervention so that it is most meaningful and relevant. Specifically findings point to the need to:

- 1) Target both low locomotor and object control FMS levels.
- 2) Build PA opportunities that help children to develop positive self-efficacy, attitude and behavioural intention.
- 3) Provide increased opportunities for participation in team games, outdoor activities, water based activities (for males), and individual sports (for females)
- 4) Ensure PE class consists of choice and is primarily non-competitive
- 5) Educate on the health benefits of PA

It has been acknowledged widely in the literature that there is strong rationale for school-based programmes aimed at increasing PA levels (Strong et al., 2005; Trudeau and Shephard, 2008; Ward et al., 2007), FMS levels (Van Beurden et al., 2003) and reducing inactivity (Centers for Disease Control and Prevention, 2011). Schools have direct contact with children and youth for on mean 6 hours per day, and for up to 13 years of their critical social, psychological, physical and intellectual development (Centers for Disease Control and Prevention, 2011). In the 2012 follow up paper to their 1991 publication describing the

importance of PE in addressing public health problems (Sallis et al., 2012), authors reiterate their recommendation of the following two goals for health related PE to (i) prepare youth for a lifetime of PA, and (ii) provide them with opportunities for PA participation during PE classes.

Based on the findings of this study it is apparent that a large number of students were insufficiently active and insufficiently skilled to benefit their current and future health. Inactive students did not demonstrate the same depth of knowledge of the health benefits of PA as did the active students, and they demonstrated significantly lower scores for Self-Efficacy and Attitude than their active counterparts. As such the Y-PATH intervention was developed with a strong focus on physical education based Health Related Activity (HRA), with key school, teacher and parent components (see figure. 3.2 below). This specific focus on students, teachers and parents is supported by a recent systematic review of PA interventions for adolescents, which suggests the importance of targeting ecological domains beyond the individual level (Perry et al., 2012). Furthermore, a systematic review of PA programmes for children and adolescents (Dobbins et al., 2009), found that positive effects on PA can be gained through a combination of printed educational materials and changes to the school curriculum.

A printed Y-PATH resource comprising two main components was developed for PE teachers. The first component was a six-lesson scheme of resources. Within each lesson there is both a direct HRA and PA focus, and also a targeted psychosocial focus aimed at improving self-efficacy and attitude towards PA of the students. The second component is a resource to guide teachers in integrating the HRA, psychosocial, and FMS targets across the remaining seven strands of the Irish Junior Cycle Physical Education curriculum (please see chapter 5 for more information on the Y-PATH intervention structure). A printed handbook was also provided to the students supporting all of the PE teachers' resources.

In short, the guiding principles of the Y-PATH intervention are:

1. The first experience of Physical Education (PE) for the students at second level school will be Health Related Activity (HRA), with a focus on PA participation [*move from PE being associated with a specific activity or sport, to being associated with learning to be active*].
2. PE lessons will focus on improving students attitude towards PA, self-efficacy and fundamental movement skill levels.
3. The climate in PE lessons will be motivational- all students learn that they can be active, and learn to challenge themselves and experience success within their own parameters.

4. Parents/guardians and teachers will be targeted as role models which can have a significant influence on students attitudes towards PA participation (*move from traditional notion of PE teacher being the person in the school with sole responsibility for health and PA*).

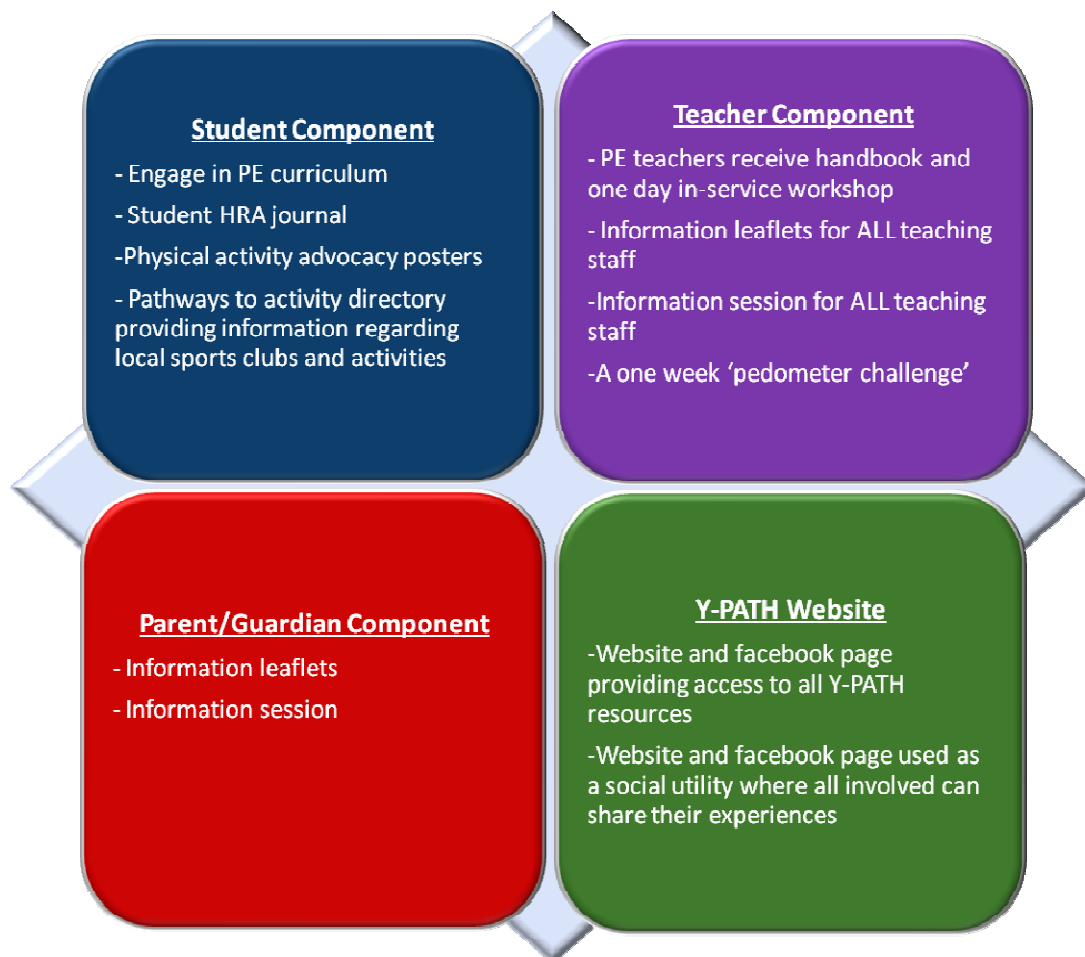


Figure 3.2 The Youth-Physical Activity Towards Health (Y-PATH) intervention structure

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3.7 Link Section Chapter 3 to Chapter 4

Purpose of Chapter 3:

To gather baseline data on levels of PA and FMS amongst 12 – 14 year old adolescent youth, along with data on current and preferred types of PA participated in, and various psychological correlates of PA. Focus group interviews were then used to explore perceptions of health, barriers and motivators to PA in the cohort. The overall objective of this chapter was to contextualize the development of a targeted school-based PE based intervention (Y-PATH) for Irish post- primary youth, based on the youth physical activity promotion (YPAP) model. The Y-PATH intervention was subsequently implemented in September 2011 (following the completion of baseline data collection). Further details outlining the specific structure of the Y-PATH intervention will be discussed in chapter 5. It is important that the reader can identify the findings of chapters 3 and 4 prior to introducing the specific Y-PATH intervention structure.

Purpose of Chapter 4:

With a noticeable absence in the literature relating to adolescent movement skill proficiency, chapter 4 assessed the performance of nine FMS during PE class amongst the same cohort of 12 to 14 year old adolescent youth outlined in the previous chapter. This study further assisted the development, design and originality of the Y-PATH intervention, specifically FMS innovation within the PE based component. The unique and timely element of this chapter was the assessment of FMS at the behavioural component level during September 2010 (baseline data); this process allowed the Y-PATH research team to identify weaknesses within performance and address commonality between individual skills. Chapter 4 is directly associated and logically connected with the previous Y-PATH intervention development study (chapter 3). Chapter 4 meticulously examines FMS proficiency amongst adolescent youth, further steering the direction of the PE intervention component for Y-PATH (to be discussed further in chapter 5).

Chapter 4

Fundamental movement skill proficiency amongst adolescent youth.

Manuscript submitted as:

O'Brien, W., Belton, S., Issartel, J. (**Physical Education and Sport Pedagogy – Revise and Resubmit**). *Fundamental movement skill proficiency amongst adolescent youth.*

4.1 Abstract

Background: Literature suggests that physical education (PE) programmes ought to provide intense instruction towards basic movement skills needed to enjoy a variety of physical activities. Fundamental Movement Skills (FMS) are basic observable patterns of behaviour present from childhood to adulthood (examples run, skip and kick). Recent evidence indicates that children now have the developmental potential to master most FMS by 6 years of age during PE, physical activity (PA) and sport.

Purpose: With a noticeable gap in the literature relating to adolescent movement patterns, the present study assessed the performance of nine FMS during PE class amongst 12 to 14 year olds. The study further assessed each of the individual skills at the behavioural component level with a view to identifying common weaknesses within and between FMS, specifically for the development of the Y-PATH PE intervention.

Participants and Setting: Baseline data were collected in September 2010 as part of a larger longitudinal study evaluating the effectiveness of the Y-PATH intervention. Two hundred and forty two (242) participants agreed to partake in the study and eligibility criteria included all 1st year post-primary students located in this geographical sector.

Data Collection: The following 9 FMS were assessed during a typical 80 minute PE lesson using reliable instrument protocol; run, skip, horizontal jump, vertical jump, kick, catch, overhand throw, strike and stationary dribble. To ensure participant consistency, no feedback from any of the trained field staff was given during skill performance.

Data Analysis: Prior to data analysis, the trained field staff were required to reach a minimum of 95% inter-observer agreement for all 9 skills on a pre-coded data set to ensure that all testers were competent. The FMS data were analysed using SPSS version 17.0 for windows using appropriate statistical analysis.

Findings: Overall, 11% were scored as either mastery or near mastery for all nine FMS. There was a significant difference in the overall mean composite FMS score (object control and locomotor) between gender, with adolescent males scoring higher ($p=0.015$). There were marked differences in the number of participants who failed to obtain mastery level across the range of the 9 FMS (e.g. Vertical Jump 87%, Run 13%) and their associated behavioural components.

Conclusions: It is alarming that adolescents aged between 12 to 14 years old entering their 1st year of post-primary PE do not display proficiency across 9 basic movement patterns. This finding indicates that adolescents will be unable to make the successful transition towards

more advanced skills within the sport specific stage. Findings suggest that targeting the weakest skill components during PE and outside of school hours may prove a valuable strategy in increasing the current FMS levels and the subsequent PA levels amongst adolescent youth.

Keywords: physical education; adolescent; fundamental movement skill; mastery; physical activity.

4.2 Introduction

Dating as far back as 1995, the National Association for Sport and Physical Education (NASPE) in the US defined that the physically educated individual should be able to demonstrate competency in many movement forms for the development of motor skills (NASPE, 1995). Furthermore, the US Secretary of Health and Human Services and the Secretary of Education (2000) emphasised that quality PE programmes ought to provide intense instruction towards motor skills needed to enjoy a variety of physical activities. A recent study by Tsangaridou (2012), investigating the importance of teaching PE emphasised the positive contribution of fundamental movement skills (FMS) in supporting the development of social, cognitive and affective skills. Despite this emergent 'shift' towards motor development in the PE environment, the importance of movement is sometimes overlooked as it is perceived a natural part of life (Cools et al., 2009). The physical growth phase and movement experiences of the child play a significant role in shaping patterns of movement; if deficiencies in FMS are not identified at an early age, children may experience lifelong problems with movement skills (Ulrich, 2000).

FMS are basic observable patterns of behaviour present from childhood; often examples exhibited during PE include running, hopping, skipping (locomotor), balancing, twisting, dodging (stability), throwing, catching and kicking (object control) (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). Children at the FMS stage (3-10 years) are building upon previously learned movements from the reflexive and rudimentary movement phases and are preparing for the acquisition of more advanced skills within the sport specific stage (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). Children have the developmental potential to master most of the FMS by the age of 6 years old (Gallahue and Ozmun, 2006). Research commissioned by the Victorian Department of Education (1996) states that all FMS can be mastered by 10-11 years. It is reasonable to expect, therefore, that Irish adolescent youth (12-14 years) should demonstrate competency in FMS during PE at post-primary level.

It is important to note that these basic movement patterns are not acquired naturally during the process of maturation (Hardy et al., 2010). Movement practitioners need to structure and implement developmentally appropriate activities for PE with continuous provision for opportunities of practice available (Logan et al., 2011). Recent research highlights that children and adolescent youth are not performing FMS to their expected developmental capability. For example, the Australian New South Wales School Nutrition

and Physical Activity Study (Hardy et al. 2010) documented the low percentage of early adolescent youth (11–12 years) achieving skill mastery across a range of seven FMS. Skill mastery did not exceed 40% for five of the seven FMS in this study. Research by Booth, et al. (1999) reported that skill mastery did not exceed 40% for five of the six FMS amongst children and adolescent youth (9-15 years). More specifically, Mitchell, et al. (2013) indicated at baseline that less than half of the children and early adolescents (5-13 years) exhibited proficiency in kicking (21%), throwing (31%) and striking (40%). In other countries similar trends have been observed, for example, in an Irish context results from a PE study (O’Keeffe, Harrison, and Smyth 2007) indicated that fundamental over arm throwing amongst adolescent youth (15-16 years) was low. The FMS proficiency of Hong Kong children (Pang and Fong, 2009) (N = 167, mean age 7.6 years) is however, slightly higher than other reported studies (Booth et al. 1999; Hardy et al. 2010; Mitchell et al. 2013) with 24% of participants achieving mastery across a range of 12 FMS. The evidence would suggest that while levels of FMS vary from country to country, performance levels remain consistently low worldwide with the majority of children and adolescents failing to surpass 50% mastery in most skills. Globally, there is a need to improve the skill proficiency levels of both children and adolescents (Van Beurden et al., 2002).

Each gross motor skill includes several behavioural components deemed necessary for successful skill completion (Ulrich, 2000). Identifying potential weaknesses at behavioural component level will allow researchers to address more precisely the low level of motor skill proficiency (Okely and Booth 2004; Van Beurden et al., 2002). While there are numerous data available in relation to overall levels of skill mastery, there is a dearth of data documenting the skill proficiency at component level of performance. Many of these components are often interrelated across the range of FMS, which if analysed may allow researchers to identify emergent trends of similar motor skill deficiency. Hence, skill analysis at behavioural component level may assist movement practitioners in improving FMS proficiency through targeted intervention programmes.

The global priority for developing FMS proficiency is further reinforced by the finding that it is positively associated with habitual levels of physical activity (PA) (Barnett et al., 2009; Fisher et al., 2005; Okely et al., 2001a). For example, cross-sectional research found that high levels of motor skill proficiency were associated with greater play activity in 8-11 year old males (Harten et al., 2008); furthermore, Jaakkola and Washington (2012) found an association between FMS and PA during adolescence. Irish research highlights that only 12% of Irish post-primary school children (12-18 years) meet current PA guidelines for health

(Woods et al., 2010) despite the compelling scientific evidence that regular PA reduces the risk of premature mortality (Fulton et al., 2004; Lee et al., 2012; World Health Organization, 2010). The National Association for Sport and Physical Education (NASPE) in America emphasize the need for both males and females to demonstrate FMS proficiently to perform a variety of physical activities necessary for health benefits such as cardiovascular endurance and muscular strength (McCall and Craft, 2004).

Gender differences across the age spectrum (3-16 years) in terms of FMS proficiency do exist (Hardy et al. 2010; Cliff et al. 2009; Breslin et al. 2012). Recent research (Hume et al., 2008) illustrates 9 – 12 year old male superiority within the FMS subtest domains of the kick, overhand throw and two-handed strike; however poor performances in both the vertical jump and the run were observed amongst male (49.6%) and female (50.4%) participants. Maturation factors, such as sex hormones and growth spurts may be the cause of gender differences in motor skill proficiency during puberty (Haywood and Getchell, 2009). Longitudinal research highlights that male children and adolescent youth possess significantly higher object control skills than females although the gender divide is not as clear within the locomotor subtest (Barnett et al., 2010). This gender differentiation within FMS highlights that additional support through potential PE interventions are paramount to facilitate females' development of object control skills.

Advancing towards the specialized movement phase within the stages of motor development depends on the maturity level of FMS development (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). Adolescent motor skill proficiency is a decisive factor in the subsequent outgrowth of the FMS phase. There has been considerable research carried out examining the health status and movement skill execution of children internationally with a noticeable depletion and gap in the literature specifically relating to adolescent movement patterns, precision and skill performance. Examining FMS in adolescence will therefore provide meaningful data assessing participants' ability to make the transition to complex movement activities for lifelong daily living utilization. The present study assessed the performance of nine FMS in a sample of 12-14 year old adolescent youth during PE class. The findings on the prevalence of skill mastery according to Irish adolescent by gender are documented and illustrated. The study further assessed each of the individual skills at the behavioural component level with a view to identifying common weaknesses within and between FMS. This FMS data collected, specifically the behavioural components have been core considerations in the development of the PE-based Y-PATH intervention (further discussed in the subsequent chapter 5).

4.3 Methods

4.3.1 Overview

Cross-sectional data were collected as part of a larger longitudinal study evaluating the effectiveness of a prescribed adolescent PE intervention (Y-PATH programme). Participants (N=242) were conveniently sampled from schools in a typical Irish town (Leinster, Ireland). Eligibility criteria included all 1st year students (12-14 years) located within this geographical sector. Data were collected at the beginning of the school term. Ethical approval was obtained from the Dublin City University Research Ethics Committee (DCUREC/2010/081). Approval from the participating schools was granted from each of the associated principals.

4.3.2 Measures

The following 9 FMS were assessed during a typical 80 minute PE lesson: run, skip, horizontal jump and vertical jump (locomotor; maximum score = 34); kick, catch, overhand throw, strike and stationary dribble (object control; maximum score = 40). This cross-sectional investigation focused exclusively on the raw scores across the selected 9 FMS. Each of the 9 gross motor skills were assessed in conjunction with the behavioural components from three established instruments: Test of Gross Motor Development (TGMD), Test of Gross Motor Development-2 (Ulrich 1985, 2000) and the Victorian Fundamental Motor Skills manual (Department of Education Victoria 1996). Having been normed on a sample of 1,208 people in the USA, the TGMD-2 assessment has a high degree of reliability and established construct validity (Cools et al., 2009; Evaggelinou et al., 2002; Wong and Yin Cheung, 2010). Similar reliability and construct validity have been obtained for the vertical jump (Department of Education Victoria, 1996) and the skip (Ulrich, 1985). These two skills were also included in the analysis due to their specificity within the Irish youth sporting framework and PE environment; these skills are two of the core FMS applied to the Irish national sporting games of Hurling and Gaelic Football. For example in both games, when retrieving the sliotar or football in flight during PE class, participants are exposed to the fundamental movements of the skip and vertical jump. To ensure that adolescent performance was constant over time across the nine selected FMS, the research team conducted a 48 hour time sampling test-retest reliability measurement amongst a sample of 35 participants aged 12-14 years. The coefficients reached 0.87 which shows that the scores across nine skills are stable over time.

4.3.3 Data Collection

During data collection in PE classes, participants were allocated numerical codes for anonymity purposes. Prior to participant performance, trained field staff members provided an accurate demonstration and verbal description of the skill to be performed. If the participant was uncertain of the task, one additional demonstration was performed by the trained FMS researcher in the PE hall. To ensure participant consistency, no feedback from any of the trained field staff was given during skill performance. All participants received a familiarisation practice trial to ensure they understood what to do. Each participant was then video recorded during each skill on two test trials. The FMS scoring process was completed at a later phase (post data collection) by the field staff.

4.3.4 Data Management

Prior to data collection, the field staff were professionally and rigorously trained to ensure all testing protocols were adhered to on-site. All data collection assistants, whom were in their final year of a PE teacher training degree, attended two training workshops in the PA research unit at the University to gain competence in the skill administration and associated equipment set up. Prior to data analysis, the trained field staff members were required to reach a minimum of 95% inter-observer agreement for all 9 skills on a pre-coded data set to ensure that all testers were competent.

The number of performance criteria varied from 3 to 6 across the range of selected FMS; all participants were given a “1” for correct execution of criteria and a “0” for a failed attempt. For each FMS, the two test trials were added together to get the total for each skill score. There were a total of 74 performance criteria for all 9 gross motor skills. Data were normalized prior to analysis; total object control and locomotor score were standardized to a score of 1 so equal weighting could be applied to both variables during subtest comparison.

4.3.5 Data Analysis

The FMS data set was analysed using SPSS version 17.0 for windows. Descriptive statistics and frequencies for FMS and their associated component variables (see table 4.2) were calculated. “Mastery” was defined as correct performance of all skill components on both trials. “Near Mastery” was defined as correct performance of all components but one on both trials (Van Beurden et al., 2002). “Poor” was any score below these two categories (i.e. if the performance was incorrect on two or more of the components on both trials). A binary variable composed of Mastery and Near Mastery (MNM) was created for each skill and is

reported in the paper as “advanced skill proficiency” (Booth et al., 2005). Raw scores for individual FMS total were collapsed into categorical variables representing mastery / near mastery coded as “1” and poor coded as “0”. The difference between overall object control and locomotor proficiency was analysed through a paired sample t-test. Gender differences in individual FMS performances were analysed using independent sample t-tests. Chi-square tests for independence identified if percentage skill differences in advanced skill proficiency by gender existed. Statistical significance was set at $p < 0.05$.

4.4 Results

Active parental consent and child assent (N=242) were requirements for eligible participants in this study (84% of total sample). Only those who had fully available FMS data for each of the 9 skills during PE were analysed; therefore, the final sample consisted of 223 participants (55.2% male, 12.50 ± 0.52 years; 44.8% female, 12.32 ± 0.49 years). Overall 11% of children were scored mastery or near mastery for all 9 FMS. Only one participant possessed complete mastery level across all 9 object related and locomotor movement skills. A paired sample t-test showed a significantly lower overall mean score for locomotor performance compared to object-related performance; $t(222) = 8.073$, $p < 0.001$. With the exception of the run, advanced skill proficiency was lower (see Figure 4.1 below) in the locomotor subtest skills compared to the object control subtest skills. The highest skill performance was the catch with 68% achieving mastery and 31% achieving near mastery.

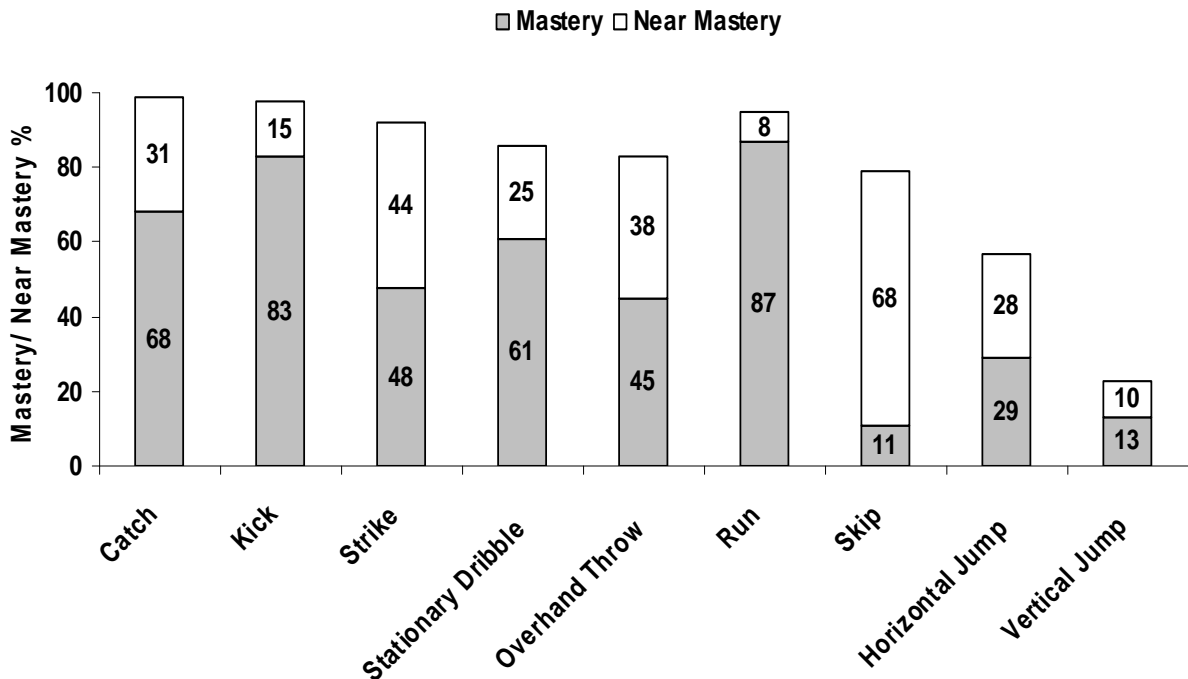


Figure 4.1 Percentage of 12-14 year old participants (N=223) advanced skill proficiency

The poorest performances were for the vertical and horizontal jumps (locomotor) where 13% and 29% respectively achieved mastery and 10% and 28% achieved near mastery. The mean skill score, standard deviation (SD) and prevalence (in percentage) of mastery among males and females are shown in Table 4.1 (see below).

There was a significant difference in the mean composite FMS score (object control and locomotor) between genders with males scoring higher; $t(221)=2.454$, $p<0.05$. An independent t-test showed that male participants obtained an overall higher object control score compared to females $t(221)=3.382$, $p<0.01$. There was no gender difference in the overall locomotor ($p>0.05$) mean score performance; females outperformed males with significantly higher advanced skill proficiency in the skip ($\chi^2_{\text{skip}}=19.084$, $p<0.001$). Males did however display higher advanced skill proficiency in the overhand throw ($\chi^2_{\text{throw}}=18.57$, $p<0.001$), run ($\chi^2_{\text{run}}=7.204$, $p=0.007$) and horizontal jump ($\chi^2_{\text{horizontal jump}}=16.603$, $p<0.001$). Table 4.2 (see below) highlights the percentage of participants below mastery level in each of the behavioural components across the 9 selected FMS.

Table 4.1¹ Mean (SD) score, prevalence (%) and 95% confidence intervals (95% CI) of mastery of fundamental movement skills among males (N=123) and females (N=100)

Fundamental movement skills	Score (M ± SD)		p-Value	Mastery (% , 95% CI)	
	Males	Females		Males	Females
Locomotor skills					
Run	7.92 (0.40)	7.45 (1.09)	0.0005 **	95.1% (89.2, 98)	76% (66.2, 83.7)
Skip	3.67 (1.36)	4.18 (0.95)	0.002 **	10.6% (6, 17.7)	11% (6, 19.2)
Horizontal Jump	6.30 (1.64)	5.22 (1.93)	0.0005 **	35.8% (27.5, 45)	20% (12.9, 29.4)
Vertical Jump	7.46 (2.68)	7.94 (2.00)	0.136	13.8% (8.5, 21.5)	12% (6.6, 20.4)
Subtest score (max score = 34)	25.35 (4.17)	24.79 (3.94)	0.308		
Object control skills					
Catch	5.57 (0.82)	5.55 (0.66)	0.850	70.7% (61.7, 78.4)	64% (53.7, 73.2)
Overhand Throw	7.08 (1.33)	6.00 (1.58)	0.0005 **	60.2% (50.9, 68.8)	27% (18.9, 36.7)
Stationary Dribble	7.05 (1.62)	6.87 (1.55)	0.404	65.9% (56.7, 74)	55% (44.8, 64.9)
Strike	9.05 (0.94)	9.25 (0.99)	0.122	43.1% (34.3, 52.3)	55% (44.8, 64.9)
Kick	7.80 (0.52)	7.64 (0.76)	0.057	86.2% (78.5, 91.5)	78% (68.4, 85.4)
Subtest score (max score = 40)	36.55 (2.62)	35.31 (2.86)	0.001**		
FMS Total (N=9)					
Total FMS Score (max score = 74)	61.90 (5.52)	60.10 (5.38)	0.015**		

¹. Table 4.1 represents the raw scores for each of the 9 FMS. For the purpose of statistical analysis, data later standardised to a score of “1” to provide equal weighting to variables

Table 4.2 Prevalence of failure among participants below mastery level (%) in each of the 9 fundamental movement skill components

Run	% Failure
1. Arms move in opposition to legs, elbows bent	63.3%
2. Brief period where both feet are off the ground	0%
3. Narrow foot placement landing on heel or toe	13.3%
4. Non-support leg bent approximately 90 degrees	66.7%
Skip	
1. A rhythmical repetition of the step-hop on alternate feet	20.6%
2. Foot of non-support leg carried near surface during hop phase	9.5%
3. Arms alternately moving in opposition to legs at about waist level	99%
Horizontal Jump	
1. Preparatory movement includes flexion of both knees with arms extended behind body	69.2%
2. Arms extend forcefully forward and upward reaching full extension above the head	73.6%
3. Take off and land on both feet simultaneously	34%
4. Arms thrust downward during landing	2.5%
Vertical Jump	
1. Eyes focused forward or upward throughout	18.6%
2. Crouch with knees bent. Arms behind the body	86.1%
3. Forceful forward and upward swing of arms	88.7%
4. Legs straighten in air	19.1%
5. Land on balls of feet. Bend knees to absorb land.	33.5%
6. Controlled landing with ≤ 1 step any direction	2.6%
Catch	
1. Preparation phase where hand are in front of the body and elbows are flexed	4.2%
2. Arms extend while reaching for the ball as it arrives	1.4%
3. Ball is caught by hands only	100%

Table 4.2 (Continued)

	% Failure
Overhand Throw	
1. Windup is initiated with downward movement of hand/arm	67.2%
2. Rotates hip and shoulder to a point where the non-throwing side faces the wall	37.7%
3. Weight is transferred by stepping with the foot opposite the throwing hand	22.1%
4. Follow-through beyond ball release diagonally across the body toward the non-preferred side	10.7%
Stationary Dribble	
1. Contacts ball with one hand at about belt level	64.4%
2. Pushes ball with fingertips (not a slap)	27.6%
3. Ball contacts surface in front of or to the outside of foot on the preferred side	52.9%
4. Maintains control of ball for 4 consecutive bounces without having to move the feet to retrieve it	5.7%
Striking a Stationary Ball	
1. Dominant hand grips bat above non-dominant hand	43.5%
2. Non-preferred side of body faces the imaginary tosser with feet parallel	3.5%
3. Hip and shoulder rotation during swing	4.3%
4. Transfers body weight to front foot	15.7%
5. Bat contacts ball	47.8%
Kick	
1. Rapid continuous approach to the ball	5.1%
2. An elongated stride or leap to immediately prior to ball contact	89.7%
3. Non-kicking foot placed even with or slightly in back of the ball	15.4%
4. Kicks ball with instep of preferred foot (shoe-laces) or toe	0%

Overall the vertical jump (23% MNM) was the poorest performed skill amongst the cohort (see Fig. 4.1 previous page). When this was looked at in further detail, it was found that a higher proportion of participants failed (86.1% and 88.7% respectively) to execute component 2 (crouching with the knees bent and arms behind the body) and component 3 (forcefully swinging the arms upright) compared to any other component. When investigating the proportion of participants not at mastery level in the horizontal jump, components 1 (flexion of both knees with arms extended behind body) and 2 (arms extend forcefully forward and upward) posed most difficulty for participants (69.2% and 73.6%). In respect to the horizontal and vertical jump, a large proportion of participants were unable to demonstrate mastery of performance criteria which involved coordinating arm and leg movements. Similarly, 99% of participants who failed to master the skip were unable to execute contralateral arm and leg movements proficiently (component 3).

In the object control subtest (catch, kick, overhand throw, strike and stationary dribble), advanced skill proficiency (%MNM) was high ranging from 83% to 99% across the 5 skills (see Figure 4.1). All participants who did not master the catch (32%) failed on criteria 3 (ball is caught by hands only). In the stationary dribble, 64.4% of participants not at mastery level (N=87) were unable to contact the ball with one hand at about belt level. Close to half of the participants (47.8%) who did not master the strike (N=115) failed on criteria 5 (make contact with the ball using a bat).

4.5 Discussion

Findings from this study highlight that only 11% of participants possess advanced skill proficiency (MNM) across a range of basic FMS during PE. This indicates that overall skill execution is low amongst adolescent youth (12-14 years). Despite the Irish primary school PE Curriculum's (1999) focus on FMS development, it appears that early Irish adolescents are making a swift transition from primary to post-primary education without acquiring the basic FMS competency. Results from this cohort (n=223) indicate that only one participant is fundamentally competent across all 9 object related and locomotor skills despite children having the developmental capacity to become fundamentally competent by 6 years of age (Gallahue and Ozmun, 2006). Previous research outside of Ireland examining the FMS proficiency of children and youth support this low level of FMS mastery (Foweather et al., 2008; Okely and Booth 2004).

It must be noted that poor scores in the vertical jump (23% MNM) considerably reduced the percentage achieving higher levels of overall advanced skill proficiency. One hundred and ninety four participants (87%) did not achieve mastery level in this locomotor skill. There were 6 performance criteria deemed necessary for mastery within the vertical jump, it can be argued, therefore, that the likelihood to fail on a given component was twice as likely in the vertical jump compared to the catch and skip which both had only 3 performance criteria. Had the vertical jump not been included in the analysis, 30.5% (N=68) of participants would have displayed advanced skill proficiency (across the remaining 8 skills). These findings for the low prevalence of vertical jump proficiency amongst participants are in line with a study by Hume et al. (2008) across 9-12 year old children. This comparative study observed that 20.3% of male and 24.0% of female participants obtained advanced skill proficiency in the vertical jump (Hume et al., 2008). This compares with 24.4% of males and 21.0% of females obtaining overall advanced skill proficiency in the vertical jump in the current study. It would appear from the present Irish investigation and previous Australian research (Hume et al., 2008) that adolescent execution of the vertical jump is poor. The recent Australian SPANS study (Hardy et al. 2010) contradict the above findings and displays a more optimistic light on the vertical jump performance amongst 13-14 year olds with 58.2% (male) and 56.1% (female) possessing advanced skill proficiency. These conflicting findings highlight differences between countries across adolescent locomotor skill proficiency. In an Irish context, 89% of post-primary level schools participate in traditional Gaelic Games (Woods et al., 2010) and the vertical jump is embedded within these native

games in PE and more broadly in sports clubs. Recent research highlights a recurring misconception that the acquisition of these basic movement patterns occur naturally (Hardy et al., 2010). Results from the present study highlight that 77% of participants cannot execute the vertical jump proficiently despite the high prevalence participating within Gaelic Games. It would appear from a physical health perspective that Irish adolescents engage in sport specific skills without learning the fundamental criteria for basic jumping and movement patterns.

In terms of gender differentiation, overall males had higher skill proficiency than females in the total FMS composite score. When subtest breakdown is considered, males had statistically higher advanced skill proficiency of object control skills compared to females (71% vs. 53% MNM) which is consistent with the current FMS literature (Barnett et al., 2010; Wrotniak et al., 2006). Males displayed significantly higher advanced skill proficiency in the overhand throw and this result may be a plausible explanation for their overall dominance within the object control subtest. Furthermore, it may be plausible that maturation factors occurring during the pubertal phase of early adolescence may contribute to the present FMS gender differences (Garcia, 1994). It was interesting to observe however, that males and females performed similarly well in both striking and kicking, particularly noting the high scores associated with female execution in both of these skills. Despite male adolescent superiority within this object control subtest, it is interesting from an Irish context that female kicking and throwing performances (98% and 71% MNM levels respectively) appear much stronger than that reported in other international adolescent youth studies over the last decade (Barnett et al., 2010; Booth et al., 1999; Hardy et al., 2010). It is conceivable and notably credible that 30% of the Irish female adolescent population participate in extra-curricular sports such as Gaelic Games and soccer (Woods et al., 2010) which may account for these competent kicking results.

When individual locomotor skills were considered, males were found to have higher advanced skill proficiency compared to females in the run and horizontal jump, while females performed significantly higher than males in the skip. Aside from the possibility of maturation differences existing between genders, it has also been suggested by Garcia (1994) that the significantly higher male performance in both the run and horizontal jump could be attributed to the competitive, individual and egocentric nature of males. Some recent evidence (Haywood and Getchell, 2009) has also suggested that females perform the skip better than males; this may in part be explained by the social nature of this more recreational skill (Okely et al., 2001a).

Overall, advanced skill proficiency was particularly weak because of the high failure amongst specific behavioural components. Each of the 9 FMS produces different outcomes yet the behavioural components often overlap between skills. Movement practitioners should be concerned with the behavioural components which were failed by a large proportion of participants. Specifically, our current findings indicate that, the component of “crouching with the knees bent and arms behind the body” was performed consistently poorly across both the vertical and horizontal jump during take off. Similarly, a large proportion of participants failed to “forcefully raise their arms upwards” during flight. Ninety nine percent of the participants who failed to execute the skip (N=199; see Table 4.2) proficiently were unable to generate “movement of the arms in opposition to legs at about waist level” correctly. It is conceivable that the poor execution of this component may be linked to the failure of participants to “forcefully raise their arms upwards” during flight in both the vertical and horizontal jump. Similarly in the object control subtest, the poor execution of “contacting the ball with one hand at belt level” in the stationary dribble potentially interlinks with the difficulty participants inability to both successfully catch “the ball with their hands only” and strike “the ball with the bat”. To ensure successful performance execution in these three object control skills, basic hand-eye co-ordination is a pre-requisite. Performing the dribble, catch and strike require different patterns of movement with varying sensory and perceptual processing. Despite the unique complexity and performance criteria associated with these 3 object control skills, results from this Irish adolescent assessment highlight that there is a deficit in the successful proficiency of hand-eye co-ordination. These findings suggest that FMS development programmes during PE class and outside of school hours are warranted allowing researchers and practitioners to specifically target these main weaknesses in FMS execution (Hardy et al., 2010; Booth et al., 1999). By planning developmentally appropriate movement activities (Logan et al., 2011), one could promote the motor skill acquisition of adolescent youth.

Tailoring interventions to focus on specific skill component weaknesses both within and across FMS is a sensible approach (Van Beurden et al., 2002) in school and PE. The efficacy of such tailored interventions has been shown in a recent study (Foweather et al., 2008) which investigated the effect of a 9 week after school multiskills club on FMS proficiency amongst 8-9 year old children, showing that important performance improvements in catching, throwing and kicking were observed. Martin et al (2009) similarly provide evidence on the positive impact of FMS performance in children across 12 skills over time in a naturalistic PE intervention setting. In the present study the high proportion who

displayed “near mastery” in the skip (68%) suggests that the number of adolescents advancing to mastery level could be improved through the delivery of school based FMS programmes during PE. Most recent evidence (Kalaja et al., 2012) reveals that it is possible to develop junior high school students’ FMS performance through PE. Developing such a movement skill intervention would be a strategic step towards improving the current levels of adolescent FMS proficiency found in this study.

Research highlights that FMS proficiency amongst children and adolescent youth can be attributed to an increased participation in PA (Barnett et al., 2011; Barnett et al., 2009; Jaakkola et al., 2009). Current Irish research by Woods et al. (2010) highlights that only 10% of Irish adolescents meet the current PE recommendations (120 minutes per week) and 12% meet the PA guidelines for health (at least 60 minutes of daily moderate to vigorous intensity PA). Strategic advice from the Children’s Sport Participation and Physical Activity (CSPPA) report (Woods et al., 2010) suggest that FMS programmes will allow children of all ages to begin their journey into sport and exercise skill development. By creating an environment whereby adolescent youth can engage in regular participation in FMS, a successful transition to the sport specific phase can occur at a later stage. Results from the current study highlight the need for future research examining the associations between FMS and PA for the adolescent population. To gain a meaningful insight into adolescent motor skill proficiency, recent recommendations suggest continuing to investigate the association of FMS over time and within interventions across differing age groups (Lubans et al., 2010).

4.6 Conclusion

Results of this study indicate that the majority of Irish adolescents entering year one of post-primary education do not display advanced skill proficiency across 9 selected FMS. If no steps are taken to counteract this problem then it is likely Irish adolescents may lead a lower quality life due to the significant role these movement capabilities play in shaping one's health status (Lubans et al., 2010). To counteract these gross motor deficiencies in Ireland, the specific FMS components of weakness identified in this study should be targeted to achieve the desired "mastery" outcome through intervention. Targeting the weakest skill components both within the PE environment and outside of school hours may prove to be significant influencing factor for increasing FMS and subsequently, the PA levels of school aged children and youth.

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4.8 Link Section Chapter 4 to Chapter 5

Purpose of Chapter 4:

As discussed, there is a noticeable gap in the literature relating to adolescent movement skill proficiency; therefore, chapter 4 assessed the performance of nine FMS during PE class amongst 12 to 14 year old adolescent youth. The findings from chapter 4 assisted the development, design and originality of the Y-PATH intervention, specifically the FMS contribution of the PE based component. The unique and timely element of this chapter was the assessment of FMS at the behavioural component level during September 2010 and constituted one part of our baseline data. This process allowed the Y-PATH research team to identify weaknesses within performance at component level and address commonality between individual skills. Specifically, there is a cross over between components as many FMS often overlap. Chapter 4 is directly associated and logically connected with the following overview of the Y-PATH intervention (chapter 5).

Purpose of Chapter 5:

Following the completion of chapters 3 and 4, it is important for the reader to contextualise the overall structure and arrangement of the Y-PATH intervention. Specifically, the Y-PATH intervention has been guided by the literature and used the YPAP model (Welk, 1999) as a theoretical framework (see Chapters 2 and 3). In this next chapter, the components of the Y-PATH intervention will be outlined, described and discussed. The reader will be able to identify the findings from baseline data collection (Chapter 3) subsumed within the intervention; furthermore, the reader will recognise specific behavioural components of FMS (Chapter 4) integrated within the PE aspect of the Y-PATH intervention. To summarise, the overall objective of chapter 5 is to rationalise the ‘Whole School Approach’, embedded within this Irish adolescent intervention for PA promotion.

Chapter 5

An overview of the Y-PATH intervention – components and content

5.1 Introduction and Rationale for the Y-PATH Intervention

As described in chapter 3, baseline data (2010/11) were collected on levels of PA and FMS amongst 12 – 14 years old adolescent youth, along with data on current and preferred types of PA participated in, and various psychological correlates of PA. Focus group interviews were then used to explore barriers and motivators to PA with the cohort. Subsequent to these overall findings, chapter 4 further examined baseline FMS proficiency amongst these 12 – 14 year old youth at the behavioural component level.

Based on the overall findings from the baseline data, it was apparent that a large number of students were insufficiently active (67%) and insufficiently skilled (89%) to benefit their current and future health. Those participants identified as inactive (self reported meeting the PA guidelines 0-2 days per week) did not demonstrate the same depth of knowledge of the health benefits of PA as did their active counterparts (self reported meeting the PA guidelines 6-7 days per week). In terms of psychological analysis, inactive participants demonstrated significantly lower scores for Self-Efficacy and Attitude compared to the active individuals. When the FMS data were explored at the behavioural component level, there was found to be common weaknesses within and between FMS; examples including ability to crouch with the knees bent, bring arms behind the body, forcefully raise the arms upwards, and move the arms in opposition to the legs.

A systematic review on youth PA intervention effectiveness (Van Sluijs et al., 2008) concluded that for adolescent youth, multi-component interventions involving the school, family and community have the potential to make important differences in the increase of youth PA. In line with the literature and guided by the findings from baseline data collection (chapters 3 & 4), the Y-PATH intervention was developed to include four components:

- 1) Student component
- 2) Parent/Guardian component
- 3) Teacher component
- 4) Y-PATH website (resource utility and use of social media)

Specifically, the Y-PATH intervention was developed with a strong focus on PE based Health Related Activity (HRA)¹ (Gittelsohn et al., 2006; Le Masurier and Corbin, 2006; McKenzie et

¹ . In the Irish post-primary education context, health related activity (HRA) is the equivalent of health education and other recently accepted terms such as health-based physical education (HBPE)

al., 2009, 2004, 2001, 1996; Murillo Pardo et al., 2013; Pate et al., 2005; Perry et al., 1997; Sallis et al., 1997, 2012; Stevens et al., 2005) and FMS (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013; Mostafavi et al., 2013), with additional school, teacher and parental components.

5.2 Research Considerations in the Development of the Y-PATH Intervention

This intervention was guided by the Medical Research Council's (MRC) new guidance document 'Developing and Evaluating Complex Interventions' (MRC, 2008) which is shown in Figure 5.1 below. The four stages outlined in this document include the following:

1. Development
2. Feasibility (cost-effectiveness)
3. Evaluation
4. Implementation (sustainability)

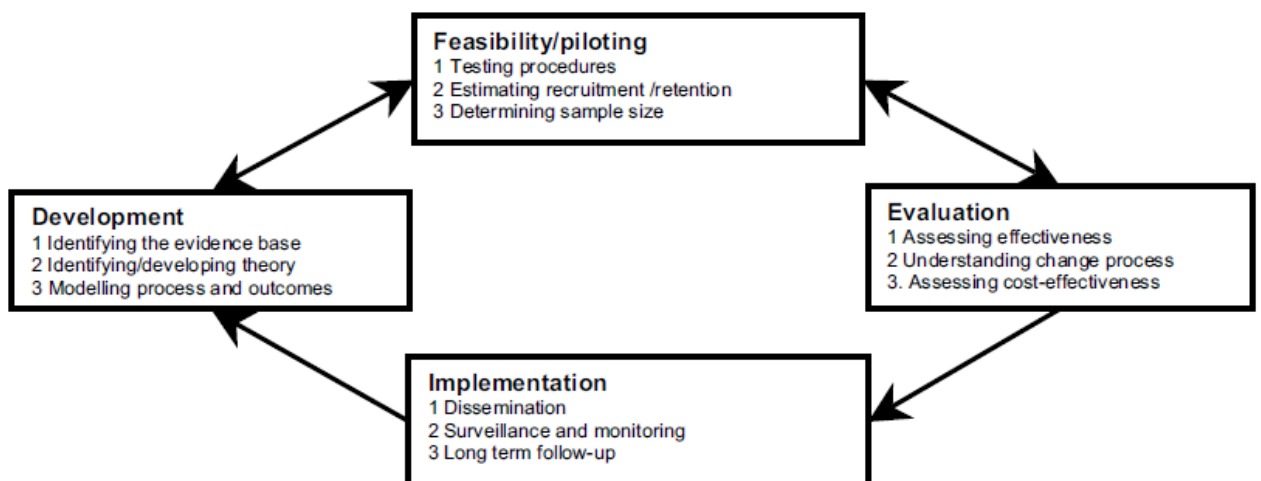


Figure 5.1 Key elements of the development and evaluation process (MRC 2008)

As discussed in chapter 3, the development of the Y-PATH intervention identified an evidence base of literature relating to youth PA and FMS promotion during PE classes. This base of literature was supported by the Youth Physical Activity Promotion (YPAP) model as a theoretical framework (Welk, 1999) (Refer to chapter 2, see figure 2.2, p45). The findings of Salmon et al., (2007) in their narrative review highlight that an intervention designed around motor skill acquisition alone would probably be insufficient to change the long term PA behaviour amongst adolescent youth. The authors (Salmon et al., 2007) further noted that if the

intervention was focussed solely on influencing school based PA, it would also be unlikely that overall PA levels would be increased.

Accounting for these research considerations in the design of a personally meaningful and socially relevant PA intervention for adolescents, the views, opinions and attitudes of the target group were sought through focus group data collection. Prior to intervention rollout, a methodical examination of perceptions of health, motivations and barriers experienced in relation to PA participation both within and beyond the school environment was undertaken. The YPAP model was used to gain an insight into the psychosocial correlates of PA in the age group. The Y-PATH intervention hypothesises that if the research team are successful in positively influencing the enabling, predisposing and reinforcing factors for PA experienced by youth, then a successful adolescent PA intervention will occur.

To conclude this section, it is important to contextualise the overall research base underpinning the Y-PATH intervention. Key priorities in the design and development of the Y-PATH intervention were:

- 1) Consideration of findings (PA, FMS, BMI, psychological influences, focus groups etc) from baseline data collection.
- 2) Cost effectiveness (Kahn et al., 2002; MRC, 2000, 2008; Van Sluijs et al., 2008).
- 3) Sustainability (beyond involvement of the research team) (Cavill et al., 2012; Dowda et al., 2005; Kriemler et al., 2011; McKenzie et al., 2009; Salmon et al., 2007).
- 4) Consideration of the YPAP theoretical framework (Welk, 1999).
- 5) Focus on predisposing factors (Welk, 1999)
 - Understanding of benefits of PA
 - Skill competency level
 - Enjoyment of PA
- 6) Focus on reinforcing factors (Welk, 1999)
 - Parental support
 - Teacher support
 - Peer support

5.3 Y-PATH Intervention Overview – Guiding Principles and Specific Content Overview

The aim of the Y-PATH intervention is to increase the PA and FMS levels of adolescent youth. This school-based PE intervention will educate children through a specifically prescribed HRA programme whilst integrating FMS in the learning environment; thereby, striving to increase participant competence to engage in more regular periods of quality PA. It is important to note that the PE component of the Y-PATH intervention is a resource that compliments the existing Irish Junior Cycle Physical Education Curriculum and has received approval from the Department of Education and Skills PE Inspectorate.

Guiding Principles

The four guiding principles of the Y-PATH intervention are:

1. That the very first experience of PE for the students at second level school will be HRA with a specific educational focus on regular PA participation [move from PE being associated with a specific activity or sport, to being associated with learning to be active] (see appendix A). The importance and contribution of HRA for youth PA promotion has been sufficiently documented previously (Gittelsohn et al., 2006; Le Masurier and Corbin, 2006; McKenzie et al., 2009, 2004, 2001, 1996; Murillo Pardo et al., 2013; Pate et al., 2005; Perry et al., 1997; Sallis et al., 1997, 2012; Stevens et al., 2005).
2. All PE lessons for the academic year will focus on improving students self efficacy and attitudes [all of which have been previously shown in the literature to consistently influence PA participation amongst youth] (Dishman et al., 2004; Kenyon et al., 2012; Lowry et al., 2013; Uijtdewilligen et al., 2011; Van Der Horst et al., 2007) and FMS proficiency levels (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013; Van Beurden et al., 2003) (see appendix B).
3. The climate in PE lessons will be motivational (Martin et al., 2009; Valentini and Rudisill, 2004) - all students learn that they can be active, experience positive skill execution, learn to challenge themselves and experience success within their own parameters [focus on attitude and self-efficacy] (see appendix A).

4. Parents/guardians and non-specialist PE teachers (see appendices C & D) as well as PE teachers will act as role models and facilitators for PA engagement. These reinforcing factors (Welk, 1999), can have a significant influence on students' attitudes towards PA participation (Fitzgibbon et al., 2012; Haerens et al., 2007; Lowry et al., 2013; Trost et al., 2003).

The Y-PATH multi-component school-based PE intervention (Grydeland et al., 2013; Perry et al., 2012; Salmon et al., 2007; Sutherland et al., 2013; Van Sluijs et al., 2008) has a specifically tailored educational focus, broken down into four distinct components (Refer to chapter 3, see figure 3.2, p147).

Specific Component Breakdown and Overview

1. Student component:

- Participants in receipt of the Y-PATH intervention were subsumed within specifically tailored PE classes (HRA and FMS) focusing on increasing self-efficacy and attitudes for the entire academic school year (see appendix A). The Y-PATH intervention was run from September 2011 to May 2012.
- The ethos of the Y-PATH intervention fits within and supported the aims and strand units (e.g. athletics, dance, gymnastics etc) of the Irish Junior Cycle Physical Education Curriculum (Department of Education and Skills, 2003). The Physical Education inspectorate from the Irish Department of Education and Skills were also consulted in this process prior to finalisation of the intervention format.
- The Health-Related Activity (HRA) strand, with a targeted psychosocial focus (self-efficacy and attitude promotion), was taught exclusively as the first unit of PE that participants were exposed to at second level (see appendix A). Subsequently, these HRA (and psychological) learning objectives were then integrated through reinforcement and continuity across the remaining 7 strands of the curriculum for the duration of the academic year, in contrast to being taught only as a discreet unit (see appendix B).

- The novel component of the Y-PATH intervention was the delivery of FMS behavioural components during PE classes. From chapter 4, participants were found to be least proficient in the execution of movements relating to
 - crouching actions,
 - foot landing,
 - arm and leg contra-lateral
 - arm and leg bilateral movements,
 - arm extension
 - hand/eye coordination.

These specific components (see appendix B) were simultaneously targeted (along with HRA focus) across the 7 strands of the PE curriculum for the academic year. This innovative approach changed the philosophy of the PE curriculum from ‘teaching a physical activity’ to ‘teaching HRA and FMS through physical activity’.

- The Y-PATH research team led a one-day in-service workshop which served to up-skill the PE teachers in the delivery of the Y-PATH intervention. Agreement was previously granted by the Principal of the intervention school to allow this day to be part of the state agreed in-service hours (‘Croke Park hours’) for continuing teacher professional development.
- A student PA journal was developed to support teacher and student learning of the Y-PATH intervention (see appendix E). A key focus of this journal was for students to self-report their PA levels (each month), with the aim of setting realistic and attainable targets to increase their activity engagement.
- Two PA advocacy posters (see appendix F) were developed for display in the intervention sports hall and one other prominent area of the school building. The first poster detailed the rationale for PA and offered suggestions on how to increase PA levels and reduce sedentary behaviour. The second poster detailed the concept of a PA pyramid whereby students could undertake gradual progression in the increase of their MVPA per week. The purpose of this specific poster was to offer a resource for ‘tailored advice’ as part of the Y-PATH intervention. Copies of these posters were also displayed in the students PA journal.
- A ‘Pathways to Activity’ document (see appendix G) and accompanying poster (see appendix H) was developed in conjunction with the ‘Local Sports Partnership’ (a local body governed by the Irish Sports Council with the role of supporting PA in the local community)

giving an inventory of the extra curricular opportunities for PA. This document detailed the activity (or sport), location of the activity, cost associated (if any), and a contact (e.mail, url, and/or phone) for the provider of the activity. This document was also available in the Y-PATH PA journal for students and the PE teacher manual.

2. Parent/Guardian component:

- Information leaflets (see appendix I) were developed for parents/guardians identifying the rationale for PA, the health benefits of PA, dangers/risks of physical inactivity, the current activity levels of youth in Ireland, and ways in which family members could become ‘active role models’ and ‘facilitators’ for youth PA provision.
- An information session of what this intervention would entail was held (prior to the intervention rollout) for the parents in conjunction with the Local Sports Partnership. The focus of this workshop was to reiterate the rationale for PA participation (amongst both child and parent/guardian alike), and provided attendees with the opportunity to engage in a question and answer PA promotion forum.

3. Teacher Component

- Similar to the parent leaflets distributed above, information leaflets were also developed for both the specialist and non-specialist PE teachers in the school (this intervention sought to actively involve all members of the academic teaching staff within the Y-PATH intervention).
- An information session was held with all teachers prior to the intervention rollout in which the focus addressed the teachers’ contribution (‘role models’) towards student PA and health promotion. From this session, a subsequent workshop was held with teachers to reinforce their role in PA promotion within the school environment (a short questionnaire was also distributed) (see appendix D). A teacher charter of adolescent PA promotion strategies (within and outside of school) was displayed in the staff room as a further prompt and intervention tool (see appendix C) – important to note that the teachers had come up with these PA promotion strategies from the previous information session prior to the intervention rollout.

- A one week voluntary ‘pedometer challenge’ was set up for all teachers within the intervention school; this ‘pedometer challenge’ was integrated during the Y-PATH intervention to stimulate teacher involvement in youth PA promotion. The ‘Walk/Step challenge’ resource developed by the Irish Heart Foundation (see appendix J) was used to facilitate this intervention – permission had been granted by the Irish Heart Foundation prior to pedometer distribution.

4. Y-PATH Website and Facebook page

- A webpage available through the Dublin City University network, contained copies of parent, student, and teacher resources for the duration of the intervention.
- See http://www.dcu.ie/shhp/y_path.shtml for access to all of the resources listed above (site is currently being developed in preparation for intervention rollout in 2013).

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5.5 Link Section Chapter 5 to Chapter 6

Purpose of Chapter 5:

As outlined in chapter 5, the Y-PATH school-based PE intervention for Irish adolescent youth was formulated from baseline findings (2010-2011) and guided by the appropriate intervention literature for youth PA promotion. In chapter 5, the reader has been introduced to the guiding principles of the PE-based intervention, specifically the educational focus of *'moving PE from being associated with a mode or sport, to being associated with learning to be active.'* It is important to note that the Y-PATH intervention consists of a multi-component approach to whole-school PA promotion in second level education. By actively engaging the student, teacher, parent and guardians in the intervention process, the Y-PATH intervention is adhering to previously successful intervention evidence. In terms of originality, the PE component of the intervention addresses psychosocial, HRA and FMS content in the promotion of skill competency, attitudes, self-efficacy and educational belief towards the importance of regular PA participation. The intervention is grounded within a cost-efficient and feasible approach to overall PA and FMS promotion.

Purpose of Chapter 6:

In terms of thesis chronology to date, the reader has been:

- 1) Introduced to the baseline findings (chapters 3 and 4), specifically the low levels of PA and FMS proficiency amongst Irish adolescent youth.
- 2) Provided a descriptive overview (chapter 5) for the development of the Y-PATH intervention.

At this stage, the rationale for the Y-PATH intervention design and development is clear with the scene in place for exploring the efficacy of this pilot intervention trial. In chapter 6, the reader will examine the primary outcome measures for this year long trial intervention by comparing PA and FMS results between intervention and control schools. The results will be illustrated through critical discussion and future directions for the Y-PATH research during 2013 will be outlined.

Chapter 6

Evidence for the efficacy of the Youth-Physical Activity Towards Health (Y-PATH) intervention

Manuscript submitted as:

O'Brien, W., Issartel, J., Belton, S. (**Advances in Physical Education – In Press**). *Evidence for the efficacy of the Youth-Physical Activity Towards Health (Y-PATH) intervention.*

6.1 Abstract

Objective: The school environment is a key opportunity to intervene because of access to children and adolescents for the purpose of increasing physical activity participation and improving fundamental movement skill proficiency.

Method: A non-randomised controlled trial involving two schools in a rural Irish town was carried out in September 2011 to evaluate the Youth-Physical Activity Towards Health (Y-PATH) intervention. Data was collected on 12 to 14 year olds (n=174) at 3 time points (pre, post and retention). Data collected included measured height and weight, physical activity measured by accelerometry and by self-report and fundamental movement skill performance.

Results: Both the control and intervention school showed significant increases in daily physical activity and gross motor skill proficiency over time. Two-way repeated measures ANOVA's showed a significant interaction effect between school attended and time for physical activity ($F(2, 38) = 6.177, p=0.005$) and fundamental movement skills ($F(2, 100) = 4.132, p=0.019$), with a significantly greater increase in physical activity and fundamental movement skills observed in the intervention school.

Conclusions: Preliminary findings from this study suggest a positive effect for the Y-PATH intervention and provide support for its potential in increasing physical activity and fundamental movement skill levels of adolescent youth. Further research involving a definitive randomised controlled trial with a larger sample size is warranted.

6.2 Introduction

Physical activity (PA) is a complex, multifaceted behaviour which can be performed in a variety of physical and social settings, and for many reasons (Ward et al., 2007). The meaning of PA has remained consistent amongst public health professionals in recent years and a standardised PA definition has become accepted as any bodily movement produced by the skeletal muscles expending energy beyond resting levels (Bouchard et al., 2007; Caspersen et al., 1985). Regular PA decreases numerous health risks for all age groups and is associated with a reduced risk of developing chronic disease such as coronary heart disease, type II diabetes, cancers and hypertension (Bouchard et al., 2007; Physical Activity Guidelines Advisory Committee, 2008). In the past, the development of these chronic diseases have been rare in children (Physical Activity Guidelines Advisory Committee, 2012) but a growing body of literature is now showing that the prevalence of these risk factors are increasing among adolescents (May et al., 2012; Woods et al., 2010).

Whilst the knowledge about the tracking of PA is limited (Telama, 2009), some studies have shown that the engagement of children and adolescents in regular PA significantly predicts PA participation during adulthood (Telama et al., 2005; Wichstrøm et al., 2012). Despite the known importance of regular PA participation in the promotion of lifelong health and well-being (Physical Activity Guidelines Advisory Committee, 2012), current evidence suggests that the levels of PA participation among children remain low, particularly noting the age related decline occurring dramatically during adolescence (Aibar et al., 2012; Kimm et al., 2000; O'Donovan et al., 2010). Irish research from the "Children's Sport Participation and Physical Activity Study" (CSPPA) found that only 12% of adolescents aged between 12 to 18 years old met the recommended 60 minutes per day PA guideline (Woods et al., 2010). Compared to Irish adolescents, recent research in the US (Eaton et al., 2012) found that a higher percentage of adolescents (29%) achieved this recommended guideline. The prevalence of PA amongst Irish adolescents is also very low when compared in a European context with 35.9% of adolescents in France and Spain reported to meet the 60 minute guideline (Aibar et al., 2012). Many interventions have been evaluated for their effectiveness in increasing the PA levels of adolescents (Haerens et al., 2007; Kalaja et al., 2012; McKenzie et al., 2004; Pate et al., 2005).

Recent research, underpinning the necessity of an active lifestyle, suggests that fundamental movement skills (FMS) are the building blocks for movement as they provide the foundation for the acquisition of more complex skills in the specialised sport specific

movement stage (Gallahue and Ozmun, 2006; Hardy et al., 2010). Furthermore, the rationale for promoting the development of FMS in childhood relies on the recent findings from a systematic review (Lubans et al., 2010) of the current and future benefits associated with the acquisition of FMS in children and adolescents. This systematic review (Lubans et al., 2010) found a relationship between FMS competency and eight potential benefits, namely global self-concept, perceived physical competence, cardio-respiratory fitness (CRF), muscular fitness, weight status, flexibility, PA and reduced sedentary behaviour. While in recent years, adolescent PA levels have shown some correlation with FMS proficiency (Barnett et al., 2011, 2009; Okely et al., 2001), further longitudinal research examining their relationship is recommended (Lubans et al., 2010).

Despite the associated physiological, psychological and behavioural outcomes for FMS proficiency and their positive impact on public health, it is apparent that a lot of children do not acquire these basic patterns of movement. There is now strong evidence that early adolescents have low levels of FMS proficiency (Booth et al., 1999; Hardy et al., 2010, 2013; Mitchell et al., 2013). A previously successful intervention amongst primary school children, 'Move it Groove It' (Van Beurden et al., 2003), provided school aged youth with opportunities to incorporate PA into their daily life while simultaneously targeting FMS. Other school-based intervention studies, in more recent years have also shown positive effects for FMS provision during childhood (Mitchell et al., 2013; Zask et al., 2012). Yet, there appears to be dearth of FMS intervention research amongst adolescents, therefore, addressing both PA and FMS may be perceived as a practical intervention approach for the journey into sport and exercise skill development (Woods et al., 2010).

In terms of increasing active adolescent behaviour, the school environment has the potential to make important differences to PA participation and presents a number of opportunities for intervention (Lavelle et al., 2012; Van Sluijs et al., 2008; Vasques et al., 2013; Ward et al., 2007). A recent report by Sallis et al., (2012) highlighted that in the past two decades, evidence-based school curricula have shown significant differences in moderate to vigorous physical activity (MVPA) during and outside of school hours. The school environment presents many opportunities for targeting the adolescent directly with many studies suggesting the importance of targeting ecological domains beyond the individual (Kahn et al., 2002; Perry et al., 2012; Sallis et al., 2012). Effective school environments present opportunities to embody a culture of care, and to be fully inclusive of the individual regardless of the existing racial or socio economic background differences (Cavanagh et al.,

2012). The development of evidence-based school programmes has seen the acceptance of Physical Education (PE) as an efficacious resource (Sallis et al., 2012).

As a viable change agent to increase PA in the school-aged population, PE is considered a very important provider of PA (McKenzie and Lounsbery, 2009; Payne and Morrow, 2009; Scheerder et al., 2008; Ward et al., 2007). PE also gives children and adolescent youth an opportunity to learn physical and behavioural movement skills (Haerens et al., 2007; McKenzie and Lounsbery, 2009; Mitchell et al., 2013; Van Beurden et al., 2003). A recent meta-analysis of the effectiveness of motor skill interventions illustrate a significantly positive association between participation in school based motor skill programmes and FMS proficiency (Logan et al., 2011). Recent intervention programmes such as “Move it Groove it” (MIGI) and “Project Energize” highlighted that both PA and FMS can be integrated during the provision of PE (Mitchell et al., 2013; Van Beurden et al., 2003).

The purpose of this chapter was to evaluate the intervention effect after 9 months (end of academic school year) and 12 months (follow-up) of a tailored PA and FMS programme for an Irish adolescent cohort (12-14 years of age). The Y-PATH intervention is an innovative whole school approach to activity promotion amongst adolescents; there is a specific gap in the literature amongst adolescents as no previous study to this researchers knowledge has examined the effect of a prescribed Health Related Activity (HRA) and FMS intervention on PA levels and its impact on public health. The study involved one intervention group who received the Youth-Physical Activity Towards Health (Y-PATH) intervention over the course of one school year, and one control group who received their usual PE programme for the same period. The main research question was to examine if the intervention group would demonstrate a significant increase in minutes of daily PA and levels of FMS proficiency over time when compared to the control group. Standard anthropometric characteristics (height and weight) were also measured over time between both groups to see if body mass index (BMI) was having any underlying effect on the intervention.

6.3 Methods

6.3.1 Participants and recruitment:

This quasi-experimental non-randomised controlled trial is part of the Y-PATH research programme which was initiated in September 2010 at Dublin City University (DCU). Following the Medical Research Council (MRC) guidelines (2000) for developing and evaluating a tailored intervention, this research represented Phase 2 on the continuum of increasing evidence – the exploratory trial. Non-randomised controlled trials can detect associations between the intervention and the outcome (Sibbald and Roland, 1998).

For this pilot study (2011-2012), a convenience sample of Irish adolescents enrolled in year one of post-primary education (12-14 years of age) from two mixed-gender schools were invited to take part in the study (N = 192). Both schools involved in this research study were from the same rural Irish town, had no school fee paying requirements (public), and were not listed as ‘Designated Disadvantaged’ schools by the Department of Education and Skills. The school with the largest sample size (n=132) was randomly selected to receive the intervention for one academic school (with the agreement that all intervention resources would be made available to the control school in October 2013 following the completion of data collection). Data collected included measured height and weight, PA measured by accelerometry and by self-report and FMS performance. Approval from each of the principals of the two participating schools was granted. Informed consent for participation was sought from each adolescent and their parent/guardian. Ethical approval was obtained from the Dublin City University Research Ethics Committee (DCUREC/2010/081).

6.3.2 The Y-PATH intervention

There are four key components to the Y-PATH intervention (as discussed in chapter 5) (1) Student component: Specific focus on HRA and FMS content subsumed within the existing PE curriculum, delivered by specialist PE teachers. (2) Parent/Guardian component: PA information evening prior to the beginning of the intervention, and distribution of specifically tailored Y-PATH PA information leaflets. (3) Teacher component: All school teachers attending two workshops (Aug 2011 and Jan 2012) which highlighted the importance of ‘active role modelling’, and voluntary participation in a one week ‘Teacher Pedometer Challenge.’ The teacher pedometer challenge was integrated mid-course during the Y-PATH intervention to further stimulate teacher involvement in youth PA promotion (teacher

pedometer data, however, was not collected as part of this pilot Y-PATH exploratory trial). (4) Website component: All student, parent and teacher resources were made readily available for all intervention participants by the Y-PATH research team (available at http://www.dcu.ie/shhp/y_path.shtml). It is important to note that those in the control condition carried on their usual PE and school programme without any researcher input during the pilot study.

6.3.3 Measurements

Measurements were taken at the beginning of the school year in September 2011 (pre), at the end of the school year in May 2012 (post), and at 3 months follow-up in September 2012 (retention). Three lead researchers administered periodic training workshops to 12 field staff to ensure that measurement assessment standards were met continuously during data collection (Berkson et al., 2013).

Body mass index: Weight was measured to the nearest 0.1kg using the Seca 761 dual platform weighing scales. Standing height was measured to the nearest 0.1cm using a portable stadiometer. BMI was calculated using the equation; $\text{weight}(\text{kg})/\text{height}(\text{m}^2)$. The Cole et al. (2000) cut off points for normal, overweight and obese participants were applied to the data in order to calculate BMI class.

Accelerometry: PA was measured using ActiGraph GT1M and GT3X accelerometers, stored in a standardised 10-second epoch to capture the intermittent and sporadic behaviour (Esliger et al., 2005) of adolescent youth. During the first day of data collection, each participant was given an accelerometer by one of the trained field staff under the supervision of one lead researcher. If a participant felt that the device was uncomfortable, the elastic belt was adjusted accordingly to ensure secure fit. This process ensured that participants could wear the accelerometer independently for the subsequent days of data collection. To further enhance accelerometer compliance, a reminder text message was sent each morning which has been shown to improve the number of students wearing monitors to school (Belton et al., 2013). Each participant was asked to wear an accelerometer during all waking hours for nine consecutive days. To account for subject reactivity where participants may artificially increase their activity with the device, the first day of data was omitted from the analysis (Esliger et al., 2005).

Accelerometer data gathered was screened using stringent inclusion criteria of a minimum of three weekdays and one weekend day (Gorely et al., 2009; Nyberg et al., 2009) with 600 minutes wear time per day (Anderson et al., 2005). Strings of “0” counts in bouts of

≥ 20 min were considered non-wear periods (Yildirim et al., 2011), and activity count values of < 0 and $\geq 15,000$ counts per minute were excluded as these values were deemed biologically implausible (Esliger et al., 2005). The mean time spent in daily MVPA was calculated by applying the Evenson age specific cutpoints (Evenson et al., 2008) to the Actilife 6.4 software data reduction programme.

Self report: PA was further measured using the Youth Physical Activity Questionnaire (YPAQ) self report questionnaire which has been previously validated against accelerometry (concurrent validity coefficient $r=0.42$, $p<0.05$) with 12 to 13 year olds (Corder et al., 2009). Reported test-retest reliability coefficients for the YPAQ ranged from .86 to .92 (Corder et al., 2009). The variable for daily minutes of MVPA was calculated by averaging the total summed minutes of MVPA across the 7 days. Participants completed the questionnaire within their class groups under the supervision of one lead researcher and four trained field staff members. If a participant was unsure of any questionnaire component or had difficulty completing the task, they were assisted upon request by one of the research team present. Participants completed questionnaires using the online tool “Survey Monkey”.

Fundamental Movement Skills: The following 15 FMS were assessed: run, skip, gallop, slide, leap, hop, horizontal jump and vertical jump (locomotor; maximum score of 66); kick, catch, overhand throw, strike, underhand roll and stationary dribble (object control; maximum score of 48); balance (stability; maximum score of 10). Each of the 15 gross motor skills were assessed in conjunction with the guidelines from the Test of Gross Motor Development (TGMD), Test of Gross Motor Development-2 (TGMD-2) and the Victorian Fundamental Motor Skills manual (Department of Education Victoria, 1996; Ulrich, 2000, 1985). To ensure that adolescent performance was constant over time across the 15 selected FMS, trained field staff conducted a 48 hour time sampling test-retest reliability measurement amongst a sample of 35 participants aged 12-13 years old. The FMS coefficients reached 0.75 (locomotor subtest), 0.78 (object control subtest) and 0.91 (overall gross motor skill subtest), showing the scores across the range of FMS to be stable over time. During the data collection, one trained field staff member provided every 5 participants with an accurate demonstration and verbal description of the skill to be performed. To ensure participant consistency within skill performance, no feedback from any of the trained field staff were given during the testing. Participants performed the skill on 3 occasions including 1 familiarisation practice and 2 performance trials. Video cameras were used to record each participant’s performance and execution of the selected 15 FMS. The FMS scoring process was completed at a later date

by the trained field staff. The trained field staff were required to reach a minimum of 95% inter-observer agreement for all 15 skills on a pre-coded data set.

6.3.4 Data Analysis

Data were analysed using SPSS version 17.0 for Windows. Descriptive statistics and frequencies for the anthropometric characteristics, objective PA and self-report PA over time were calculated. Differences in BMI mean scores at pre, post and retention according to gender and school type were analysed using two-way repeated measures ANOVA.

Chi-square tests for independence were used to identify from the self-report data whether percentage differences in meeting the ≥ 60 minutes MVPA guideline according to school type existed at pre, post and retention. For FMS analysis, the binary variable “mastery and near mastery” (MNM) was created. “Mastery” was defined as correct performance of all skill components on both trials. “Near Mastery” was defined as correct performance of all components but one on both trials (Van Beurden et al., 2003). Pre, post and retention FMS scores were calculated for all 15 FMS and subtests for the intervention group relative to the control using independent t-tests.

Individual two-way repeated measures ANOVA’s were conducted to explore the impact of gender and school type (intervention group relative to control) over time (pre, post and retention) on objective daily MVPA minutes, self-report daily MVPA minutes, and FMS gross motor skill proficiency. Statistical significance was set at $p < 0.05$.

6.4 Results

6.4.1 Study Sample

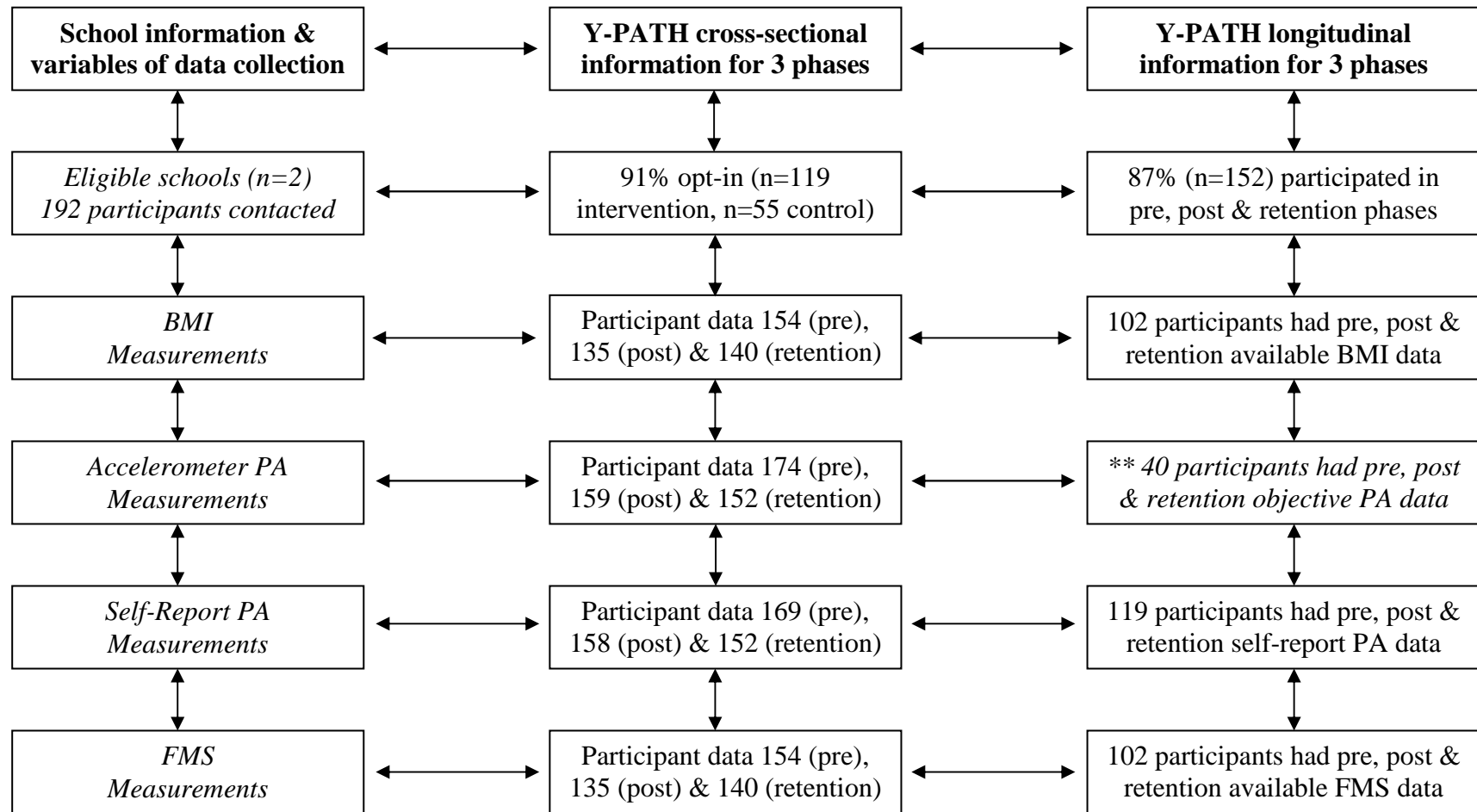
One hundred and ninety two participants from two schools were invited to participate in this study in September 2011 with consent from 174 participants provided (91% of total sample, n=119 intervention, n=55 control group). Of these 174 participants, only those who had full data sets available across all three time periods were included in the statistical analysis. An overview of the variables measured is given in Figure 6.1 (see below).

6.4.2 BMI and PA

BMI: BMI characteristics, objective PA and self-report PA descriptive statistics at pre, post and retention phases, for both the control and intervention groups, are summarised in Table 6.1 (see below). There were no significant differences between gender and school type for BMI across the three time periods.

Accelerometer PA: Based on the inclusion criteria applied to the accelerometer data, 23% of participants had fully available PA data across three time periods (see Table 6.1 below). There was a significant interaction between school and time for PA ($F(2, 38) = 6.177$, $p = 0.005$) with both schools showing an increase in daily MVPA over the three time periods, with a significantly greater increase in daily MVPA occurring within the intervention school.

Self-Report PA: Figure 6.2 illustrates the percentage of participants who accumulated ≥ 60 minutes of MVPA each day according to the self-report data. There was no school type differences observed in the overall percentage accumulating the ≥ 60 minutes MVPA guideline ($p > 0.05$) according to self-reported data at pre, post or retention phases. When comparing self-reported minutes of daily MVPA according to school type (intervention, control) and gender over time (pre, post and retention), no significant interaction between school attended, gender and self-reported minutes of PA over time was found.



Note. ** High loss of PA objective data due to large sample size not meeting the stringent accelerometer inclusion criteria. If participants failed to meet the inclusion criteria on any given period, they were not included within the longitudinal (pre, post and retention) analysis. Adolescent PA levels were subsequently measured through self-report PA measurement as an additional verification of adolescent PA engagement to accelerometer data collection.

Figure 6.1 Y-PATH Study: A descriptive overview relating to the outcome variables measured in this 1 year study

Table 6.1 The anthropometric characteristics and mean (SD) values for average accelerometer and self-report daily minutes of MVPA of Irish post-primary adolescent youth from 2011 – 2012 (pre, post and retention data collection phases) according to intervention and control condition

Time	BMI (kg/m²)	Accelerometer Daily MVPA¹	Self-Report Daily MVPA
Pre			
<i>Intervention</i>	(n=103) 20.36 ± 3.38	(n=61) 51.38 ± 20.70*	(n=70) 85.17 ± 66.00
<i>Control</i>	(n=51) 20.35 ± 3.26	(n=34) 43.48 ± 13.96*	(n=49) 91.78 ± 55.70
Post			
<i>Intervention</i>	(n=89) 20.69 ± 3.37	(n=39) 47.76 ± 17.72	(n=70) 80.48 ± 45.64
<i>Control</i>	(n=46) 20.50 ± 3.11	(n=36) 55.20 ± 20.52	(n=49) 88.40 ± 39.76
Retention			
<i>Intervention</i>	(n=89) 20.72 ± 3.26	(n=30) 59.17 ± 19.33	(n=70) 71.83 ± 46.57**
<i>Control</i>	(n=51) 20.96 ± 3.25	(n=34) 51.95 ± 17.89	(n=49) 93.21 ± 36.90**

Note: **n** = number of participants with available data. * = $p < 0.05$; ** = $p < 0.01$
MVPA = moderate to vigorous physical activity; **BMI** = body mass index;

¹. Those who had available accelerometer data and met the inclusion criteria at each phase of data collection (pre, post and retention)

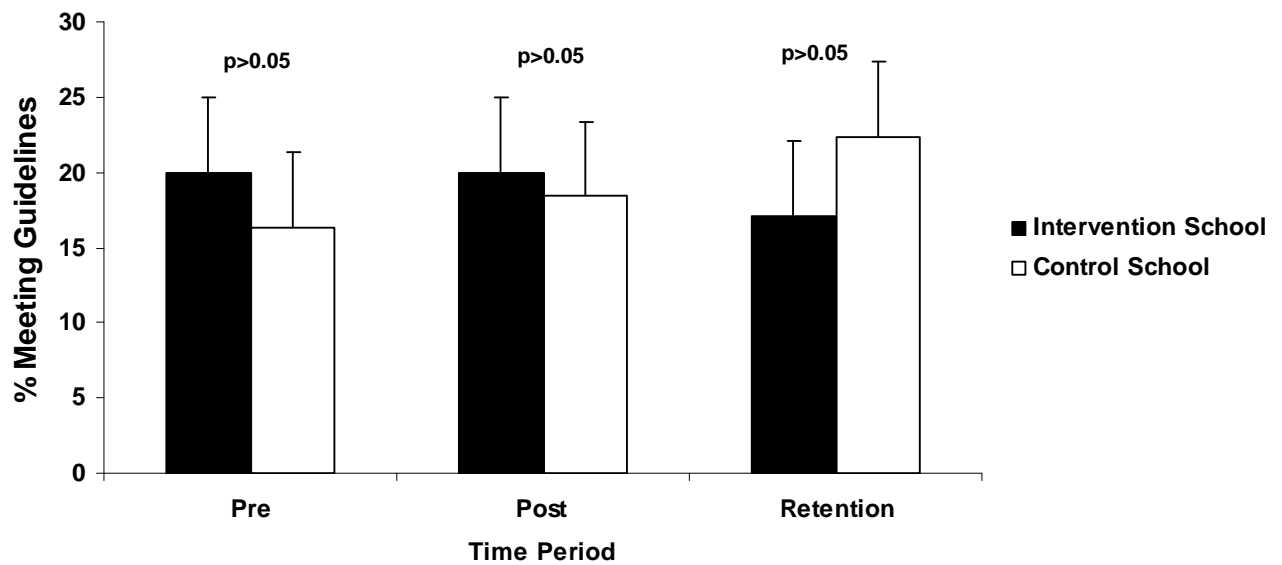


Figure 6.2 Percentage of participants self-reporting ≥ 60 minutes of MVPA on all 7 days per week at pre, post and retention

6.4.3 FMS

The mean scores for each of the 15 FMS and the associated subtests at pre, post and retention phases, for both the control and intervention groups, are summarised in Table 6.2 (see below). At pre-test, school-specific profiles differed with the control group displaying significantly greater proficiency in the vertical jump ($p < 0.01$), the object control subtest ($p < 0.05$), and total gross motor skill proficiency ($p < 0.05$).

There was a significant difference in improvement from pre-test to retention test between both intervention and control condition for gross motor skill proficiency ($F(2, 100) = 4.132, p = 0.019$) with a significantly greater increase occurring within the intervention school over time.

Table 6.2 FMS (n=15) raw mean scores at pre, post and retention phases for intervention group relative to control

Skill / Condition	Pre FMS mean score	Post FMS mean score	Retention FMS mean score
Run (max score 8)			
Intervention	7.69	7.63	7.77
Control	7.71	7.66	7.68
Gallop (max score 8)			
Intervention	6.45	6.41	6.78
Control	6.29	6.92	6.71
Hop (max score 10)			
Intervention	8.48	8.55	9.59
Control	8.66	8.12	9.37
Slide (max score 8)			
Intervention	6.70	6.84	7.39
Control	6.58	7.08	6.97
Leap (max score 6)			
Intervention	3.67	4.27	4.63
Control	4.03	4.53	4.42
Vertical Jump (max score 12)			
Intervention	9.09	10.13	10.62
Control	10.32	10.63	11.39
	<i>p<0.01**</i>		<i>p<0.01**</i>
Horizontal Jump (max score 8)			
Intervention	3.94	5.61	6.53
Control	4.45	5.55	6.50
Skip (max score 6)			
Intervention	5.03	5.48	5.20
Control	5.18	5.32	5.26
Locomotor Subtest Total (max score 66)			
Intervention	51.06	54.91	58.52
Control	53.21	55.79	58.32

Table 6.2 (continued)

Skill / Condition	Pre FMS mean score	Post FMS mean score	Retention FMS mean score
Kick (max score 8)			
Intervention	7.70	7.05	7.63
Control	7.63	6.58	7.05
Bounce (max score 8)			
Intervention	6.86	7.28	7.59
Control	6.73	7.24	7.74
Catch (max score 6)			
Intervention	5.73	5.68	5.63
Control	5.71	5.84	5.61
Strike (max score 10)			
Intervention	8.27	8.45	9.06
Control	8.79	7.82	8.87
Overhand Throw (max score 8)			
Intervention	6.27	2.89	6.95
Control	6.76	3.32	6.87
Underhand Roll (max score 8)			
Intervention	5.59	6.03	7.05
Control	6.11	6.26	6.71
Balance (max score 10)			
Intervention	7.45	7.45	7.97
Control	7.76	6.63	7.63
		<i>p</i> <0.05*	
Object Control Subtest (max score 48)			
Intervention	40.42	37.38	43.91
Control	41.74	37.05	42.84
	<i>p</i> <0.05*		
Total Gross Motor Skills (max score 124)			
Intervention	98.94	99.73	110.39
Control	102.71	99.47	108.79
	<i>p</i> <0.05*		

6.5 Discussion

The preliminary results from this pilot study suggest that it may be possible to increase 12 to 14 year olds participation in daily MVPA within a one year time frame, through a collaborative, school-based PE intervention. In the present study, participants in the intervention school appeared to accumulate 7.2 minutes more daily MVPA (when measured by accelerometry) than participants in the control school at the retention phase of the intervention (see Table 6.1). Similar increases in PA reported from this study correspond to a previous school based intervention on adolescents after one year (Haerens et al., 2006), where female intervention participants accumulated 6.4 minutes more daily MVPA than those in the control group. Another recent study, by Kriemler et al., (2010), evaluating the effect of a school based PA programme on children found that intervention participants successfully obtained 11 more minutes of daily MVPA than control participants. Similar to previous interventions (Dishman et al., 2004; Jamner et al., 2004; McKenzie et al., 2004; Pate et al., 2005; Slootmaker et al., 2010), results of this study are comparable in that the Y-PATH multicomponent school-based PE intervention can contribute positively towards increasing and sustaining adolescent youth PA. There is now strong evidence under the behavioural and social approaches to increasing PA that school-based programmes are effective amongst children and adolescent youth (Lavelle et al., 2012; Salmon et al., 2007; Vasques et al., 2013).

Due to the small number of participants with full objective accelerometer data, it was important to consider the self-report data to compliment MVPA findings. Consistent with previous studies (Prince et al., 2008; Slootmaker et al., 2009), the mean minutes of self-report MVPA was substantially higher over time compared to the objective accelerometer findings (see Table 6.1). The original research question was to explore if the intervention group would demonstrate a significantly greater increase in minutes of daily MVPA over time, however, results showed no significant differences between groups. This is in contrast to other recent school based PA programmes, which highlighted significantly greater self-report minutes of MVPA at follow-up for those exposed to intervention conditions (Haerens et al., 2007; Taymoori et al., 2008). In terms of considering why the intervention school was not significantly more effective in the increase of self-report minutes of MVPA, it is important to note that children and youth (both intervention and control) often have difficulty accurately recalling PA participation (Hands et al., 2006; Townsend, 2012; Trost, 2007). In addition, a previous study by Trost et al. (2000) investigated children's (mean age 9.8 ± 0.3 years) understanding of PA, in which the results found that 60% of participants had difficulty in

differentiating between sedentary activities and active pursuits. Based on this finding, it appears that young people may be unable to accurately quantify time spent in MVPA through self-report. This may explain why no significant differences in self-reported MVPA existed between intervention and control group over time, and again emphasises the importance of using objective measures of PA where possible.

It is plausible that the greater self-reported minutes of daily MVPA in the control group at follow-up may in part be attributed to the fact that, while both groups received the same amount of PE time (80 minutes) each week over the course of the school year, control participants received an additional 120 minutes 'games class' per week for one school year (Sept 2011 – May 2012). This additional 120 minutes of activity time was a specific school policy which was beyond the control of the research team. Yet despite this school policy, it is important to note that the control school did not self-report significantly higher MVPA over time compared to the intervention school, indicating that the intervention participants may have participated in more activity outside of school to 'make-up' for the reduced activity time they were exposed to as part of their school PE curriculum. .

Recent intervention results highlight a significant positive association between participation in school based movement skill programmes and FMS proficiency (Logan et al., 2011). FMS performance in a PE setting has previously found significant intervention effects for children and early adolescents (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013). Preliminary results from this pilot study are consistent with these FMS findings, indicating that adolescents exposed to a prescribed FMS climate during PE as part of the Y-PATH programme significantly improved in their overall movement skill proficiency relative to their control counterparts. It is particularly encouraging from a research perspective that these findings have emerged over the course of 12 months and even more so, when we consider that at baseline (pre-test), control school participants displayed significantly greater overall gross motor skill proficiency. Previous research highlights that younger children can achieve greater gains in motor skill proficiency (Mitchell et al., 2013) compared with older participants and hence, childhood is a critical period for FMS development (Gallahue and Ozmun, 2006; Hardy et al., 2010; Zask et al., 2012). Findings from this study suggest that adolescent youth aged 12 to 14 years old can significantly improve in FMS performance through a teacher led education intervention over one year. This finding is in line with other intervention programmes which have demonstrated significant improvements in FMS proficiency for children and adolescents through the school environment (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013; Van Beurden et al., 2003). Such improvements in

adolescent FMS proficiency are crucial to helping ensure a successful transition to more advanced skills in the specialised movement stage during adolescence (Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). The well informed opinion of Loitz (2013) suggests that the development of FMS during childhood and adolescence will help individuals to participate in PA and gain additional health benefits.

In light of this pilot study, it is important to consider that the effects of the intervention may be attributed to confounding factors other than the Y-PATH programme such as individual school characteristics or physical fitness levels etc. As both the control and intervention school had similar socio economic status (SES) and are situated in the same rural Irish setting, results of this study cannot be generalised without further research. For these reasons, the next stage of the Y-PATH research programme will undertake a definitive randomised controlled trial (RCT) in 24 mixed gender post-primary schools in September 2013 (to be discussed further in chapter 9). This robust surveillance of Y-PATH will precisely evaluate the overall intervention effectiveness for adolescent PA promotion.

Study limitations and strengths

Specific limitations of these analyses were the use of two mixed-gender schools only, resulting in a small number of participants involved in the study. In terms of matching criteria, both schools were selected for inclusion based on geographical location and gender distribution; in terms of sample size, however, the control school was not an exact match to the intervention which is acknowledged as a limitation. The control school having an additional 120 minutes games class per week compared to the intervention school can similarly be viewed as a limitation. Further details regarding participant characteristics and measurement variables such as nutrition, body fatness and cardio-respiratory fitness level would have allowed the researchers to explore the effectiveness of the intervention more robustly. The stringent inclusion criteria for accelerometer analysis was applied in order to obtain a detailed, representative pattern of objectively measured habitual adolescent PA behaviour but these research decisions had a significant adverse effect on the number of participants with available data for inclusion at each time point. Further details regarding the limitations of the overall Y-PATH study are discussed in Chapter 9.

A unique aspect of this research was the involvement of all teaching staff, parents and guardians within this whole-school approach towards adolescent PA promotion in the Y-PATH programme. A novel component of Y-PATH was the integrative approach of HRA and FMS in the PE environment for adolescents. Intervention and control settings were matched

based on gender and age distribution – furthermore, there were no differences in SES between participants. The use of accelerometry in conjunction with self-report questionnaire heightened the strength of PA measurement accuracy. Finally the measurement of 15 FMS will contribute significantly to the previously published literature in adolescent movement skill competency (Barnett et al., 2011, 2010; Hardy et al., 2010, 2013; Kalaja et al., 2012; Mitchell et al., 2013; Okely and Booth, 2004).

6.6 Conclusion

In the wake of the positive objective PA findings over time in this study, preliminary findings advocate for the simultaneous integration of HRA and FMS in school PE class, along with parent and teacher involvement, in efforts to improve the overall PA levels of adolescent youth. Preliminary findings of the Y-PATH intervention suggest that adolescent FMS proficiency can significantly improve through a one year teacher led intervention component. Recent evidence on the health benefits of FMS competency in children and adolescents (Lubans et al., 2010) found that 11 of the 13 identified studies indicated strong positive relationships between skill ability and PA components. Teaching children and young people during school PE classes to become competent and confident performers of FMS may lead to a greater willingness to participate in PA which in turn, may provide additional opportunities to improve physical fitness levels and reduce the risk of increased weight status (Barnett et al., 2008; Cliff et al., 2011; Morano et al., 2011). In light of the Y-PATH intervention, preliminary findings extend the knowledge on total PA participation amongst adolescents. Further longitudinal data is warranted to support these initial positive findings.

Role of the funding source

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6.8 Link Section Chapter 6 to Chapters 7 & 8

Purpose of Chapter 6:

In chapter 6, the efficacy of the Y-PATH intervention was evaluated by comparing the intervention group to a controlled trial, specifically assessing changes in PA participation and FMS proficiency over time. It was encouraging to observe through our results that over the year of the intervention, there was an increase in the intervention group's participation in daily MVPA. Furthermore, a significant improvement in overall gross motor skill acquisition for those exposed to the prescribed FMS climate during PE relative to their control counterparts was detected. In addition it is recognised that while preliminary research findings may be valid in the rural Irish adolescent setting, without further intervention examination (to be discussed additionally in chapter 9), these results must be interpreted with caution.

One of the concluding statements in chapter 6 is the suggestion that the development of FMS proficiency amongst adolescents may be associated with a reduced likelihood of becoming overweight and/or obese. For these reasons, it is important to consider the involvement of adolescent weight status on the variables outlined in the thesis to date, namely PA, FMS and sedentary behaviour.

Purposes of Chapters 7 & 8:

Chapters 7 and 8 are two cross-sectional observations from the pre-test Y-PATH data (prior to the intervention roll-out). These specific chapters are concerned with the rising prevalence of overweight and obesity amongst youth. While both of these chapters used data collected at pre-test, they were otherwise independent of the Y-PATH intervention evaluation. Chapter 7 explores the relationship between PA (accelerometry), FMS and weight status amongst early adolescent youth. Chapter 8 is an additional supplement of this cross-sectional data by determining the overall impact of PA (accelerometry), screen time (self-report) and weight status. Both chapters extend our knowledge within the field of adolescent PA behaviour and are timely contributions to the examination of weight status amongst adolescents.

Chapter 7

Deciphering the adolescent obesity epidemic - relationship between physical activity, fundamental movement skills and weight status

Manuscript submitted as:

O'Brien, W., Belton, S., Issartel, J. (**European Physical Education Review – Revise and Resubmit**). *Deciphering the adolescent obesity epidemic - relationship between physical activity, fundamental movement skills and weight status.*

7.1 Abstract

Objective: The background to this study was to determine if a potential relationship between physical activity (PA), fundamental movement skills (FMS) and weight status exists amongst early adolescent youth.

Method: Participants were a sample of 85 students; 54 boys (mean age = 12.94 ± 0.33 years) and 31 girls (mean age = 12.75 ± 0.43 years). Data gathered during physical education (PE) class included PA (accelerometry), FMS and anthropometric measurements.

Results: Standard multiple regression revealed that PA and total FMS proficiency scores explained 16.5% ($p < 0.001$) of the variance in the prediction of BMI. Chi square tests for independence further indicated that compared with overweight or obese adolescents, a significantly higher proportion of adolescents classified as normal weight achieved mastery / near mastery in FMS.

Conclusion: This study highlights the need to address basic movement skills at an earlier age during PE in order to undertake preventative measures for ensuring healthy weighted individuals entering early adolescence. The importance of specifically tailored PA programmes by the guided instruction of qualified PE specialists for overweight early adolescents may also be deemed a sensible strategy for combating FMS deficiencies which occur in this age cohort of youth.

7.2 Introduction

The proportion of overweight and obese school aged children and youth has reached unprecedented levels in recent years with an ‘epidemic’ emerging almost unbeknownst to the global population (Wang and Lobstein, 2006). Surveillance data from a European perspective indicate that the proportion of obese children has dramatically increased in the last 30 years through emergent growing trends (Ledergerber and Steffen, 2011). Irish cross-sectional data from the ‘Children’s Sport Participation and Physical Activity Study’ (CSPPA) found that one in four children (N= 1215; 13.4 ± 2.1 yrs) were unfit, overweight or obese and had high blood pressure (Woods et al., 2010). A recent conceptual model (Stodden et al., 2008) argue that there is a dynamic and reciprocal relationship between obesity, physical activity (PA), motor skill competence, perceived motor competence and physical fitness.

The importance of movement is sometimes overlooked as people perceive that movement will occur naturally as part of life. A recent study by Tsangaridou (2012) investigating the importance of teaching PE emphasised the positive contribution of fundamental movement skills (FMS) in supporting the development of social, cognitive and affective skills. Determining the point in which the development of movement becomes impaired is critical (Staples and Reid, 2010). FMS are basic observable patterns of behaviour present from childhood; often examples exhibited during physical education (PE) include running, hopping, skipping (locomotor), balancing, twisting, dodging (stability), throwing, catching and kicking (object control) (Breslin et al., 2012; Department of Education Victoria, 1996; Gallahue and Ozmun, 2006). Research suggests (Gallahue and Ozmun, 2006) that children have the developmental potential to master most of the FMS by age 6. The Australian New South Wales Schools Physical Activity and Nutrition Study (SPANS) (Hardy et al., 2010) highlights that the majority of children should have mastered the key FMS by ages 9 to 10 prior to the successful transition of more advanced skills within the sport specific stage (Department of Education Victoria, 1996). FMS is a critical component for determining whether young people have the ability to engage in activities that require a more advanced level of development (Castelli and Valley, 2007). FMS skills can be meticulously learned, practiced and reinforced during PE (Robinson and Goodway, 2009). The rate of mastery amongst these basic movement skills varies according to gender profile with marked performance differences across the age spectrum (3-16 years old) existing (Breslin et al., 2012; Hardy et al., 2010). Maturation factors such as sex hormones and growth spurts may be the

cause of gender differences in motor skill proficiency during puberty (Haywood and Getchell, 2009). Generally, it has been found that greater female movement skill proficiency is positively associated with cooperative and shared play time as opposed to the male egocentric dominated competitive skill environments (Hardy et al., 2010).

The literature relating to movement skill execution would suggest that children from 6 to 12 years old have relatively low levels of FMS proficiency, including those with a disability (Houwen et al., 2009; Pan et al., 2009), with slight increases observed during the early adolescent years (Mitchell et al., 2013). Furthermore, recent results from the SPANS study (Hardy et al., 2010) document the low percentage of early adolescent youth (11–12 years old) achieving skill mastery and near mastery across a range of seven FMS. A novel and innovative approach towards the explanation of these poor FMS performances amongst children and adolescent youth could be attributed to the escalating prevalence of childhood obesity (Lopes et al., 2012). There is a pressing and immediate call to implement effective PE based FMS interventions to strategically reduce the existing obesity ‘epidemic’ through the promotion of these movement skills at childhood.

Evidence based FMS interventions during childhood are important considerations in the sustainable development of motor skill proficiency (Van Beurden et al., 2003). Contemporary intervention results illustrate a significantly positive association between participation in school-based motor skill programmes and FMS proficiency (Logan et al., 2011). In the last decade, intervention programmes such as ‘Move it Groove it’ (MIGI) and ‘Project Energize’ highlighted that FMS can be positively integrated for children and early adolescents within the PE environment (Mitchell et al., 2013; Van Beurden et al., 2003). A meta-analysis of the effectiveness of FMS interventions, indicates that motor skill interventions led by PE teachers are successful in improving FMS in children (Logan et al., 2011). A systematic review of the associated health benefits of FMS in children and adolescents strongly supports the contribution of motor skill proficiency towards children and adolescents physical, social and psychological development (Lubans et al., 2010). There is now a platform of research to suggest that the relationship between percentage time spent in PA is positively associated with the execution of FMS amongst children and adolescent youth (Houwen et al., 2009; Okely et al., 2001; Wrotniak et al., 2006). A recent study among 7 to 12 year olds (Castelli and Valley, 2007) further highlights that there is a moderate relationship between PA and total motor competence

indicating that those with high levels of motor competency are more physically active in various PA settings (Castelli and Valley, 2007; Houwen et al., 2009).

PA is an important mechanism in maintaining a healthy body weight and preventing the chronic health conditions connected with obesity (Woods et al., 2010). A study amongst children aged 9 – 10 years old found that the sufficient development of motor skill proficiency and PA in children are important contributors to health (Haga, 2008). Irrespective of the emergent gender differences in PA participation of children and youth (O'Donovan et al., 2010), motor skill proficient children are more likely to become active adolescents (Barnett et al., 2009; Erwin and Castelli, 2008). Low levels of PA and large amounts of sedentary behavior are two known determinants to be causally involved in the etiology of the obesity epidemic (Must and Tybor, 2005). FMS proficiency is associated with PA (Erwin and Castelli, 2008) and we can delineate through this existent causal relationship that FMS proficiency in children and early adolescence have a positive effect with habitual levels of PA (Barnett et al., 2009; Fisher et al., 2005; Okely et al., 2001). In the combat of obesity (Castelli and Valley, 2007; Stodden et al., 2008), examining the relationship between PA and FMS is not yet well defined in the adolescent population and hence, further studies would seem a logical and crucial next step.

Few studies have investigated the relationship between weight status and motor skill execution amongst early adolescents (Cliff, Okely and Margarey, 2011; Hardy et al., 2010; Lopes et al., 2012). Consistent findings from these existing studies indicate that significant inverse relationships exist between weight status and motor skill performance. The SPANS study speculate based on the consistency of findings that overweight and obese participants execute lower locomotor performance due to the discomfort of engaging in locomotion which require greater movement of body mass against gravity (Hardy et al., 2010). Further longitudinal research in schools and with teachers is warranted to explore the effect of FMS programmes on children's motor competence (Breslin et al., 2012) and the causal nature of these inverse relationships between FMS and BMI (Lubans et al., 2010). This present investigation serves as a comparison for existing studies and, to the best of the author's knowledge, has never been reported previously amongst a European adolescent population.

The present study investigates the possible differences in both PA participation and FMS proficiency according to the weight status of early adolescent youth. In line with the literature,

the article further determines if an overall relationship between PA participation, FMS proficiency and weight status exists amongst Irish youth 12 – 14 years old.

7.3 Methods

7.3.1 Overview

Data were collected as part of a larger study being carried out at Dublin City University titled ‘Youth-Physical Activity Towards Health’ (Y-PATH). Data gathered included accelerometry (PA), FMS performance, and anthropometric characteristics (height and weight). Ethical approval was obtained from the Dublin City University Research Ethics Committee (DCUREC/2010/081). Approval from each of the participating schools was granted by the school principals. Active parental consent and child assent were requirements for eligible participants in this study (92% opt-in).

7.3.2 Participants

Two mixed-gender second level schools located within a typical Irish town were recruited to participate within this study. One hundred and seventy four students (out of a total 192) aged between 12 to 14 years old participated. The final sample comprised of 85 participants providing fully available and inclusive FMS, PA and BMI data; 54 boys (mean age = 12.94 ± 0.33 years) and 31 girls (mean age = 12.75 ± 0.43 years).

7.3.3 Measures

Fundamental movement skills: FMS data were collected during PE classes. The following 15 FMS were assessed: run, skip, gallop, slide, leap, hop, horizontal jump and vertical jump (locomotor; maximum score of 66); kick, catch, overhand throw, strike, underhand roll and stationary dribble (object control; maximum score of 48); balance (stability; maximum score of 10). Each of the 15 gross motor skills were assessed in conjunction with the guidelines from the Test of Gross Motor Development (TGMD), Test of Gross Motor Development-Second Edition (TGMD-2) and the Victorian Fundamental Motor Skills manual (Department of Education Victoria, 1996; Ulrich, 2000, 1985). Although these instruments are not specifically designed for youth over age 10 years, the purpose of this study was to obtain a measure of FMS proficiency in this population, not to make normative comparisons. Other studies using a similar age population (Frey and Chow, 2006; Houwen, et al., 2009; Houwen et al., 2007) have applied similar rationale when assessing gross motor skills. To ensure that adolescent performance was constant over time

across the 15 selected FMS, trained field staff conducted a 48 hour time sampling test-retest reliability measurement amongst a sample of 35 participants aged 12-14 years old. The FMS coefficients reached 0.75 (locomotor subtest), 0.78 (object control subtest) and 0.91 (overall gross motor skill subtest), showing the scores across the range of FMS to be stable over time. Prior to the participant performance, one trained field staff member provided an accurate demonstration and verbal description of the skill to be performed. To ensure participant consistency within skill performance, no feedback from any of the trained field staff were given during the testing. Participants performed the skill on 3 occasions including 1 familiarisation practice and 2 performance trials. Video cameras were used to record each participant's performance and execution of the selected 15 FMS. All trained field staff were final year undergraduate students enrolled in PE degrees.

The FMS scoring process was completed at a later date by the trained field staff. The trained field staff were required to reach a minimum of 95% inter-observer agreement for all 15 skills on a pre-coded data set. Each skill consisted of a number of performance criteria used for assessing FMS proficiency. Performing the component correctly was marked present with a score of 1 and if not performed correctly, the component was marked absent with a score of 0. 'Mastery' was defined as correct performance of all skill components on both trials. 'Near Mastery' was defined as correct performance of all components but one on both trials. 'Poor' was categorised as any score below these variables (Van Beurden et al., 2003). Each of the 15 FMS consisted of between three to six components. The number of components performed correctly was summed for each individual skill, for all locomotor, object-control, stability subtests and an overall FMS score was generated for all the skills for each participant.

Physical activity: PA was objectively measured during nine consecutive days using Actigraph GT1M and GT3X devices. PA was recorded in 10 second epochs to capture the intermittent and sporadic behaviour of youth (Esliger et al., 2005). Devices were worn during all waking hours except during bathing, water based activities and contact sports for which an adult deemed it unsafe to wear. Accelerometer data gathered was screened using stringent inclusion criteria. The first (accounting for subject reactivity) and last day from the recorded data (minimum three weekdays, one weekend and 10 hours wear time per day) were omitted from the analysis (Esliger et al., 2005). Strings of '0' counts in bouts of ≥ 20 min were considered non-

wear periods and activity count values of <0 and $\geq 15,000$ counts per minute were excluded as these values were deemed biologically implausible (Esliger et al., 2005).

The mean number of minutes that participants wore the accelerometers and the number of movement counts per minute were calculated. Minute-by-minute activity counts were uploaded to determine the amount of time spent in moderate-to-vigorous physical activity (MVPA). The mean time spent in MVPA daily was calculated by applying movement thresholds to the Actilife 5.10 software data reduction programme. The Evenson age specific count ranges relating to the activity intensity levels of sedentary, light, moderate and vigorous were applied across the data set (Evenson et al., 2008).

Body mass index: Weight was measured to the nearest 0.1kg using the Seca 761 dual platform weighing scales. Height was measured to the nearest 0.1cm using a portable stadiometer. Adhering to the ethical gender protocol, two field staff (1 male, 1 female) were trained by the principal investigator prior to data collection. Body Mass Index (BMI) was calculated using the equation; $\text{weight}(\text{kg})/\text{height}(\text{m}^2)$. A recently published study supports the role of PE teachers to measure height and weight for reliable and practical school-based BMI surveillance (Berkson et al., 2013). The cut off points, defined by the International Obesity Task Force (Cole et al., 2000) for normal, overweight and obese participants, were applied to the data in order to calculate BMI class. Later, the overweight and obese categories were collapsed to one level due to the small sample number of participants within the obese category.

7.3.4 Data Analysis

Data were analysed using SPSS version 19.0 for Windows. Descriptive statistics and frequencies for the demographic, physical characteristics, PA and FMS variables were calculated. Gender differences in PA mean scores were analysed using independent sample t-tests. Chi-square tests for independence were used to identify whether percentage skill differences in mastery/near mastery levels by gender and weight status existed. Pearson product-moment correlations examined the strength of relationship among FMS proficiency scores and PA, FMS proficiency scores and BMI scores, and PA and BMI scores. Standard multiple regression was performed to examine the overall interaction between the measurement of PA and total FMS proficiency scores in the prediction of adolescent levels of BMI. Statistical significance was set at $p<0.05$.

7.4 Results

The descriptive data of the physical characteristics and PA of the sample are presented in table 7.1. The mean age of participants was 12.86 years of age with 27.5% of males and 32.4% of females classified as overweight or obese. There were no significant gender differences between the percentages of overweight or obese individuals. In relation to the PA data, there was a significant gender difference with males accumulating more minutes ($M = 55.83$, $SD = 18.67$) of daily MVPA compared to females ($M = 40.80$, $SD = 12.18$; $t(83) = -4.14$, $p < 0.0001$).

Figures 7.1 and 7.2 portray the prevalence of overall mastery / near mastery for males and females across the 15 FMS. There were no significant gender differences in the performance of any of the individual FMS; equally when subtest scores were calculated, no statistical gender differences existed between overall object-control, locomotor and stability performance.

Table 7.2 portrays the overall prevalence of mastery / near mastery for each of the individual FMS skills according to weight status. Significant mastery / near mastery differences between normal weight and overweight/obese participants were observed in the horizontal jump ($\chi^2 = 7.032$, $p = 0.008$), balance ($\chi^2 = 4.717$, $p = 0.030$) and roll ($\chi^2 = 4.035$, $p = 0.045$); in each of these three skills, a statistically higher proportion of normal weight participants achieved mastery /near mastery. On a subtest level, significant differences were also observed in overall object control ($\chi^2 = 4.747$, $p = 0.029$) performance with an increased percentage of normal weight participants obtaining mastery / near mastery compared to overweight / obese individuals.

The relationship between FMS, PA and BMI scores according to gender is shown in Table 7.3. Among males, BMI showed medium, negative correlations with total locomotor, stability and overall FMS proficiency ($r = -.37$ to $-.45$). Male BMI scores were not significantly correlated with any of the PA variables. Finally, male FMS proficiency had no association with any of the PA variables.

Among females, BMI showed a medium, negative correlation with total locomotor skill proficiency ($r = -.34$). Similar to males, female BMI scores were not significantly correlated with any of the PA variables. Finally, for females, total locomotor and overall FMS proficiency showed medium, positive correlations with vigorous physical activity ($r = .36$ to $.37$).

Finally, standard multiple regression was used to assess the ability of PA and total FMS proficiency to predict adolescent levels of BMI. After the entry of these variables, the model as a whole revealed that PA and total FMS proficiency scores explained 16.5% of the variance in the

prediction of BMI ($F(2, 82) = 8.121, p < 0.001$). Of the two independent variables, total FMS proficiency scores made the largest unique contribution ($\beta = -.383$) explaining 14.6% of the variance in the prediction of adolescent levels of BMI. PA did not make a significant contribution to the model ($\beta = .158$).

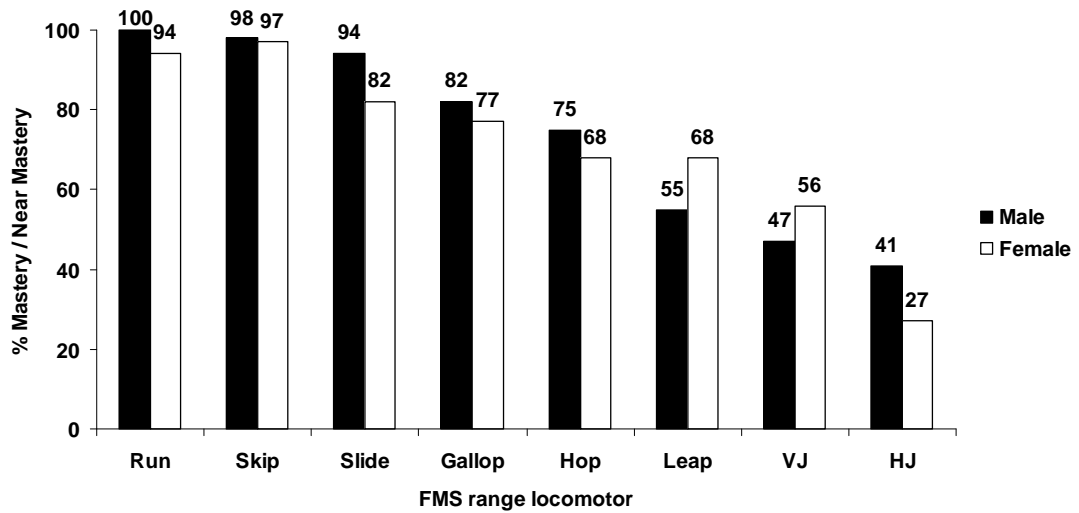


Figure 7.1 Locomotor subtest prevalence of mastery / near mastery by gender.
VJ = Vertical Jump. HJ = Horizontal Jump

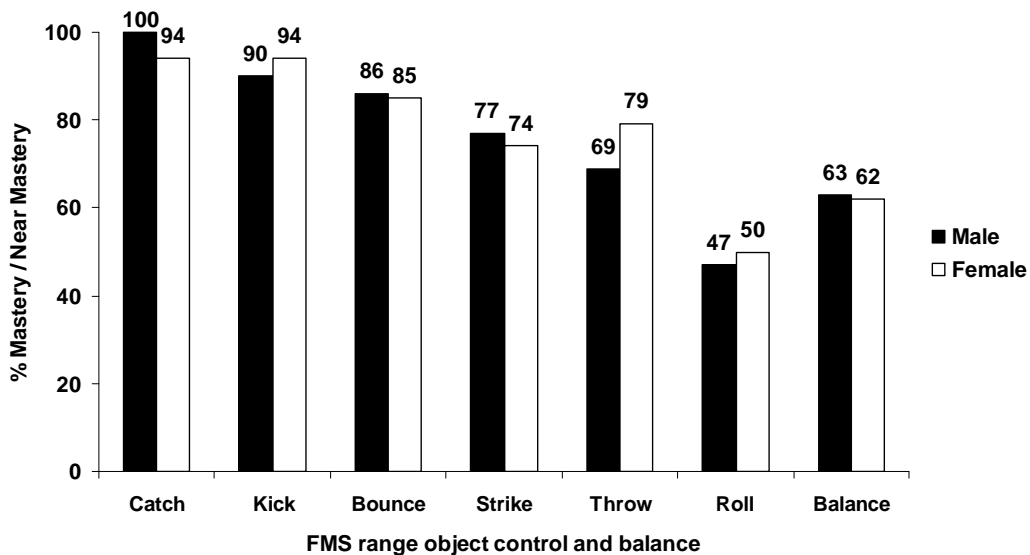


Figure 7.2 Object related and stability subtest prevalence of mastery / near mastery by gender

Table 7.1 Descriptive data for the physical characteristics and PA of early adolescent youth

Variable	Boys (n=54)		Girls (n=31)		t	p-Value
	M	SD	M	SD		
Age (years)	12.94	.33	12.75	.43	-2.325	.023
Min/day moderate PA	34.09	8.40	27.07	6.60	-4.096	.0001**
Min/day vigorous PA	21.75	12.65	13.73	6.89	-3.374	.001*
Min/day MVPA	55.83	18.67	40.80	12.18	-4.140	.0001**
Height (cm)	155.70	8.65	153.04	6.10	-1.553	.124
Weight (kg)	51.14	11.75	47.60	9.48	-1.464	.147
Range	31.50-85.00		27.50-63.00			
BMI (kg/m ²)	29.95	3.82	20.18	3.18	-.968	.336
Range	13.28-30.48		14.74-26.56			
					x ²	p-Value
% overweight/obese (BMI kg/m ²)**	27.5		32.4		.06	.80

Note. M = mean; SD = standard deviation; PA = physical activity; MVPA = moderate to vigorous physical activity; BMI = body mass index. Differences between % overweight/obese males and female examined using chi-square tests; differences in all other variables examined using independent t-tests.

* $p < .05$. ** $p < .01$.

Table 7.2 Descriptive data for the physical characteristics and PA of early adolescent youth

Variable	Normal Weight (n=60)	Overweight / Obese (n=25)	χ^2	p
	Mastery / Near Mastery %	Mastery / Near Mastery %		
Run	98%	96%	0.418	0.518
Gallop	82%	76%	0.089	0.766
Hop	70%	76%	0.087	0.768
Slide	92%	84%	0.435	0.509
Leap	67%	44%	2.892	0.089
Vertical Jump	50%	52%	0.028	0.867
Horizontal Jump	45%	12%	7.032	0.008**
Skip	98%	96%	0.418	0.518
Kick	92%	92%	0.003	0.959
Bounce	87%	84%	0.104	0.748
Catch	98%	96%	0.418	0.518
Strike	73%	80%	0.139	0.709
Overhand Throw	73%	72%	0.016	0.900
Roll	57%	28%	4.717	0.030*
Balance	70%	44%	4.035	0.045*

Note. Differences between normal weight and obese / overweight participants in FMS mastery / near mastery of individual skills examined using chi-square tests * $p < .05$. ** $p < .01$.

Table 7.3 Pearson correlations among FMS, PA and BMI scores according to gender

Correlations Variables	Total Locomotor	Total Object Control	Total Stability	Total FMS
Male				
<i>Moderate PA p/day</i>	-.068	-.229	-.050	-.157
<i>Vigorous PA p/day</i>	.058	-.065	.018	.013
<i>MVPA p/day</i>	.009	-.147	-.010	-.062
<i>BMI scores</i>	-.367**	-.171	-.491**	-.449**
Female				
<i>Moderate PA p/day</i>	.138	.060	-.206	.078
<i>Vigorous PA p/day</i>	.369*	.245	-.141	.355*
<i>MVPA p/day</i>	.284	.171	-.191	.243
<i>BMI scores</i>	-.341*	.058	.141	-.272

Note. MVPA = moderate to vigorous physical activity. * $p < .05$. ** $p < .01$

7.5 Discussion

The present study examined if the possible differences in gender, PA participation and FMS proficiency varied according to weight status amongst early adolescent youth. The interaction of PA participation and total FMS proficiency scores within this investigation explained 16.5% of the variance in the prediction of adolescent levels of BMI. Total FMS proficiency, however, made the largest unique contribution in predicting adolescent levels of BMI. This regression model revealed that FMS proficiency may have an important role in determining adolescent weight status (Stodden et al., 2009).

Considering the overall significance of this regression model, it is important to flag that this finding is in contrast to a previous study across 248 children (9-12 years old) where no significant interaction effect among PA participation, FMS proficiency, and weight status was found (Hume et al., 2008). Overall, the present result implies that FMS proficiency has a small yet uniquely contributing effect in the prediction of BMI levels amongst early adolescent youth. Authors are not dismissing the estimated value of predicted variance, however, further research is warranted to further investigate this area.

In line with the literature (Erwin and Castelli, 2008; O' Donovan et al., 2010) significant differences were found in PA participation between genders, with males accumulating more minutes of daily MVPA than females. It is important in this study to treat these objective PA results with caution as participants did not wear the accelerometers in the water or during contact sports which increases the potential for error in underestimating the representative PA levels of adolescents. These PA findings highlight that early adolescent males were significantly more active offering a plausible explanation for the higher percentage of males classified as normal weight. This finding is consistent with the recent national CSPPA Study (n=5397; mean age 13.8 ± 2 years), which also found that females are less active and have a higher BMI profile than males (Woods et al., 2010). In relation to the growing trend of adolescent inactivity, there is now strong evidence to suggest that males are more physically active and physically fitter than females (Stodden et al., 2009), and also engage in more vigorous PA (O'Donovan et al., 2010). The reoccurring PA gender disparities found in the literature, highlight the need to target additional approaches for enhancing female PA participation both within and outside of school hours.

No significant results were found in terms of gender differences in FMS performance which similarly corresponds to a recent study in young people aged 7 to 12 years old (Castelli and Valley, 2007). It was interesting to observe that while male performance in the locomotor subtest was better than females in five of the eight FMS skills, no overall significant differences were found. In the object control subtest and balance skill, male and female FMS execution was similar. The findings from this present study contradict recent literature in that males are perceived to possess significantly higher object related skills (Erwin and Castelli, 2008), and that advanced locomotor skill proficiency is associated with female performance (Hardy et al., 2010; Hume et al., 2008). The small sample size involved in this study may be a limiting factor and a plausible explanation to suggest that no overall gender FMS differences were observed. Another explanation for these results corresponds to research which states that existent and emergent gender differences occurring after puberty may be due to a dynamic interplay between psychosocial and biological factors (Wrotniak et al., 2006). Adolescent females are considered to have a delay in puberty if breast development has not started by 13.3 years old (Gallahue and Ozmun, 2006). Contrary to this, the male adolescent peak pubertal growth spurt occurs between 14 to 15 years old (Gallahue and Ozmun, 2006). The onset of puberty occurring in females during the years of 12 to 13 may account for the non-existent gender differences found in this study cohort ($12.86 \pm .38$). It seems possible therefore, through the onset of adolescent puberty that females may have 'caught up' with their male counterparts in terms of FMS proficiency.

Results from this investigation highlight that the percentage of mastery/near mastery levels for both males and females ranged from 27% to 100% across the selected 15 FMS. The recent Australian SPANS survey provides evidence that rural Australian early adolescent youth (13-14 years old) perform FMS less proficiently (Hardy et al., 2010). Whilst no gender differences were observed in the present study, there is evidence to suggest from these current findings that Irish male and female FMS proficiency is higher than that of recent research amongst Australian adolescents (Hardy et al., 2010).

Results from the current investigation indicate that weight status is an important correlate of FMS proficiency. This supports a recent systematic review of the associated health benefits of FMS in children and adolescents where an inverse association was found between FMS proficiency and weight status (Lubans et al., 2010). Conversely, another study which observed FMS proficiency among 6-18 year olds with mild intellectual disabilities suggests that weight

status has no impact on youth motor skills (Frey and Chow, 2006). Yet, findings from this study are consistent with other studies amongst children and adolescents, where it has been shown that overweight individuals exhibit low locomotor skill proficiency (Cliff, Okely, Morgan, et al., 2011; Cliff, Okely and Magarey, 2011). In this study, participants within the normal weight category displayed significantly higher mastery/near mastery levels in the horizontal jump, underhand roll and balance compared to overweight/obese individuals. A possible explanation for horizontal jump differences according to weight status suggests that obese children and adolescent youth find it more difficult to engage in locomotion which require greater movement of body mass against gravity (Hardy et al., 2010). While causality cannot be inferred from these early adolescent data, we suggest that improved locomotor skill proficiency can potentially lead to a reduction in weight status.

Taking into consideration that the balance is an essential pre-requisite to competently perform most activities of daily living, it is rather concerning that overweight/obese early adolescent youth are significantly lacking in terms of balance skill proficiency. Along this line, our results illustrate similar significant findings in terms of the underhand roll performance according to weight status. The performance criteria of the underhand roll require the individual to reach behind the trunk and stride forward almost simultaneously. Performing this simultaneous body movement during the execution of the underhand roll could be a reasonable suggestion as to why overweight individuals experience difficulty executing this component.

Observations from this study highlight the potential importance of prescribing specific movement skills during PE (Le Masurier and Corbin, 2006; Tsangaridou, 2012; Ward et al., 2007) in children and early adolescents to alleviate the increasing emergence of overweight and obesity across school aged youth. The school based PE setting is now considered the only setting where young people, can accumulate vigorous PA and learn important generalisable FMS (McKenzie and Lounsbery, 2009). Results from this study potentially indicate, with future supporting data, that the prescription of FMS programmes during PE (Kalaja et al., 2012; Martin et al., 2009; Mitchell et al., 2013) can be considered a practical approach to undertake preventative measures for ensuring healthy weighted individuals make the transition to early adolescence. A recent conceptual model (Stodden et al., 2008) hypothesises that young people who do not have sufficient levels of FMS will not continue to be physically active in later years and, therefore will not further develop or maintain aspects of health-related fitness.

7.6 Conclusion

Findings from the current study suggest that early adolescent males appear to be significantly more active than females yet a gender divide in FMS proficiency is not as apparent. Data findings are consistent with the majority of cross-sectional studies in that weight status showed to be an important correlate for individual skill execution in the horizontal jump, balance and underhand roll across early adolescence. The significant inverse relationship found between locomotor skill proficiency and BMI across both gender types provides important information to guide future school-based PE intervention strategies. Deciphering the adolescent ‘obesity’ epidemic through the prescription of PA and particularly, locomotor-based FMS during PE class by qualified specialists (Strong et al., 2005), can be deemed a sensible and cost-efficient approach to combat this major threat to public health. Continuing to address the performance outcomes of motor competence may lead to regular PA participation (Castelli and Valley, 2007; Erwin and Castelli, 2008) and an active lifestyle (Houwen et al., 2009).

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Chapter 8

Relationship between Physical Activity, Screen Time and Weight Status Among Adolescents.

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8.1 Abstract

Background: It is well established that lack of physical activity (PA) and sedentary behaviour are now associated with all-cause and cardiovascular mortality. The purpose of this study was to investigate the relationship between PA participation, overall screen time and weight status among 12 to 14 year olds.

Methods: One hundred and ninety two year one students from two mixed-gender Irish post-primary schools were invited to participate in September 2011, with 174 consenting to participate (91% opt-in). Data gathered in the present study included PA (accelerometry), screen time (self-report) and anthropometric measurements.

Results: Overweight and obese participants accumulated significantly more minutes of overall screen time daily compared to their normal weight counterparts ($p < 0.05$). Correlations between PA and daily television viewing were evident among females ($r = -.348$; $p < 0.05$). No significant interaction was apparent when examining daily PA and overall screen time in the prediction of early adolescent BMI scores.

Conclusions: Results suggest the importance of reducing screen time in the contribution towards a healthier weight status among adolescents. Furthermore, PA appears largely unrelated to overall screen time in predicting adolescent weight status, suggesting that these variables may be independent markers of health in youth.

8.2 Introduction

Physical activity (PA) is now perceived as the cornerstone in the physical development of infants, young and older children, and adolescents approaching adulthood (Ward et al., 2007). Most current evidence (Moore et al., 2012) highlights that an increase in PA levels equivalent to brisk walking for a minimum of 75 minutes per week is associated with a gain of 1.8 years in life expectancy. Contrary to PA, “sedentary living” reduces longevity and is associated with significant health risks because this behaviour refers to activities that do not increase energy expenditure substantially above the resting level (Pate et al., 2008). In light of this sedentary phenomenon, it seems logical that physical inactivity is now identified as the fourth largest risk factor of mortality (World Health Organization, 2010) causing an estimated 5.3 of the 57 million deaths globally in 2008 (Lee et al., 2012). In recent years, sedentary pursuits such as television viewing, playing computer games and using the internet have become the preferred mode of passive entertainment in daily living among youth (Biddle, Pearson, et al., 2010; Oliver et al., 2012). Surveillance data from a European perspective indicates that youth PA levels have substantially decreased (Currie et al., 2012) with the proportion of obese children having dramatically increased in the last 30 years (Ledergerber and Steffen, 2011).

There are now numerous studies to suggest that levels of PA are falling short of recommended minimum guidelines, and that levels decline during adolescence (Currie et al., 2012; Kimm et al., 2000; O’Donovan et al., 2010; Physical Activity Guidelines Advisory Committee, 2012). A recent study on the health behaviour in school aged children (HBSC) (Currie et al., 2012) found that the majority of adolescents in European countries reported no more than 20% to 24% of males and females meeting the 60 minute MVPA guideline. The most recent Irish study on the PA levels of youth indicate that only 12% of 12 to 18 year old adolescent youth meet the PA guidelines (Woods et al., 2010). With these documented low levels of youth PA engagement, numerous cross sectional studies have further highlighted relationships between low levels of PA, increased levels of sedentary pursuits and BMI among children and adolescents (Marshall et al., 2004; Viner and Cole, 2005).

The concept of sedentary behaviour is not a newborn phenomenon (Biddle, Pearson, et al., 2010), with findings from the past decade indicating that higher levels of sedentary behaviours are negatively associated with cardio-metabolic risk factors (Cleland et al., 2013). Yet, this area has gathered momentum in recent years with a plethora of research addressing

sedentary behaviours amongst youth due to the attraction of the home environment, the desire to engage in screen based activities and the over reliance of motorised vehicular transport (Biddle, Cavill, et al., 2010). Furthermore, specific research interest has been generated towards the independent health risks associated with prolonged sitting time (Owen et al., 2009; Pate et al., 2008; Troiano et al., 2012). A recent study found that a reduction in television viewing during adolescence in addition to regular PA, may improve cardiometabolic health later in life (Wennberg et al., 2013). While the independent effects of sedentary behaviour on health outcomes can vary in degree of magnitude (Mitchell et al., 2009), this concept is of considerable importance, warranting further study and examination in young people (Biddle et al., 2011).

There is a need to develop specified sedentary behaviour guidelines for children and youth in Ireland (Woods et al., 2010) and worldwide (Hamilton et al., 2008). The Canadian Sedentary Behaviour Guidelines for Children (5-11 years of age) and Youth (12-17 years of age) recently published recommendations (Tremblay et al., 2011) stating that for health benefits, recreational screen time should be limited to no more than 2 hours per day. Recent studies suggest that a high proportion of children and adolescent youth engage in high amounts of daily television viewing, video game usage, with screen time recreation the most common (Eaton et al., 2012; Hardy et al., 2010; Oliver et al., 2012). The recent HBSC report (Currie et al., 2012) found that between 63% to 65% of adolescents (13 to 15 years old) worldwide watch television for more than 2 hours per day on weekdays; had time spent playing video games been added to the HBSC report, this statistic for sedentary behaviour would be much higher. From an Irish perspective, this concerning trend towards sedentary behaviour seems most apparent, with less than 1% of children and youth meeting the health recommendations of no more than 2 hours of screen time during daylight hours (Woods et al., 2010).

Recent systematic reviews found that higher levels of habitual PA are protective against obesity (Jiménez-Pavón et al., 2010) and higher levels of sedentary behaviour are associated with an increased risk of obesity (Rey-López et al., 2008) among adolescents. If the evidence among young people now suggests that the daily sedentary behaviours are increasing and PA levels decreasing (Currie et al., 2012), investigating the relationship, therefore, between PA and sedentary behaviour in their association with weight status is an important and timely issue that could inform obesity prevention strategies among adolescents (Basterfield et al., 2012). The present study examines possible differences in both PA participation and screen time behaviours

according to the weight status of early Irish adolescent youth aged 12 to 14 years old. Separate analyses will be conducted for both males and females as recent evidence suggests clear gender differences in PA, screen time and overweight (Brug et al., 2012; De Bourdeaudhuij et al., 2012; Koezuka et al., 2006).

8.3 Methods

8.3.1 Overview

This Irish cross-sectional study is part of a longitudinal study entitled the Youth-Physical Activity Towards Health (Y-PATH) research programme which was initiated in September 2010 at Dublin City University (DCU). Data gathered in the present study included PA (accelerometry), screen time (self-report) and basic anthropometric measurements (height and weight). Approval from the principals of the two participating schools was granted. Informed consent for participation was sought by each adolescent and their parent/guardian. Ethical approval was obtained from the Dublin City University Research Ethics Committee (DCUREC/2010/081).

8.3.2 Participants

A convenience sample of Irish adolescents enrolled in year one of post-primary education (12-14 years of age) from two mixed gender schools were invited to take part in the study. The overall sample comprised of 192 adolescents, with 174 participants consenting to participate (91% opt-in).

8.3.3 Measurement

Moderate-to-vigorous physical activity (MVPA): MVPA was objectively measured for one hundred and seventy four participants (174) during nine consecutive days using two types of Actigraph accelerometers (GT1M and GT3X models). Participants were shown how to wear the accelerometer above the iliac crest of the right hip (Troost et al., 2006), as recent evidence suggests the highest percentage of correctly classified activities is achieved when using data from the hip (De Vries et al., 2011). Participants were asked to wear the accelerometer during all waking hours unless showering, swimming or taking part in a contact activity for which an adult deemed it unsafe to wear. A member of the research team met with the students each school morning to ensure students were complying with accelerometer wear instructions. In order to try increase participant compliance with the wear protocol, participants received an SMS each morning of the 9 days to remind them to wear the monitor (Belton et al., 2013) (see appendix K).

In line with previous recommendations (Esliger et al., 2005), the first and last day of accelerometer data were omitted from analysis. Minutes in light, moderate and vigorous PA were estimated from the data using the recently validated Evenson cutpoints (Evenson et al., 2008) for youth of this age group (Troost et al., 2011); Sedentary ≤ 100 , Light PA: > 100 , Moderate PA: ≥ 2296 , and Vigorous PA: ≥ 4012 (all values counts per minute). Monitor non-wear periods was defined as ≥ 20 consecutive minutes of zero counts (Yildirim et al., 2011). In line with other studies, a day was deemed valid (and thereby included in analysis) if there was a minimum of 600 minutes recorded wear time per day (Nyberg et al., 2009). The minimum number of valid days required for inclusion in analysis was 3 weekdays and 1 weekend day (Gorely et al., 2009; Rowlands et al., 2008).

Screen Time: Screen time activities were derived using the Youth Physical Activity Questionnaire (YPAQ) (Corder et al., 2009) which has been previously validated against accelerometers (concurrent validity coefficient $r=0.42$, $p<0.05$) amongst 12 to 13 years olds. The three types of screen time activities analysed in the present study included 1) television viewing, 2) playing video games and 3) using the computer. Overall screen time (Anderson et al., 2008) was calculated by summing the mean number of minutes per day for each of the 3 variables. Data was collected on participants in their class groups (maximum $n = 30$) during a 2-hour school visit, with a ratio of 1 researcher to 15 students for questionnaire completion. In cases where computer networks failed, participants completed hardcopies of the questionnaire. Test re-test reliability among a sample of 35 participants (11-12 years of age) was carried out to ensure comparability of the two administration protocols (computer versus hardcopy); reliability coefficients reached 0.94, showing the scores across both formats of the questionnaires to be very stable over time.

Body mass index: Weight was measured to the nearest 0.1kg using the Seca 761 dual platform weighing scales, while height was measured to the nearest 0.1cm using a portable stadiometer. BMI was calculated using the equation; weight (kg)/ height (m^2). The cut off points, defined by the International Obesity Task Force (Cole et al., 2000) for normal, overweight and obese participants, were applied to the data in order to calculate weight status.

8.3.4 Data Analysis

Data were analysed using SPSS version 17.0 for Windows. Descriptive statistics and frequencies for the demographic, physical characteristics, PA, types of screen time activities and overall screen time were calculated; when broken down by gender and weight status, descriptive statistics further explored the percentage of participants accumulating at least 30 minutes, 45 minutes and 60 minutes MVPA daily.

Gender differences in PA, types of screen time activities and overall screen time were analysed using independent sample t-tests. Chi-square tests for independence were further used to examine whether gender and weight status differences in PA and screen time recommendations existed. Correlation coefficients examined the strength of relationship among types of screen time activities and PA, overall screen time and PA, types of screen time activities and BMI scores, overall screen time and BMI scores and PA and BMI scores. Standard multiple regression was performed to examine how much of the variation in BMI could be explained by accelerometer derived MVPA and self-reported overall screen time. Statistical significance was set at $p < 0.05$.

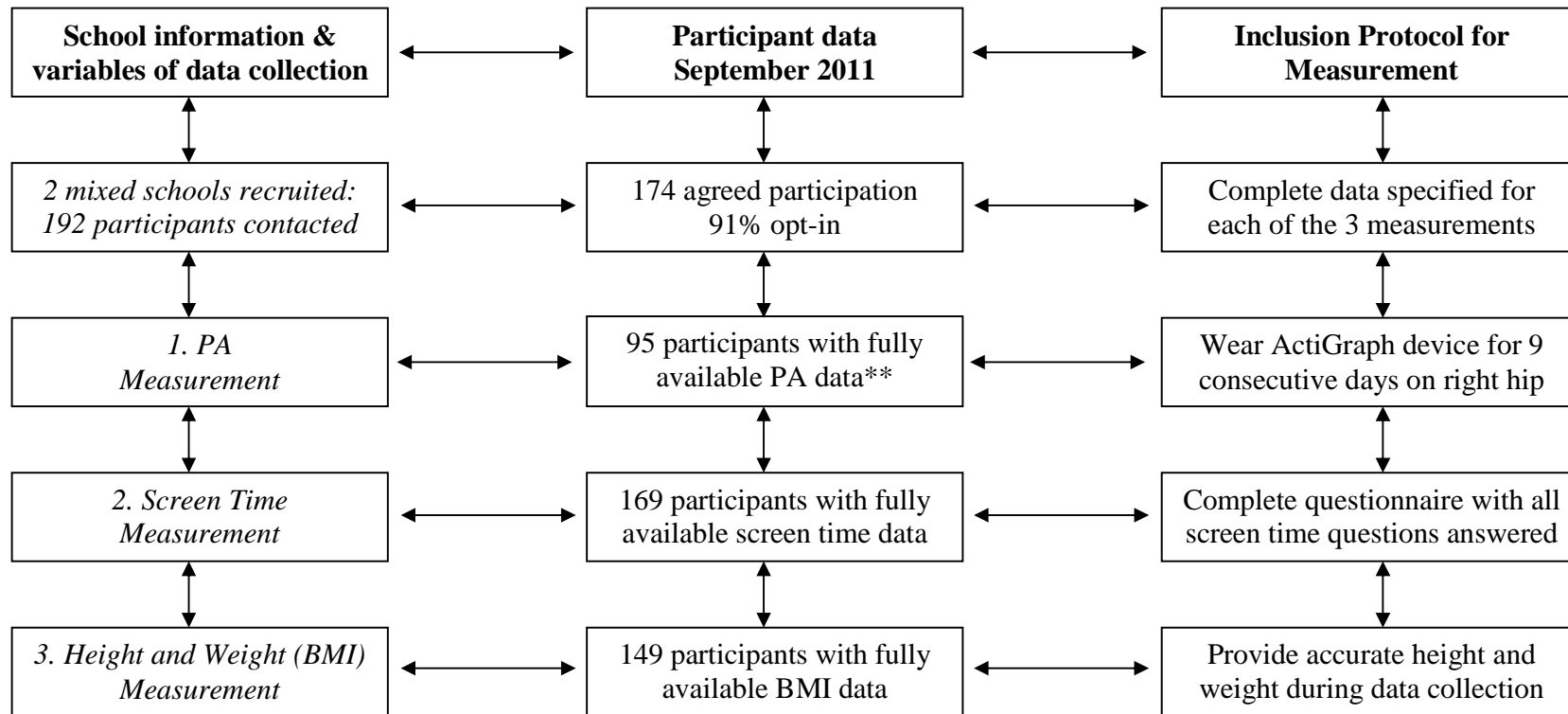
8.4 Results

Participants were included in the analysis if they had fully available and valid accelerometer PA (n=95), self-report screen time (n=169) and BMI data (n=149). Figure 8.1 (see below) outlines the descriptive overview and the protocol for participants with PA, screen time and BMI data.

The descriptive data of the physical characteristics according to gender and the types of screen time activities of the sample are presented in Table 8.1. The mean age of participants was 12.88 ± 0.45 years of age with 25.5% of males and 29.4% of females classified as overweight and/or obese. There were no significant gender differences between the percentages of overweight or obese individuals. In relation to the types of screen time activities, independent sample t-tests confirmed that there was a significant gender difference with males accumulating more minutes ($M = 23.32$, $SD = 53.88$) of daily video game usage compared to females ($M = 7.19$, $SD = 14.34$; $t(167) = 2.199$, $p = 0.029$).

The overall mean daily screen time for participants were 82.24 ± 109.41 minutes per day (min/d). Table 8.2 outlines the overall daily screen time and adherence to the associated screen time recommendations according to gender and weight status. Male participants accumulated more minutes (90.76 min/d) of daily screen time than females (65.05 min/d); yet, statistically, there were no significant gender differences. When broken down by weight status, overweight/obese weight participants accumulated 103.5 min/d screen time compared to 64.09 min/d screen time for normal weight participants. Independent t-tests subsequently confirmed that there was a significant weight status difference with overweight and obese participants accumulating more minutes per day of screen time compared to normal weight participants

Descriptive statistics showed that overall 25.3% of participants met the 60 min/d MVPA guideline. The mean min/d MVPA was higher for male participants (53.99 min/d) than females (39.64 min/d) with an independent sample t-test confirming that males accumulated significantly more min/d MVPA.



Note. ** High loss of PA objective data due to large sample size (n=79) not meeting the stringent accelerometer wear time inclusion criteria; thus, these data were eliminated from the final analysis.

Figure 8.1 Descriptive overview and protocol for participants with PA, screen time behaviour and BMI data

Table 8.1 Descriptive data for the physical characteristics and types of screen time activities according to gender

Variable	Boys (n=113)		Girls (n=56)		t	p -Value
	M	SD	M	SD		
Age (years)	12.89	.34	12.87	.61	.275	.784
Min/day television viewing	44.96	52.78	35.20	33.96	1.259	.210
Min/day video game usage	23.32	53.88	7.19	14.34	2.199	.029*
Min/day computer usage	22.47	48.92	22.65	28.31	-.026	.980

	Boys (n=98)		Girls (n=51)		t	p -Value
	M	SD	M	SD		
Height (m)	1.55	.09	1.55	.06	.311	.756
Weight (kg)	49.15	11.10	49.48	9.99	-.177	.860
BMI (kg/m ²)	20.22	3.38	20.48	3.15	-.450	.653
% overweight/obese (BMI kg/m ²)		25.5		29.4	χ^2 .099	p -Value .753

Note. **M** = mean; **SD** = standard deviation; **Min/day**= minutes per day; **BMI** = body mass index. Differences between % overweight/obese males and female examined using chi-square tests; differences in all other variables examined using independent t-tests; *p≤.05. **p≤.01.

Table 8.2 Overall screen time and adherence to the associated recommendations according to gender and weight status

Variable	Boys (n=113)		Girls (n=56)		t	p -Value
	M	SD	M	SD		
Min/day overall screen time	90.76	126.78	65.05	58.17	1.442	.151
Met screen time recommendations ≤ 2 h/d (%)	75.2%		82.1%		χ^2 .670	χ^2 .413
Variable	Normal Weight (n=109)		Overweight/Obese (n=40)		t	p -Value
	M	SD	M	SD		
Min/day overall screen time	64.09	57.37	103.50	171.93	-2.105	.037*
Met screen time recommendations ≤ 2 h/d (%)	80.7%		77.5%		χ^2 .042	χ^2 .837

Note. **M** = mean; **SD** = standard deviation; **Min/day**= minutes per day; **h/d**= hours per day. Gender and weight status differences in daily minutes screen time examined using independent t-tests; differences in % who met screen time recommendations examined using chi-square tests for independence; *p≤.05.

Figures 8.2 and 8.3 (see below) illustrate the prevalence of those accumulating at least 30 min/d, 45 min/d and 60 min/d of MVPA for both gender and weight status. Chi-square tests for independence indicated that significant gender differences were again observed in those who accumulated at least 45 min/d ($X^2=6.062$, $p=0.014$) and 60 min/d MVPA ($X^2=7.415$, $p=0.006$); a statistically higher proportion of males accumulated at least 45 and 60 min/d MVPA.

When broken down by weight status, the mean min/d MVPA was higher for normal weight participants (50.53 min/d) than those in the overweight and obese category (45.41 min/d). Yet statistically, chi-square tests for independence indicated that weight status had no significant effect on those accumulating at least 30min/d, 45 min/d and 60 min/d of MVPA.

Table 8.3 (see below) shows the correlations among types of screen time activities, overall screen time, PA and BMI by gender. Male BMI scores showed a weak but significantly positive correlation with playing computer games only ($r = .20$, $p <0.05$). Among females, time spent in MVPA showed a significant medium negative correlation with daily television viewing only ($r = -.35$, $p <0.05$).

Finally, standard multiple regression was used to assess the ability of gender, PA and overall screen time to predict adolescent levels of BMI. After the entry of these variables, the model revealed that no significant interaction was apparent.

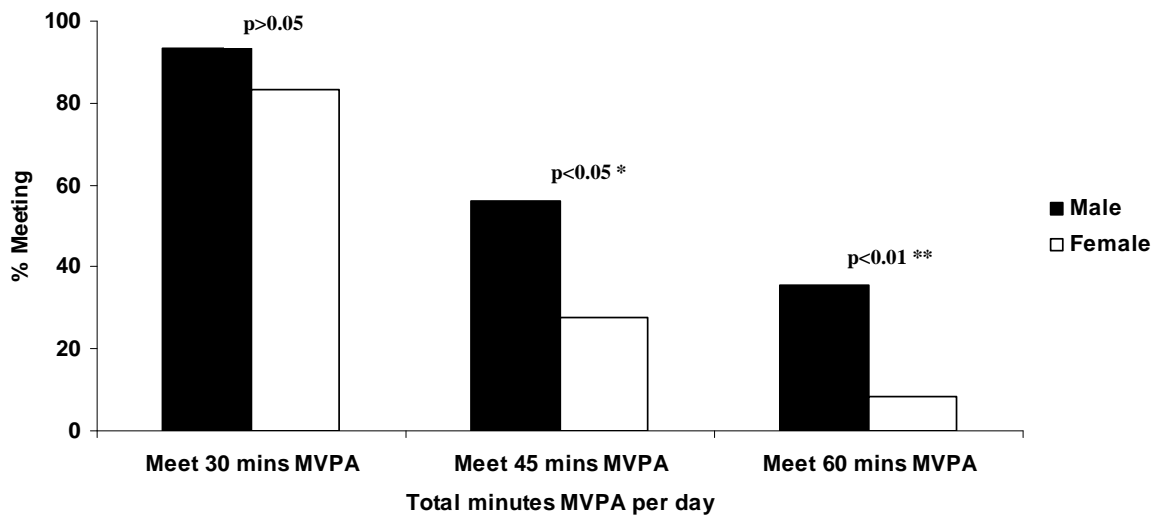


Figure 8.2 Percentage of male and female participants meeting 30 to 60 minutes MVPA per day

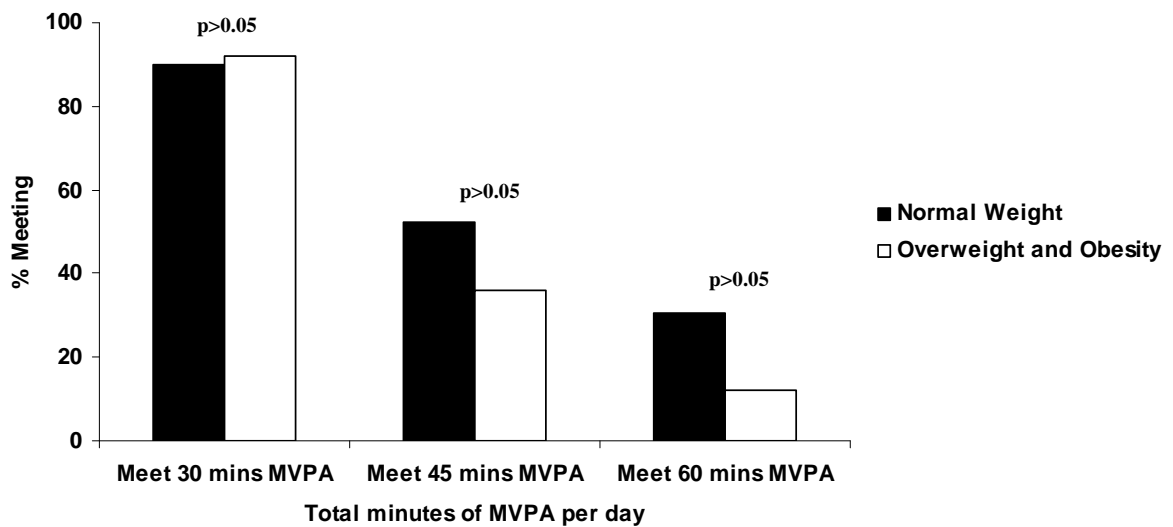


Figure 8.3 Percentage of normal weight and overweight/obese participants meeting 30 to 60 minutes MVPA per day

Table 8.3 Coefficients for correlations among types of screen time activities, overall screen time, PA and BMI scores according to gender

Correlations Variables	Daily Television Viewing	Daily Video Games	Daily Computer Usage	Overall Screen Time
<i>Male</i>				
<i>Moderate PA p/day</i>	.021	-.211	.042	-.016
<i>Vigorous PA p/day</i>	-.062	-.227	-.101	-.126
<i>MVPA p/day</i>	-.031	-.211	-.051	-.072
<i>BMI scores</i>	-.077	.201*	.018	.087
<i>Female</i>				
<i>Moderate PA p/day</i>	-.260	.274	-.004	-.088
<i>Vigorous PA p/day</i>	-.341	.259	.127	-.084
<i>MVPA p/day</i>	-.348*	.330	.081	-.087
<i>BMI scores</i>	.041	-.168	.028	.034

Note. **p/day** = per day; **PA** = physical activity; **MVPA** = moderate to vigorous physical activity;
* $p \leq .05$.

8.5 Discussion

The present study examined if possible differences in gender, objectively measured PA participation and self-reported screen time varied according to weight status among 12 to 14 year olds. It further investigated if an overall interaction effect between daily MVPA, screen time and BMI was emergent among early adolescent youth.

Consistent with recent gender differences in adolescent PA literature (Eaton et al., 2012; O'Donovan et al., 2010; Woods et al., 2010), present findings indicate that adolescent males accumulate significantly more minutes of MVPA than females and are significantly more likely to meet the recommended PA guidelines for health. Conversely to these male PA results, the present study found that adolescent females accumulated significantly less minutes of daily video game usage than males. The finding of the present study compares to a similar study examining the relationship between sedentary activities and physical inactivity among adolescents (Koezuka et al., 2006), in which females accumulated substantially less video game time than males. This may in part be explained by the fact that traditionally video games are perceived to belong in the male domain (Heeter et al., 2004), which lends support to the tangible solution of replacing screen time with desirable recreational activities (Haywood and Getchell, 2009) for increased female PA participation.

It was interesting, yet unsurprising, to observe in the present study that an increase in weight status appeared to have a significant effect on minutes of daily screen time engagement. A recent prospective longitudinal cohort study (Hands et al., 2011) examining the associations between physical activity, screen time and weight status from 6 to 14 years of age found that the relationship between screen time and weight status existed from an early age. An early hypothesis by Robinson (2001) suggested that screen time behaviours such as television viewing cause obesity because they displace PA, increase calorie consumption and reduce resting metabolism. A recent study (Brug et al., 2012), similarly reports that the high screen time activities of European school children increases the likelihood of becoming overweight and/or obese. The present result implies that in order to regulate healthy weight status among early adolescents, interventions to reduce screen time are indeed warranted (Biddle, Cavill, et al., 2010).

Due to the cross-sectional design of the study, a cause-and-effect relationship between PA and screen time cannot be determined. For this reason, interpreting the result which

highlighted a significant negative relationship between female MVPA and daily television viewing (see Table 8.3) proves difficult. Recent evidence (Fakhouri et al., 2013) suggests that screen time viewing and PA have no association in elementary school children aged between 6 to 11 years old; it is argued, that both variables are separate constructs. However, the present result for female adolescents is consistent with a previous study (Robinson et al., 1993) in which it was shown that after-school television viewing was weakly negatively associated ($r = -.086$, $p = .026$) with PA levels among adolescent females. While the association found in the present study was slightly stronger ($r = -.348$, $p < .05$), the result is difficult to interpret from a female perspective only. This female finding between MVPA and daily television viewing cannot be dispelled; further research is warranted in order to counter the compelling evidence reported in previous studies (Biddle et al., 2004; Fakhouri et al., 2013) that PA and sedentary behaviour are unrelated (De Bourdeaudhuij et al., 2012).

Finally, no overall interaction effect was found between daily MVPA participation and screen time in the prediction of early adolescent BMI in the present study. This finding contradicts a recent study among 10 to 12 year old males and females in Europe (De Bourdeaudhuij et al., 2012), whereby it was found that higher bouts of MVPA and less engagement time within sedentary behaviour were associated with a healthier weight status. Findings of the present study can be compared to a recent study by Basterfield et al. (2012) who also found no significant association when assessing the relationships between 2- year changes in objectively measured PA, sedentary behaviour, and BMI in a younger cohort of 7 to 9 year old children. Equally, previous other cross-sectional and longitudinal studies (Mitchell et al., 2009; Steele et al., 2009) have found non-significant associations between PA, sedentary behaviour and BMI. Findings lend support to the argument that adolescent sedentary behaviour may now be the other side of the coin (Marshall et al., 2002), unrelated and independent of PA.

Limitations / Strengths

Limitations of the current study include the relatively low proportion (due to noncompliance) of participants with accelerometer data sets meeting the inclusion criteria. Furthermore, while simple non-invasive height and weight anthropometric measures were undertaken by trained field staff to determine adolescent weight status, the use of BMI as an indicator of weight status may also be considered a limitation. Had an alternative measure such

as a fat mass index been used, researchers may have been able to derive additional information regarding body compartmental fat mass in adolescents (Steele et al., 2009).

A major strength of this study was the rigorous assessment of adolescent PA behaviour via accelerometry, and the use of stringent and widely endorsed inclusion criteria (Esliger et al., 2005; Gorely et al., 2009; Nyberg et al., 2009). To gather information on sedentary behaviour authors investigated multiple screen time behaviours as a combination marker for health risk (Marshall et al., 2002). A recent study (Biddle et al., 2009) highlighted how examining television viewing only, appears to be an unrepresentative marker of sedentary behaviour in adolescents, thus the present study went beyond the prevalence of television viewing in an attempt to understand this complex behaviour.

8.6 Conclusion

This article extends the relationship debate between adolescent PA, screen time and weight status. Findings imply that collectively the variables of MVPA participation and screen time have little or no effect in the prediction of BMI which corresponds to some recent evidence (Biddle, Cavill, et al., 2010). The present finding lends support to previous studies which found no association between adolescent sedentary behaviour and PA (Ekelund et al., 2006; Mutunga et al., 2006) highlighting that both variables can be regarded as being independent to some extent. Despite these results, recent recommendations suggests that it is prudent to further examine whether sedentariness displaces PA (Rey-López et al., 2008). While causality cannot be inferred from these data, results do suggest the importance of reducing screen time in the contribution towards a healthier weight status among adolescents; this finding corresponds with previous studies (De Bourdeaudhuij et al., 2012; Hands et al., 2011). The existing relationship for females found in this study between MVPA and time spent television viewing is of some importance. Consistent with recent findings (Oliver et al., 2012), it seems plausible that females may benefit most from interventions simultaneously focusing on a decrease in television viewing and the promotion of daily MVPA. In line with most recent recommendations (Brown et al., 2013), future strategies promoting youth PA should statistically examine the mediating effects of interventions for the most effective implementation of programmes.

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Chapter 9

Conclusions and Future Directions Y-PATH

9.1 Overview of Thesis

The Y-PATH research study was an exploration into the design, development, implementation and evaluation of a whole school PE based PA intervention for Irish adolescent youth. The Y-PATH research is a response to the recently documented low levels (self-report and accelerometer) of adolescent PA participation (Aibar et al., 2012; Currie et al., 2012; Eaton et al., 2012; Troiano et al., 2008) worldwide. In an Irish context, these low levels of PA participation are consistent with the literature, with only 12% of 12 to 18 years olds reporting to meet the PA guidelines for health (Woods et al., 2010). In a first step to address these alarming low levels of youth PA participation, a feasible, cost efficient and sustainable exploratory intervention (Y-PATH) trial was carried out in Ireland from 2011 to 2012.

Much research for youth PA promotion suggests that multi-component interventions are most effective (Perry et al., 2012; Salmon et al., 2007; Van Sluijs et al., 2008) with quality PE providing an opportunity to increase overall PA among youth (European Commission et al., 2013; Masurier and Corbin, 2006; McKenzie and Lounsbery, 2009; Physical Activity Guidelines Advisory Committee, 2012). The structure of the Y-PATH intervention was guided by the literature evidence gathered from previously successful school-based interventions amongst young people (Kalaja et al., 2012; McKenzie et al., 2009, 2004; Pate et al., 2005; Sallis et al., 1997; Stevens et al., 2005).

Chapter 3, the first study in this thesis, contextualised the development of the Y-PATH intervention for Irish adolescent youth. Within this chapter, the evidence and background to the development of the Y-PATH intervention is given. Findings from the baseline data which informed the development of the intervention, included low levels of adolescent PA, insufficient levels of FMS proficiency, and substantial differences in self efficacy, attitude towards PA, perceptions of health, and barriers to participation amongst the inactive participants. This opening study reinforced the need for a specifically tailored adolescent PA intervention. From these specific baseline findings, the Y-PATH intervention was constructed based on the YPAP theoretical framework (Welk, 1999).

Chapter 4 was a particularly novel examination of adolescent FMS proficiency from baseline data. With many studies now reporting positive associations between FMS and PA in young people (Barnett et al., 2011, 2009; Fisher et al., 2005; Hume et al., 2008; Okely et al., 2001; Wrotniak et al., 2006), chapter 4 examined the overall levels of FMS proficiency amongst

Irish adolescents prior to the Y-PATH intervention. This chapter was a distinctive examination of FMS at the behavioural component level whereby weaknesses within performance across individual skills were identified. Findings indicated a basic deficit in movement competency across many skills relating to crouching actions, foot landing, hand-eye coordination, contra lateral and bilateral arm/leg movements.

Chapter 5 provided a detailed insight into the contextual overview of the Y-PATH intervention, namely the student, parent/guardian, teacher and website components. This chapter laid the foundations for the overall evaluation of Y-PATH, as described in chapter 6. Chapter 5 introduced the reader to the originality of the Y-PATH intervention; *'specific educational focus on moving PE from being associated with a specific mode or sport, to being associated with learning to be active.'* A clear focus of this chapter was to highlight the positive role of simultaneously targeting health related activity (HRA) and FMS within the PE environment. By documenting each pillar associated with Y-PATH, the reader was provided with an overview of this multi-component intervention.

Chapter 6 evaluated the Y-PATH intervention effect after 9 months (end of academic school year) and 12 months (follow-up) amongst an Irish adolescent cohort aged 12 to 14 years of age. The study involved one mixed gender intervention group who received the Y-PATH intervention over the course of one school year (2011 to 2012), and one mixed gender control group who received their usual PE programme for the same period without any researcher input or influence. It was encouraging to observe through our results that over the year of the intervention, there was an increase in the intervention group's participation in daily MVPA. Furthermore, a significant improvement in overall gross motor skill acquisition for those exposed to the prescribed FMS climate during PE relative to their control counterparts was detected. This preliminary Y-PATH trial provides support for the simultaneous integration of HRA and FMS during PE classes amongst Irish adolescents. Yet, as is acknowledged and discussed in chapter 6, the relatively small sample size within the two mixed-gender schools must be considered a limiting factor when interpreting these findings. In addition, it is recognised that while preliminary research findings may be valid in the rural Irish adolescent setting, without further intervention examination, these results must be interpreted with caution. For these reasons, a definitive randomised controlled trial (RCT) with a larger sample is recommended to confirm results.

Finally, two cross-sectional chapters (7 and 8) examined issues relating to the ‘unprecedented’ rise in the prevalence of youth overweight and obesity levels (Al-Nakeeb et al., 2007; Lobstein et al., 2003; Murray et al., 2013; Wang and Lobstein, 2006). Both chapters represent critically important pieces of research in further interpreting the complex behaviour of adolescent PA. Chapter 7 determined if a potential relationship between PA, FMS and weight status existed amongst early adolescent youth. Results of this study specifically highlighted the need to address basic movement skills at an earlier age during PE in order to undertake preventive measures for combating obesity amongst young people. Chapter 8 investigated the relationship between PA participation, overall screen time and weight status amongst 12 to 14 year olds. Results from this closing chapter suggested the importance of reducing screen time in the contribution towards a healthier weight status among adolescents. It was interesting to observe in chapter 8 that PA appeared largely unrelated to overall screen time in predicting adolescent weight status; a stimulating and thought provoking suggestion towards the end of this study was that these variables (PA and sedentary behaviour) may be independent markers of health in youth (Marshall et al., 2002; Mitchell et al., 2009; Steele et al., 2009).

9.2 Y-PATH Research Strengths

Results from this thesis, specifically chapters 3 to 8 have introduced the reader to a vast array of themes amongst early adolescent youth, namely PA promotion, FMS proficiency, overweight/obesity, sedentary behaviour, effective intervention design/ development and the importance of research innovation. While the Y-PATH research programme was not absent of shortcomings (which will be discussed later), there is strong evidence presented that the design, development, implementation and evaluation of the Y-PATH intervention was based on meticulous research considerations.

One of the most immediate strengths of the Y-PATH research programme has been the use of practical measurement tools, guided by the literature for the measurement of adolescent PA levels (Troost, 2007). For the purpose of this school-based research, the Y-PATH team have integrated both subjective and objective PA measurement techniques (Kohl et al., 2000; Trost, 2007) in order to obtain a detailed, representative insight into the habitual levels of adolescent PA. Specifically, the use of the YPAQ self-report measurement (Corder et al., 2009), previously validated amongst 12 to 13 year olds against accelerometry ($r=0.42$, $p<0.5$) was an effective instrument in gathering MVPA data, and providing important information relating to the type of activity participated in. The use of ActiGraph accelerometer devices (GT1M and GT3X) (De Vries et al., 2006; Freedson et al., 2005; Trost, 2007; Trost et al., 2002), provided contextually rich information pertaining to PA intensity, duration and frequency. Furthermore, the use of stringent inclusion criteria for the accelerometer data (minimum wear time, non-wear periods, cut points etc) as guided by the literature (Esliger et al., 2005; Gorely et al., 2009; Rowlands et al., 2008; Trost et al., 2011) ensured strength within our PA methodology.

Another key strength within the Y-PATH study design was the use of qualitative research, specifically the information obtained from the adolescent focus groups (Bauer et al., 2004; Merriam, 1998; Wilson et al., 2005) during baseline data collection. These focus groups allowed the Y-PATH research team to collect rich meaningful data, specifically relating to participants perceptions of health. It was important that this data was analysed as a guiding platform for the intervention, particularly influencing the emphasis which was placed on HRA within the PE component of Y-PATH.

A unique component of this research programme in the Irish adolescent context was the consistency and scientific rigor within FMS data collection. A core element of this intervention,

as guided by the YPAP model (Welk, 1999) was to enable skill development and competency amongst adolescent youth. Since the beginning of FMS data collection in 2010, the Y-PATH research team have continued to collect reliable data using consistent protocol guided by previously successful FMS methodology worldwide (Barnett et al., 2009; Hardy et al., 2010; Hume et al., 2008; Mitchell et al., 2013; Okely and Booth, 2004). As this exploratory trial approaches its final stage, the Y-PATH research team have access to FMS data across 15 types of skills (kick, strike, vertical jump and run etc) on over 400 adolescents aged 12 to 14 years of age.

When we acknowledge the strong research considerations for all the variables within this study (PA, FMS, BMI, focus groups and psychological data), it is important to note that a novel and innovative (Narayan et al., 2013) intervention was designed and developed for the Irish context. A thorough examination of the evidence-based literature was completed to inform decisions on the Y-PATH research. A significant strength of this multi-component Irish adolescent PA intervention has been the simultaneous integration of HRA (McKenzie et al., 2004; Pate et al., 2005; Sallis et al., 1997; Stevens et al., 2005) and FMS (Kalaja et al., 2012; Mitchell et al., 2013; Van Beurden et al., 2003) during PE class (McKenzie and Kahan, 2008; McKenzie and Lounsbery, 2009).

Subsidiary to the primary objectives of this longitudinal pilot intervention programme, this thesis also examined the rising prevalence of overweight and obesity amongst young people (Arora et al., 2012; Department of Health and Children, 2005; Lobstein et al., 2003; Ogden et al., 2012; Wang and Lobstein, 2006). Prior to discussing the future directions of the Y-PATH research programme, it is important to note that the pilot phase of this exploratory trial had some limitations, many beyond the control of the researcher; these will be discussed in the next section.

9.3 Y-PATH Research Limitations

1. *Physical Activity Accelerometry:* During baseline data collection in 2010, a sub sample of participants (n=117) wore either Actigraph GT1M or GT3X accelerometers for a period of 9 days in order to provide an objective measure of habitual PA participation; however, due to a firmware malfunction with the Actilife software, a large amount of the collected accelerometer data was lost and subsequently omitted from the baseline data analysis.
2. *Physical Activity Inclusion Criteria:* The stringent inclusion criteria (wear time, number of weekdays and weekend etc) was a strength of the accelerometer analysis during the Y-PATH intervention (2011-2012). This stringent inclusion criteria was applied in order to obtain a detailed, representative pattern of objectively measured habitual adolescent PA behaviour. While this is a significant strength of the study, these decisions had an adverse effect on the number of participants with fully available accelerometer data for inclusion at each time point.
3. *Physical Activity Compliance:* Participant compliance in wearing the accelerometers was a limitation of this study during all phases of data collection. While many strategies were implemented to increase the number of participants wearing the accelerometers (reminder text messages sent each morning and afternoon, principal investigator of the Y-PATH research team present each school morning to check monitor wearing etc), a substantial amount of data was lost to due to non-compliance. Further research is warranted to determine the most effective strategies for accelerometer compliance in adolescents.
4. *Fundamental Movement Skills:* The use of the TGMD-2 instrument to measure FMS performance in 12-14 year olds can be perceived as a study limitation. The TGMD-2 is a criterion and norm referenced instrument designed to assess gross motor development among children aged between 3.0 to 10.11 years. It is a valid and reliable (test-retest reliability=0.88–0.96) process-orientated test which is used for FMS research (Ulrich, 2000), but has not as yet been validated with older age groups. Although this instrument is not specifically designed for youth over 10 years old, the purpose of this study was to obtain a measure of FMS proficiency in this population, not to make normative comparisons. A recently validated FMS tool for children and adolescents entitled 'Get Skilled Get Active' has many similar performance criteria across skills which can be comparable to the TGMD-2 instrument for FMS performance analysis.

5. *Sedentary Behaviour Measurement:* In chapter 8, sedentary behaviour is measured through the implementation of the YPAQ self-reported screen time instrument. This can be interpreted as a limitation due to the possibility of participants' inability to recall activities precisely. Although using self-report to measure screen time is consistent with the majority of published studies reporting on sedentary behaviour, an objective measurement may have provided a more robust surveillance of early Irish adolescent sedentary behaviour.
6. *Intervention Study Design:* Limitations of the study design were the minimum number of schools and participants involved in this exploratory trial (n=2). In terms of matching criteria, both schools were selected for inclusion based on geographical location and gender distribution; in terms of sample size, however, the control school was not an exact match to the intervention. Furthermore, due to circumstances beyond our containment, the control school received an additional 120 minute 'games class' per week in comparison to the intervention group.
7. *Intervention Fidelity and Process Evaluation:* While intervention adherence forms for PE teachers were designed at the beginning of the programme, they were not consistently monitored by the principal PhD investigator during the course of the academic school year. Information on intervention fidelity was collected, yet, these data were excluded from the analysis due to weaknesses within fidelity design. For September 2013's definitive RCT, the Y-PATH intervention will implement a robust surveillance of intervention fidelity as guided by the literature (MRC, 2008, 2000; Saunders et al., 2006) (including PE teachers, staff members, parents, community participants and students where possible).

9.4 Future Directions Y-PATH 2013

The Y-PATH pilot study as evaluated in chapter 6 was a quasi-experimental non-randomised controlled trial. Following the MRC (2000) framework (as discussed in chapter 1) for complex interventions, this research study has undertaken the theory (pre-clinical), modelling (phase 1) and exploratory trial (phase 2) phases of investigation in the evaluation of Y-PATH.

Following from the findings of the exploratory trial, it is important that the Y-PATH study progressively expands to the definitive randomised controlled trial (RCT) (Phase 3) in September 2013. This next phase will compare the fully-defined Y-PATH intervention to an appropriate control alternative using a protocol that is theoretically defensible, reproducible and adequately controlled with appropriate statistical power (MRC, 2000).

In terms of strengthening the Y-PATH intervention, an important recommendation is to expand the efficacy of the online resources, namely the website component and the social media resource of 'Facebook' to build in more motivationally tailored feedback for participants. Another area of the Y-PATH study that may need further development is the process of monitoring 'intervention fidelity', specifically when dealing with a larger sample size and selection of schools. An important recommendation for the RCT in September 2013 is to implement a consistent surveillance of intervention fidelity between schools, similar to previous PA intervention research amongst adolescents (Saunders et al., 2006).

Following from the research presented in this thesis, the following are this researchers recommendations for future directions:

- Evaluate the Y-PATH intervention within single gender post-primary schools following the completion of the RCT in 2014.
- Expand the Y-PATH intervention across the Irish Junior Cycle PE programme, ranging from 1st to 3rd year post-primary youth (12 to 15 years old).
- Validate the TGMD-2 instrument amongst an adolescent cohort for FMS assessment.

Since its inception in 2010, the aim of the Y-PATH research has been to:

“Develop an evidence-based intervention that will reduce inactivity and help improve the quality and quantity of PA among youth.”

Preliminary results of this exploratory trial indicate positive PA and FMS findings. The RCT roll-out in 2013 will further strengthen the generalisability of Y-PATH findings. If successful,

the end product will be a practical, sustainable and highly cost effective PA intervention that can be disseminated through schools (physical education teachers) across Ireland and internationally.

9.5 Closure – the Conclusion to this PhD Journey

In terms of the Y-PATH school-based PE intervention, the primary objective has been to increase total PA participation amongst Irish adolescents through a collaborative, whole school approach at post-primary level education. A recent research article by Alberga et al. (2013) outlined specific PA intervention lessons learned from overweight and obese young people. It was encouraging to observe that many of the conclusions in this study (Alberga et al., 2013) are comparable to the future development of Y-PATH:

The PA setting and context is important

- Physical activities should be varied and fun
- The role of the parent-guardian should be considered
- Individual, physical and psychosocial characteristics should be accounted for
- Realistic goals should be set
- A multidisciplinary approach should be taken
- Barriers should be identified early and a plan to overcome them developed
- The right message should be communicated

Recent research suggests that developing and maintaining physical literacy is a lifelong journey (Loitz, 2013). Physical literacy is a relatively new term that has come to light in recent years, specifically in terms of youth PA promotion (Quinn, 2013). While the term physical literacy has not been referred to during this thesis, I suggest that the future directions of Y-PATH consider the importance of this ‘hot’ topic:

“A disposition in which individuals have the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for maintaining purposeful physical pursuits throughout the lifecourse.” (Whitehead, 2010)

Developing physical literacy amongst Irish youth will take a combined effort from parents, schools, community recreation and sport (Quinn, 2013). It is a challenging process and requires careful planning and quality delivery, yet, Y-PATH can and should strive for physically literate Irish adolescents over time.

The unique and original component of the Y-PATH intervention has been the integration of FMS in a PE-based climate for adolescent youth. Preliminary results indicate positive

increases in overall gross motor skill proficiency within the intervention group, as compared to the control group. The well-informed opinion of Loitz (2013) suggests that the child is better positioned to be physically active during the teenage years through the acquisition of FMS. Much literature suggests that FMS can be learned at any age (Gallahue and Ozmun, 2006; Hardy et al., 2010; Haywood and Getchell, 2009; Stodden et al., 2009), yet, it typically takes more time and practice to develop FMS in adulthood, especially compared to the teenage years (Loitz, 2013). For these reasons, the Y-PATH focus on FMS, as a mechanism for PA increases, seems most relevant, and makes it difficult to refute the notion that people who are more physically literate are more likely to be active over time.

'When a person feels competent and skilled in fundamental movement skills and ABCs, it supports them in their work-related physical activity, their leisure-time physical activity and in all kinds of daily living activities.' (Loitz, 2013, p.4)

In summary, during the course of my 3 year PhD research study, I have observed and engaged in the tedious, complex and often unpredictable nature of PA intervention research. Data collection from 2010 to 2012 was undeniably the most important component in both my understanding and navigation of the research. Consistent protocol for storing the data has been crucial for efficient planning and retrieving the data without difficulty. The development of the Y-PATH intervention has been insightful in terms of critically reviewing the literature around the area. The overall research process for designing, developing, implementing and evaluating this pilot study has been challenging, unyielding, yet an ultimately fruitful learning experience.

This PhD research study has successfully ensured that the next stage of evaluation of the Y-PATH intervention can be carried out in September 2013 through the definitive RCT. In light of this overall thesis, my three closing statements are a true reflection on my 3 year research experience at Dublin City University:

1. *'Don't knock the weather. If it didn't change once in a while, nine out of ten people couldn't start a conversation.'*

(Kin Hubbard)

2. *'You have to know how to accept rejection and reject acceptance.'*

(Ray Bradbury)

3. *'Tell me and I forget, teach me and I may remember, involve me and I learn.'*
(Benjamin Franklin)

9.6 References

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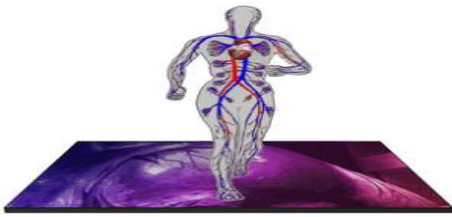
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Appendix A

Health-Related Activity Lesson Plans x 6

Y-PATH



Y-PATH


Youth – Physical Activity Towards Health



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

“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.

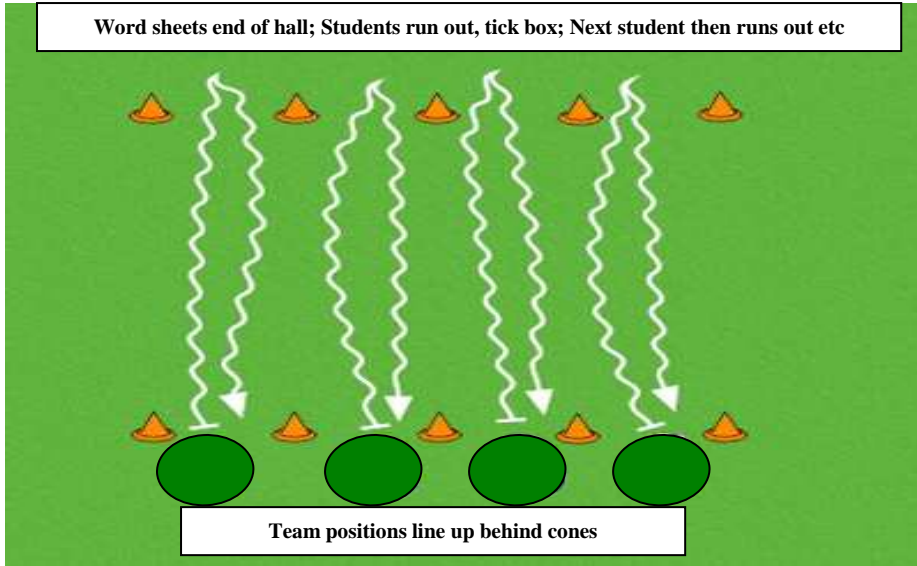
HRA Topic Lesson 1 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
<p>Health benefits of physical activity:</p> <ul style="list-style-type: none"> self esteem sense of well-being lifelong physical activity  <p>... that's active living !</p>	<p><u>Psychomotor:</u> Engage in a variety of physical activities specific to individual, pair and teamwork challenges.</p> <p><u>Cognitive:</u> Comprehend the importance of meeting the physical activity (PA) daily guidelines.</p> <p><u>Affective:</u> Participate in class discussions and show ability to problem solve collectively.</p>	<p><u>Warm Up (15 mins)</u> 1. Team Challenge – Word Run <i>Principles and Guidelines of PA taught – Progress Intensity.</i></p> <p><u>Development Stage 1 (10 mins)</u> 2. Rats & Rabbits or alternative. <i>PA is fun, enjoyable and helps student make friends.</i></p> <p><u>Development Stage 2 (20 mins)</u> 3. Students exposed to 3 mins each of individual, pair, team and sedentary activities. <i>Students explore different types of activities.</i></p> <p><u>Cool-Down (15 mins)</u> 4. Thematic expression: students express the number “60” on the ground followed by PA Journal week 1. <i>Students lower heart rate through group reflection.</i></p>	<p>Warm – Up: Teacher needs true / false statement sheet, word sheets & pencils/pens.</p> <p>Development Stage 1: Cones or court markings for boundaries in rats & rabbits.</p> <p>Development Stage 2: Cones to divide 4 zones into individual, pair, team and sedentary areas. Writing paper and sheets for sedentary task. Specific equipment for activities pending the teacher decision.</p> <p>Cool – Down: No equipment needed: maximum use of hall and space for final activity. PA journal week 1.</p>	<p>Teacher Assessment: Visually observe both child motor skill proficiency and activity engagement in lesson 1.</p> <p>Self-Assessment: Individual student must reflect upon content of lesson within the re-capitulation phases particularly during the cool – down activity.</p> <p>Peer Assessment: Students give feedback to each other during development stage 2 and the cool down activity.</p> <p>Homework: Fill out student physical activity journal week 1.</p>

**HEALTH RELATED ACTIVITY
LESSON 1**

School of Health & Human Performance Dublin City University

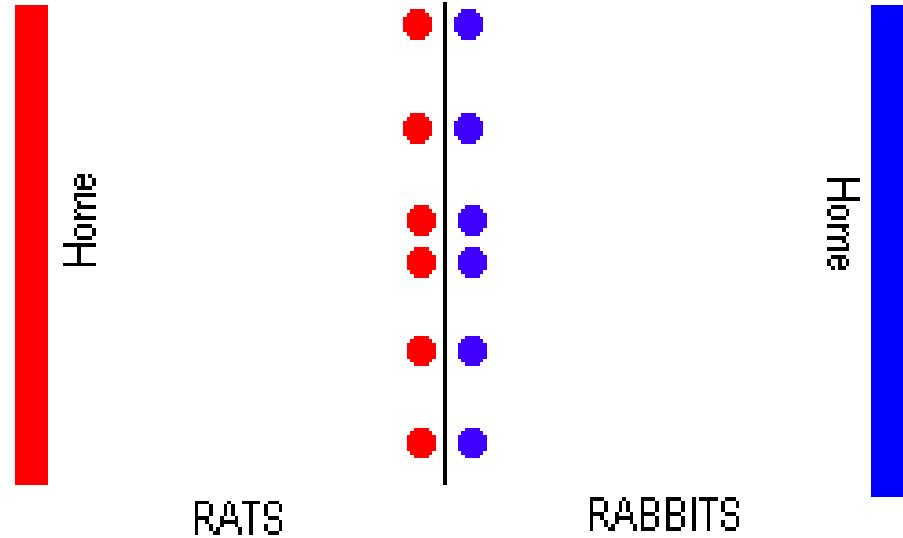
1. Team challenge: word run

“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

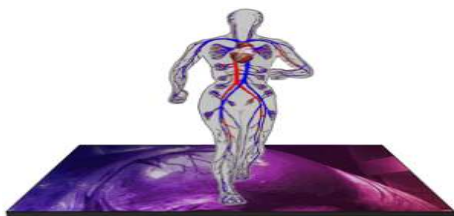
Students exposed to 3 minute activities including sedentary writing task



4. Thematic expression

Class challenge: represent number 60 on floor or alternative word if time





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Youth – Physical Activity Towards Health



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

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

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.

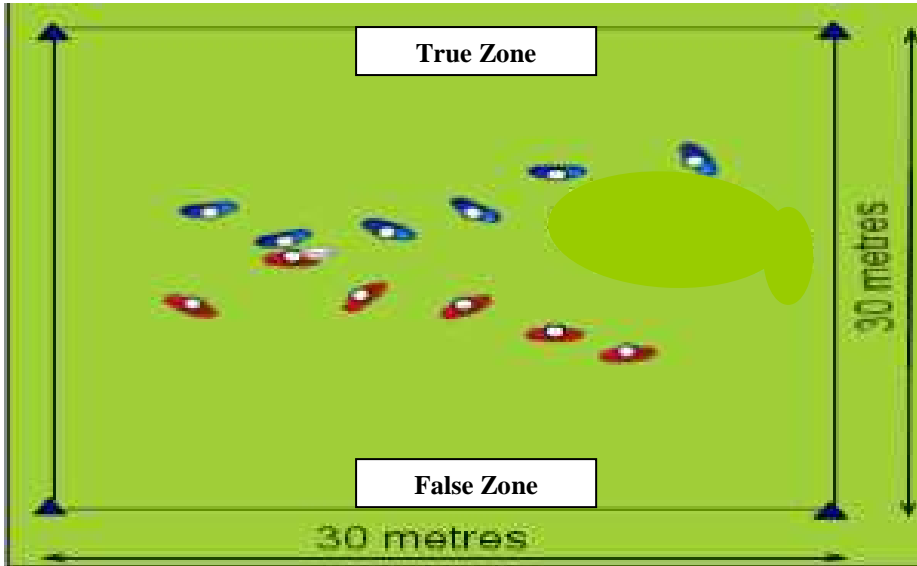
HRA Topic Lesson 2 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
<p>Health benefits of physical activity:</p> <ul style="list-style-type: none"> self esteem sense of well-being lifelong physical activity 	<p><u>Psychomotor:</u> Partake in a selected variety of physical activities specific to general exercises (jogging, jumping) and sport (basketball, dancing).</p> <p><u>Cognitive:</u> Recognise and appreciate that physical activity choice is specific to individual preference.</p> <p><u>Affective:</u> Conceptualise the importance of comradeship and teamwork within physical education; Respect individual choice within the physical activity environment.</p>	<p><u>Warm Up (15 mins)</u> 1.Moderate Dance Warm-Up True/false statements – zones. <i>Re – cap lesson 1 through activity.</i></p> <p><u>Development Stage 1 (10 mins)</u> 2.Students re-cap 5 key words & design fun body movement. <i>Task to express PA.</i></p> <p><u>Development Stage 2 (20 mins)</u> 3. Six stations – MVPA activities. Individual choice at each station – autonomous decision making. <i>PA highly individualised.</i></p> <p><u>Cool-Down (15 mins)</u> 4.Group Interaction – students given task card to perform. <i>Focus on variety within PA.</i></p>	<p>Warm – Up: Music player, cones for designating zone A (true) and zone B (false).</p> <p>Development Stage 1: 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.</p> <p>Development Stage 2: each station pending teacher decisions will have specific equipment – e.g. skipping ropes, benches, basketballs, footballs.</p> <p>Cool – Down: Task Cards with specific group performance – cater for 4 groups within the lesson (4 physical activity scenarios need to be set).</p>	<p>Teacher Assessment: Teacher question students understanding of previously acquired knowledge during re-cap phases : warm up and development stage 1</p> <p>Self-Assessment: Within this lesson, students are expected to make independent activity choices highlighting that physical activity is individualised : development stage 2</p> <p>Peer Assessment: Work collaboratively to re-cap during the pair work task within development stage 1</p> <p>Homework: Fill out student physical activity journal week 2.</p>

**HEALTH RELATED ACTIVITY
LESSON 2**

School of Health & Human Performance Dublin City University

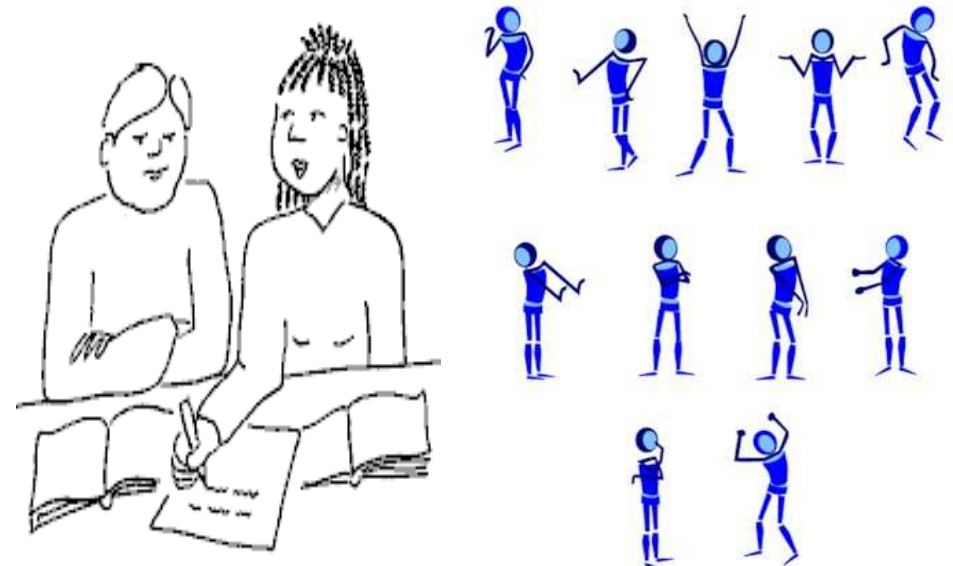
1. Moderate dance warm-up

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



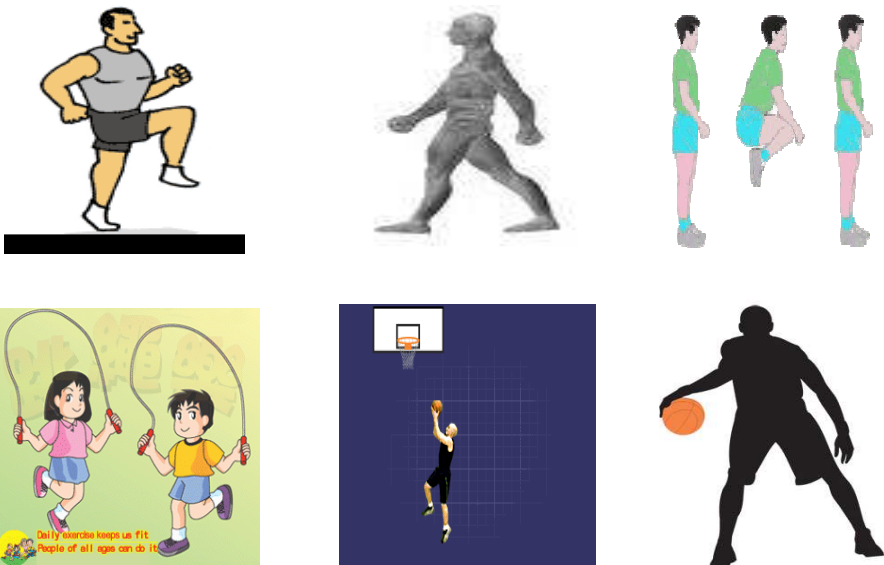
2. Re-cap & design fun body movement

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



3. Six stations – choice in physical activity

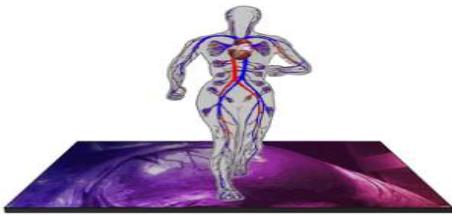
Students have an option at each station e.g. walk or run on the spot



4. Group interaction

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





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Youth – Physical Activity Towards Health

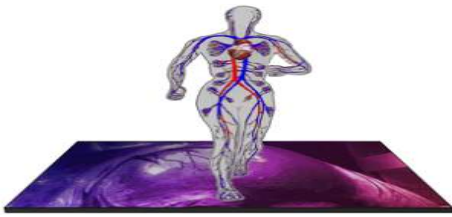


HEALTH RELATED ACTIVITY
LESSON 3
School of Health & Human Performance Dublin City University

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



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Youth – Physical Activity Towards Health



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

“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.

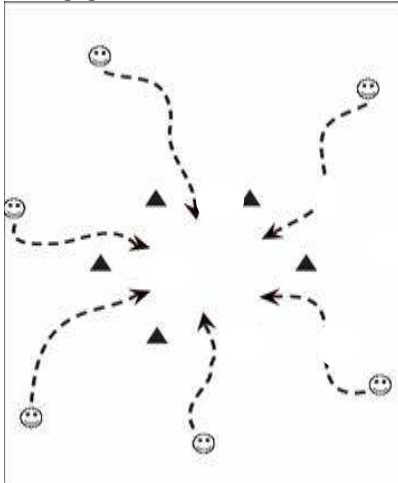
HRA Topic Lesson 4 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: heart increased heart rate Health related fitness: cardiovascular endurance flexibility physical education activities Warm-up and cool-down: distinction and purpose	<p><u>Psychomotor:</u> Perform static flexibility stretching exercises with an emphasis on the major muscle groups.</p> <p><u>Cognitive:</u> Identify the principle of endurance within activity: sustained and continuous period of activity.</p> <p><u>Affective:</u> Recognise individual differences associated with flexibility and cardiovascular endurance.</p>	<p><u>Warm Up (15 mins)</u> 1.Increased HR warm up Everybody’s It (x3) intensities 2.Flexibility – 8-10 secs stretch <i>Re-Cap HR intensity & introduce purpose of warm-up.</i></p> <p><u>Development Stage 1 (15 mins)</u> 3.Fun Game – Cannon Ball <i>Increase HR, teamwork & fun.</i> 4.Student re – cap: brainstorm questioning session on HR.</p> <p><u>Development Stage 2 (20 mins)</u> 5.Cardiovascular endurance – 4 activities x 3 minute duration Record HR after each activity <i>Long periods – continuous PA at 120-140 HR fat burning. **</i></p> <p><u>Cool-Down (10 mins)</u> 6.Walking game endzone ball 7.Flexibility – teacher led <i>HR & purpose of cool-down.</i></p>	<p>Warm – Up: Court markings needed for the boundaries within everybody’s it game. Task card prompts for major muscle group stretching. HR record sheet. Pencils/pens.</p> <p>Development Stage 1: Cannon ball activity requires 30 foam tennis balls. Whiteboard/ flipchart brainstorming re – cap. HR record sheet.</p> <p>Development Stage 2: The 5 stations may require skipping ropes, footballs, basketballs, music players, benches & steps. HR record sheet for students after each activity.</p> <p>Cool – Down: Endzone ball activity requires benches (x2), centre line of cones and foam balls (x10-15).</p>	<p>Teacher Assessment: Teacher will visually observe and monitor students control and technique of stretching during flexibility phases – warm up and cool down</p> <p>Self Assessment: Students will have to self evaluate and record their HR after each of the 4 CVE activities in development stage 2</p> <p>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.</p>

HEALTH RELATED ACTIVITY LESSON 4

School of Health & Human Performance Dublin City University

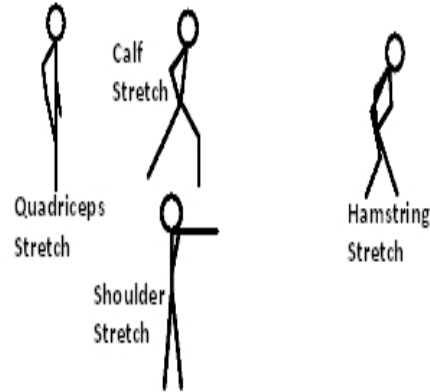
1 & 2. Warm-Up- increase HR activity & flexibility

Tag game to increase HR; teacher led stretching exercise



Everybody's it – tag game

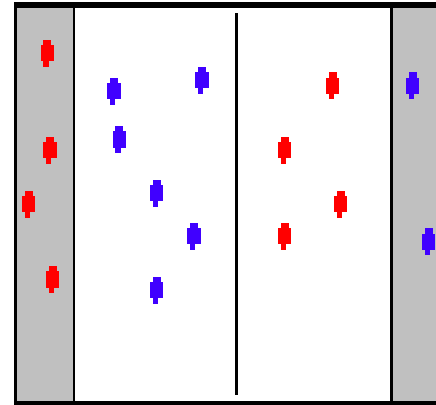
Examples of Static Stretches:



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 re-cap



Cannon ball- throw as many balls into opposing team zone as possible



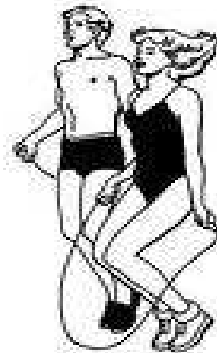
Brainstorm- teacher led re-cap lessons 1-4

5. Cardiovascular endurance activities

Students record HR after each of the 3 min CVE activities



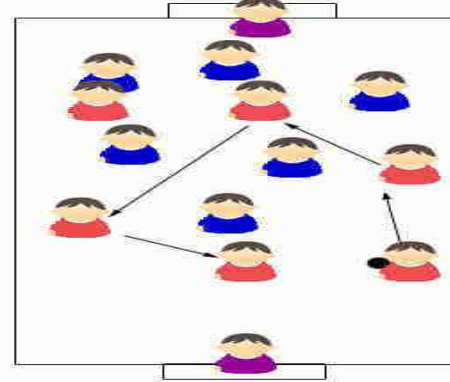
Dance aerobics 3 mins



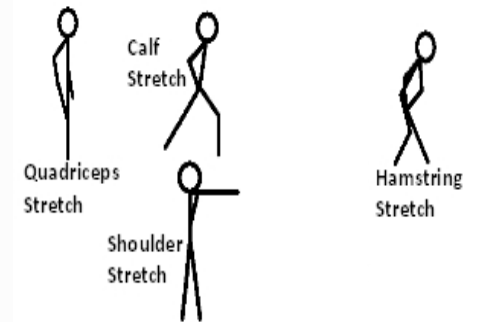
Skipping with or without rope 3 mins

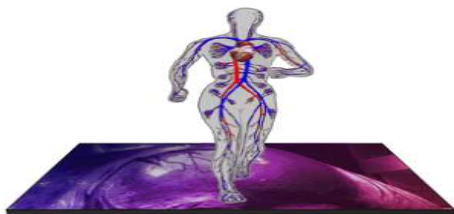
6 & 7. Cool Down – walking modified game & flexibility

Slow walking pace activity followed by teacher led cool down stretching



Examples of Static Stretches:





Y-PATH

Youth – Physical Activity Towards Health



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

“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”.

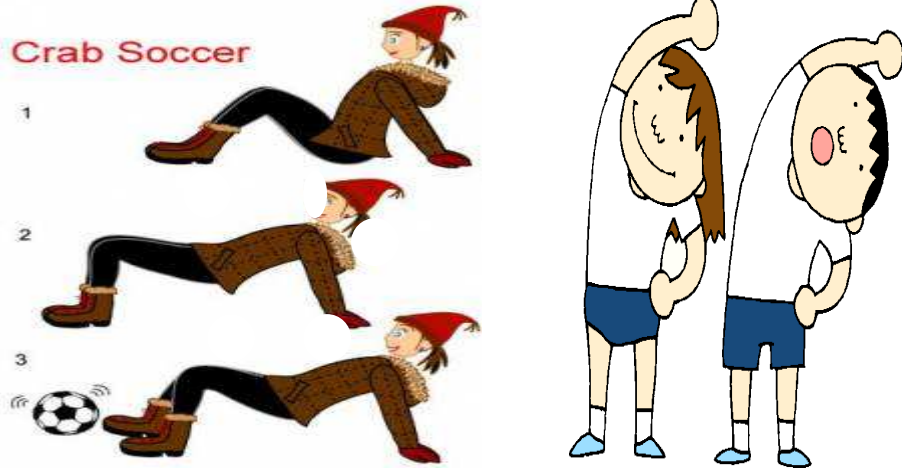
HRA Topic Lesson 5 60mins	Learning Outcomes	Class Structure & Content	Resources / Equipment	Assessment Strategy
Activity and the body: <i>heart</i> <i>increased heart rate</i>	<u>Psychomotor:</u> Engage in light and brisk walking movements; carry out the physical movements necessary to obtain the pre – determined goal of “100 steps per minute”	<u>Warm Up (15 mins)</u> 1.Crab soccer 2.Peer led stretching <i>pulse raise/reciprocal teaching</i>	Warm – Up: 2 separate courts for crab football games; Bibs to differentiate between teams; cones and increase number of sponge balls as required.	Teacher Assessment: Teacher will formally assess student ability to increase step count within the lesson (development stage 1 & 2).
Health related fitness: <i>flexibility</i> <i>physical education activities</i>	<u>Cognitive:</u> Apply the mathematical formula needed to calculate the average step count per minute based on the pedometer output.	<u>Development Stage 1 (15 mins)</u> 3.Pedometer introduction; demo& explanation teacher 4.Slow walk challenge 3mins <i>device introduction and arithmetic avg. step / min.</i>	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.	Self-Assessment: Students will attempt to calculate avg. step/min following completion of 3 min tasks (development stage 1 & 2).
Warm-up and cool-down: <i>distinction and purpose</i>	<u>Affective:</u> Experience success based on the completion of the pedometer step challenge and achievement of the target step count.	<u>Development Stage 2 (20 mins)</u> 5.Brisk walk, jog & run challenge – 3 mins per activity <u>Development Stage 3 (time**)</u> 6.Modified game – step count <u>Cool-Down (10 mins)</u> 7.Flexibility stretching in pairs <i>Peer work – reciprocal method</i>	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.	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.

**HEALTH RELATED ACTIVITY
LESSON 5**

School of Health & Human Performance Dublin City University

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 min light walking

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



How to wear and use device



3 min 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

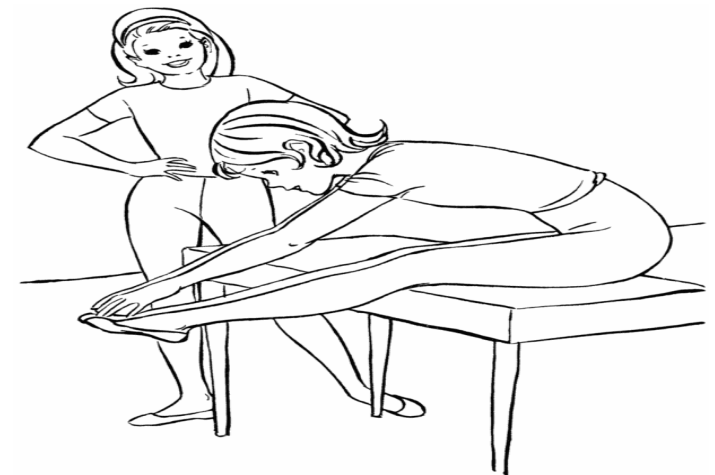
Moderate intensity = 100 steps per minute

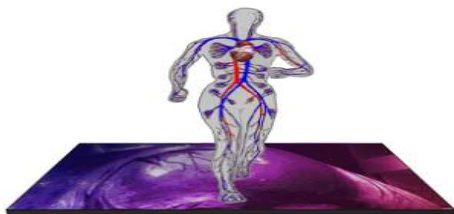


Average step count per minute and heart rate after different intensities

7. Cool Down – flexibility stretching with partner

Peer assessment – observe and correct stretching technique





Y-PATH

Youth – Physical Activity Towards Health



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

“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 will design 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 heart rate 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	<p><u>Psychomotor:</u> Participate in a variety of moderate to vigorous physical activities through individual and team based challenges.</p> <p><u>Cognitive:</u> Re-cap 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.</p> <p><u>Affective:</u> Demonstrate a positive attitude towards physical activity engagement. Experience success and feel included within the learning environment.</p>	<p><u>Warm Up (15 mins)</u> 1. Resting heart rate recorded 2. Pulse raiser: ladders or other 3. Self-led stretching <i>Re-Cap HR & warm-up.</i></p> <p><u>Development Stage 1 (15 mins)</u> 4. Individual challenge – 500 steps within 5 minute duration 5. Team challenge – Tank tracks carry gym mats overhead <i>HR, step count & PA benefits.</i></p> <p><u>Development Stage 2 (15 mins)</u> 6. Student Choice – Fun, inclusive game; student decide. <i>Well-being, self-esteem, heart.</i></p> <p><u>Cool-Down (15 mins)</u> 7. Peer-led stretching: teacher observes. Pupils brainstorm. <i>Summative HRE assessment.</i></p>	<p>Warm – Up: Cones set up boundaries for ladders game; pending teacher decision for pulse raiser equipment may vary. Worksheet for resting HR- pens/pencils.</p> <p>Development Stage 1: Pedometers x 30 for individual challenge, 2 x gymnastic mats for team challenge. Worksheet for HR and step count.</p> <p>Development Stage 2: Based on student enjoyment, desired activity chosen. 2 x playing areas for fun activity choices.</p> <p>Cool – Down: Brainstorming, 30 student worksheets Gold standard summary sheet at end of class to students.</p>	<p>Teacher Assessment: Teacher will formally assess students at end of 6 week HRE through prescribed brainstorming task during closing phase of lesson. <u>Teacher will collect sheet for grading.</u></p> <p>Self-Assessment: Individual challenge development stage 1. Identification of individual activity preference development stage 2.</p> <p>Peer Assessment: Peer stretching during cool-down.</p> <p>Homework: Fill out student physical activity journal week 6.</p>

**HEALTH RELATED ACTIVITY
LESSON 6**

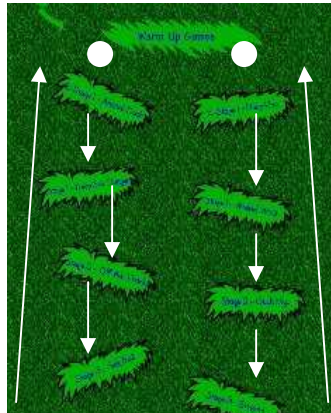
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1, 2 & 3. Resting heart rate, pulse raiser & flexibility

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



Resting HR recorded



Ladders: step over classmate legs

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



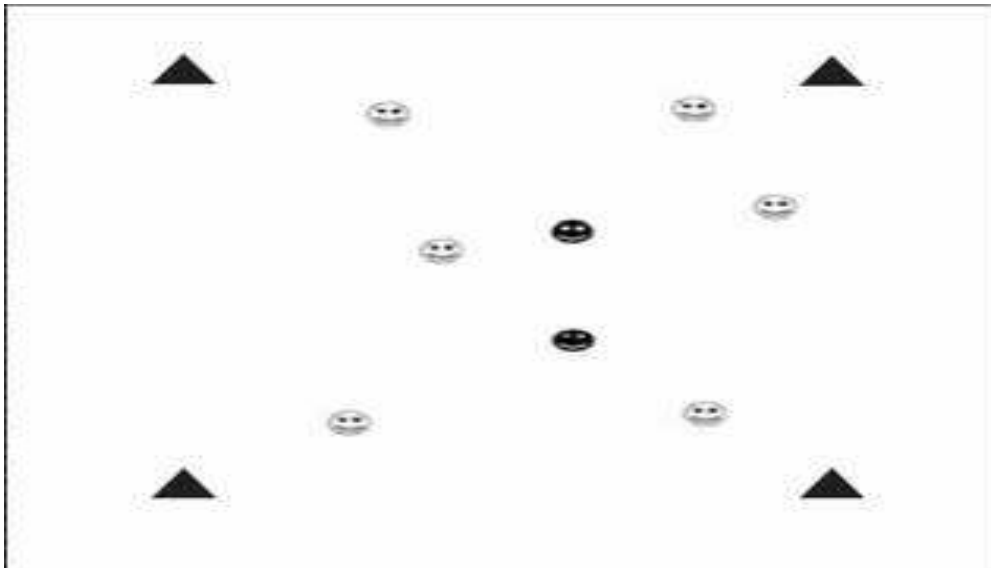
> 500 steps in 5 min timeframe



Team building activity – fun & inclusive

6. Student choice – record step count post activity

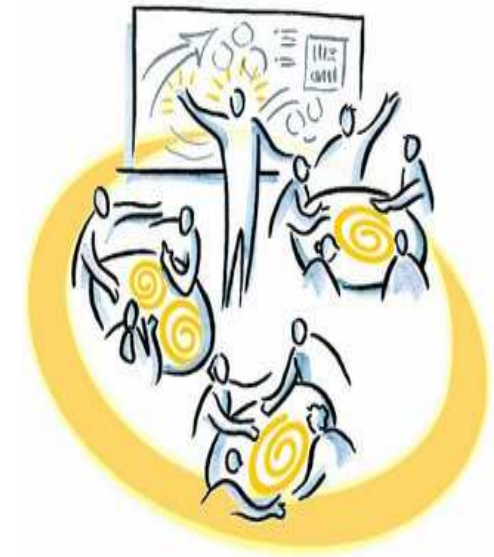
Culminating HRA activity – student enjoyment; step count & HR recorded



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

7. Cool Down – flexibility with partner & summative assessment

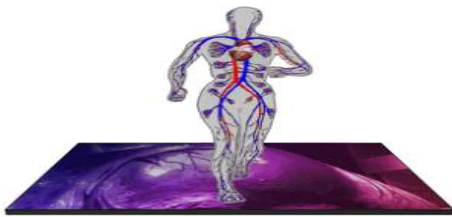
Peer assessment – observe and correct stretching technique



Student re-cap closure: brainstorm sheet

Appendix B

Health-Related Activity & Fundamental Movement Skills Integrated Y-PATH



Y-I-PATH

Youth – Physical Activity Towards Health



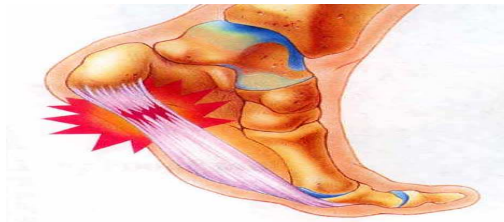
ADVENTURE ACTIVITIES
INTEGRATING HRA & FMS IN UNIT
School of Health & Human Performance Dublin City University

Health Related Activity Focus

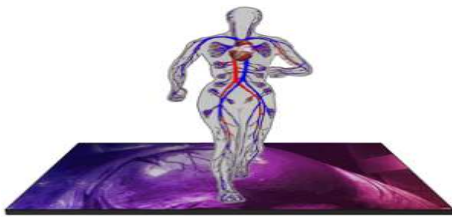
- 1. Meeting the daily 60 minutes guideline;
- 2. Exposure to individual and team-based activities;
- 3. Choice in the physical activity environment

Fundamental Movement Skill (FMS) Focus

- 1. Improving ability to crouch;
- 2. Improving ability to land on the balls of feet;
- 3. Improving co-ordination of arms and legs



<p style="text-align: center;">Example of activity 1: <i>60 min guideline and ability to crouch</i></p>	<p style="text-align: center;">Example of activity 2: <i>Forms of activity and landing on balls of the feet</i></p>	<p style="text-align: center;">Example of activity 3: <i>Choice in physical activity and co-ordination</i></p>
<p style="text-align: center;"><i>Leap Frog Tag & Blind Leap Frog</i></p> <ul style="list-style-type: none"> • Leap Frog Tag: Students play tag but from a crouched “frog-like” position. Blind-Folded Leap Frog: Student must reach the target based on fellow student directions. Teacher highlights the importance of meeting the 60 min guideline through a variety of daily physical activities. • FMS Skills: Horizontal and vertical jump addressed in this crouched action. Components of skip and run incorporated also. <p><u>Teacher Reflection:</u> Crouch skill addressed in this unit? Students aware of the 60 minute guideline?</p>	<p style="text-align: center;"><i>Individual & Team Orienteering</i></p> <ul style="list-style-type: none"> • Individual & Team Orienteering: Students participate in orienteering individually and as part of a team. Using the balls of the feet to sprint to the flag can integrate FMS in this lesson. • FMS Skills: Run and skip addressed through the balls of feet action. Components of both vertical and horizontal jump incorporated also. <p><u>Teacher Reflection:</u> Landing on balls of the feet addressed in this unit? Students aware of individual and team activities?</p>	<p style="text-align: center;"><i>Rock-climbing</i></p> <ul style="list-style-type: none"> • Choice in rock-climbing: Students introduced to rock-climbing - beginner and advanced choice in route. Arm and leg co-ordination inadvertently integrated in this adventure activity. • FMS Skills: Components of over-arm throw, skip, run and balance incorporated in arm/leg co-ordination. <p><u>Teacher Reflection:</u> Arm/leg co-ordination addressed in this unit? Students aware of choice in physical activity?</p>



YOUTH -PATH

Youth – Physical Activity Towards Health



AQUATICS
INTEGRATING HRA & FMS IN UNIT
School of Health & Human Performance Dublin City University

Health Related Activity Focus

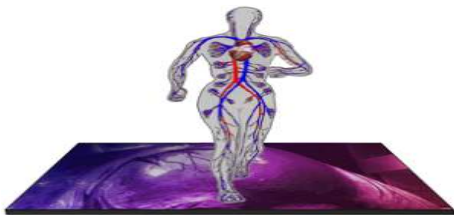
1. Meeting the daily 60 minutes guideline;
2. Exposure to individual and team-based activities;
3. Choice in the physical activity environment

Fundamental Movement Skill Focus

1. Improving ability to crouch;
2. Improving ability to extend arms;
3. Improving co-ordination of hand and eye



Example of activity 1: <i>60 min guideline and ability to crouch</i> <i>Aqua fitness – Water Aerobics</i>	Example of activity 2: <i>Forms of activity and extension of the arms</i> <i>Individual and Relay Swimming</i>	Example of activity 3: <i>Choice in physical activity and co-ordination</i> <i>Water Polo</i>
<ul style="list-style-type: none"> Water aerobics: Teacher incorporates crouching actions during water aerobics lesson. 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. 	<ul style="list-style-type: none"> Swimming Activities: Teacher addresses the component of arm extension in the freestyle swimming technique. 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. 	<ul style="list-style-type: none"> Water Polo: 2 x simultaneous games of water polo (fun and competitive) - student choice. Catching and over-arm throwing in water polo assesses hand/eye co-ordination. FMS Skills: The catch and over arm throw addressed during water polo game. Components of the run, skip and balance incorporated also.
<p><u>Teacher Reflection:</u> Crouch addressed in this unit? Students aware of the 60 minute guideline?</p>	<p><u>Teacher Reflection:</u> Extending arms addressed in this unit? Students aware of individual and team activities?</p>	<p><u>Teacher Reflection:</u> Hand/eye co-ordination addressed in this unit? Students aware of choice in physical activity?</p>



YOUTH -PATH

Youth – Physical Activity Towards Health



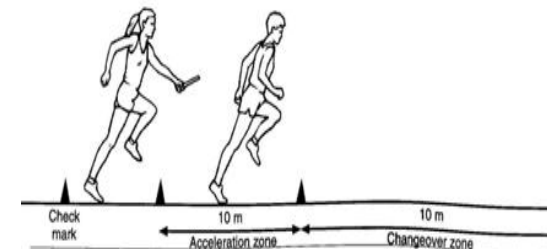
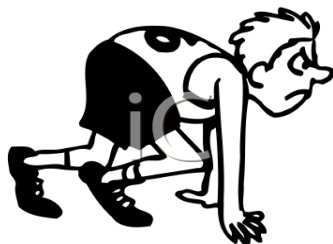
ATHLETICS
INTEGRATING HRA & FMS IN UNIT
School of Health & Human Performance Dublin City University

Health Related Activity Focus

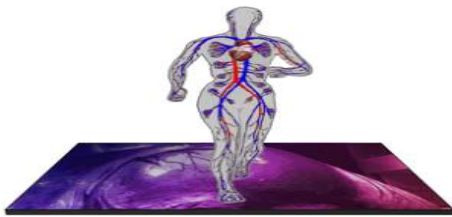
1. Intensity – moderate and vigorous;
2. Record heart rate (HR) – pulse taking
3. Step count increase - pedometers

Fundamental Movement Skill Focus

1. Improving ability to crouch and extend arms
2. Improving ability to land on the balls of the feet
3. Improving co-ordination of hand/eye & leg/arm



<p>Example of activity 1: <i>2 x Intensities, ability to crouch and extend arms</i> <i>Jogging and Sprinting</i></p>	<p>Example of activity 2: <i>Record heart rate and landing on balls of the feet</i> <i>Hurdles</i></p>	<p>Example of activity 3: <i>Increase step count and body co-ordination</i> <i>Relay-Running</i></p>
<ul style="list-style-type: none"> • Jogging and Sprinting: Address moderate and vigorous intensity in both types of activities. Heart rate can be recorded. Starting position technique of the sprint incorporates both the crouch and arm extension focus. • FMS Skills: Run addressed in this activity. Components of the over-arm throw (arm extend), horizontal & vertical jump incorporated also. <p><u>Teacher Reflection:</u> Crouch and arm extension addressed in this unit? Students aware of moderate/vigorous intensity?</p>	<ul style="list-style-type: none"> • Hurdles: Students record HR pre and post hurdles activity. Landing on the balls of the feet is a key skill component to be addressed when performing the hurdle jump. • FMS Skills: Run addressed in this activity. Components of skip (opposite arm/leg), horizontal and vertical jump (balls of feet) incorporated also. <p><u>Teacher Reflection:</u> Landing on balls of the feet addressed in this unit? Students able to record pulse pre/post activity?</p>	<ul style="list-style-type: none"> • Relay-Running: Wear pedometer during relay running, record step count. Baton exchange focuses on hand/eye and arm/leg co-ordination. • FMS Skills: Run (leg/eye) addressed in this activity. Components of the catch, over arm throw (hand/eye) and kick (arm/leg) incorporated also during baton exchange. <p><u>Teacher Reflection:</u> Body co-ordination addressed in this unit? Students aware of step increase in relay run?</p>



YOUTH -PATH

Youth – Physical Activity Towards Health



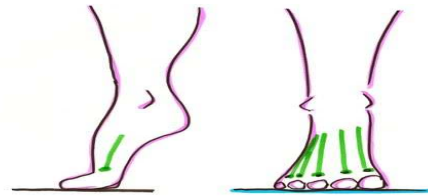
DANCE
INTEGRATING HRA & FMS IN UNIT
 School of Health & Human Performance Dublin City University

Health Related Activity Focus

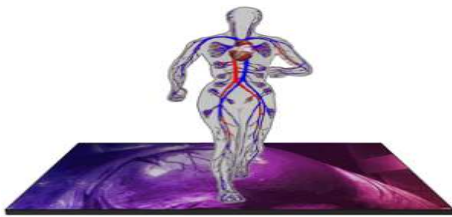
- 1. Cardiovascular endurance (CVE)
- 2. Flexibility
- 3. Intensity – moderate and vigorous

Fundamental Movement Skill Focus

- 1. Improving ability to crouch and extend arms
- 2. Improving ability to land on the balls of the feet
- 3. Improving co-ordination of leg and eye



<p style="text-align: center;">Example of activity 1: <i>CVE, ability to crouch and extend arms</i> <i>Dance Aerobics</i></p>	<p style="text-align: center;">Example of activity 2: <i>Flexibility and landing on balls of the feet</i> <i>“Cha Cha Slide” Routine</i></p>	<p style="text-align: center;">Example of activity 3: <i>2 x intensities, improving co-ordination leg and eye</i> <i>“Hip-Hop Sequence”</i></p>
<ul style="list-style-type: none"> Dance aerobics: Students engage in sustained and continuous periods (3 – 5mins) of dance aerobics. Crouch movement and arm extension included in aerobic routine. FMS Skills: Horizontal and vertical jump addressed in dance aerobic routine. Components of the balance and run also incorporated in routine. 	<ul style="list-style-type: none"> Cha cha slide: Flexibility addressed during warm up and cool down. This specific dance routine challenges students to land on the balls of their feet. http://www.youtube.com/watch?v=wZv62ShoStY FMS Skills: Components of run, skip, horizontal and vertical jump incorporated in this dance routine. 	<ul style="list-style-type: none"> Hip-hop: Moderate intensity introduction, then perform at vigorous intensity (with music). Heart rate can be recorded. Leg and eye co-ordination addressed in the step routine actions. <i>(Hip hop for beginners you tube routines.)</i> FMS Skills: Components of kick and balance actions incorporated in the hip-hop routine
<p><u>Teacher Reflection:</u> Crouch and arm extension addressed in this unit? Students aware of cardiovascular endurance?</p>	<p><u>Teacher Reflection:</u> Landing on balls of the feet addressed in this unit? Students conscious of flexibility component?</p>	<p><u>Teacher Reflection:</u> Leg-eye co-ordination addressed in this unit? Students aware of moderate/vigorous intensity?</p>



YOUTH -PATH

Youth – Physical Activity Towards Health



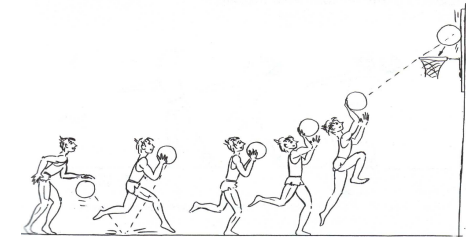
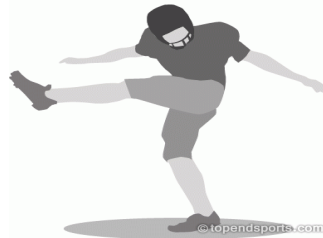
INVASION GAMES
INTEGRATING HRA & FMS IN UNIT
 School of Health & Human Performance Dublin City University

Health Related Activity Focus

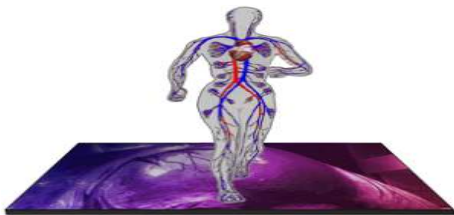
- 1. Increased Heart Rate (HR)
- 2. Physical activity – well being/self - esteem
- 3. Flexibility

Fundamental Movement Skill Focus

- 1. Improving co-ordination of arm / leg
- 2. Improving co-ordination of leg / eye
- 3. Improving co-ordination of hand/eye



<p>Example of activity 1: <i>Increase HR and co-ordination arm / leg</i> <i>Hockey Indian Dribble</i></p>	<p>Example of activity 2: <i>Health benefits of PA and co-ordination leg / eye</i> <i>Punt Kick Countdown</i></p>	<p>Example of activity 3: <i>Flexibility and co-ordination hand / eye</i> <i>Basketball Lay-Ups</i></p>
<ul style="list-style-type: none"> • Hockey: Possession games x 2 (light and moderate intensity). Record HR after each game. Focus on Indian dribble assesses student ability to co-ordinate opposite arm/leg and hand/eye. • FMS Skills: Components of balance, bounce and strike incorporated in the co-ordination of this skill. <p><u>Teacher Reflection:</u> Arm/leg co-ordination addressed in this unit? Students aware of increase in HR with intensity?</p>	<ul style="list-style-type: none"> • Countdown: 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). Punt kick practice improves co-ordination of leg/eye. • FMS Skills: Kick and balance addressed in this punt kick routine. <p><u>Teacher Reflection:</u> Leg/eye co-ordination addressed in this unit? Students can identify benefits of PA participation?</p>	<ul style="list-style-type: none"> • Lay-ups: Teacher sets up competitive and fun lay-up activities – student choice. Flexibility addressed during warm up and cool down. Lay up focus improves co-ordination of hand / eye. • FMS Skills: Components of vertical jump, run, catch and bounce incorporated in this lay-up activity. <p><u>Teacher Reflection:</u> Hand/eye co-ordination addressed in this unit? Students conscious of flexibility component?</p>



Youth – Physical Activity Towards Health



NET & FIELDING GAMES
INTEGRATING HRA & FMS IN UNIT
 School of Health & Human Performance Dublin City University

Health Related Activity Focus

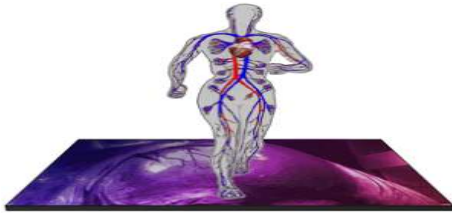
1. Meeting the daily 60 minutes guideline;
2. Individual and partner-based activities;
3. Physical activity – wellbeing/self-esteem

Fundamental Movement Skill Focus

1. Improving ability to crouch;
2. Improving ability to land on the balls of feet;
3. Improving ability to extend arms



<p style="text-align: center;">Example of activity 1: <i>Meet 60 mins and ability to crouch</i> <i>The Dig Volleyball</i></p>	<p style="text-align: center;">Example of activity 2: <i>Forms of activity and landing on the balls of feet</i> <i>Court positioning badminton</i></p>	<p style="text-align: center;">Example of activity 3: <i>Choice in physical activity and extend arms</i> <i>Over arm throw rounders</i></p>
<ul style="list-style-type: none"> • The dig pair work: 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. Crouched action needed to perform the volleyball dig successfully. • FMS Skills: Components of the strike, balance, horizontal and vertical jump incorporated in this volleyball skill. 	<ul style="list-style-type: none"> • Reaction game: Students respond to partner commands such as “right”, “left”, “forward” and “back”. Without racket initially, add in racket after few minutes. Objective – remain on the balls of the feet when on court (responsive and reactive). • FMS Skills: Balance and run addressed in this activity. Components of horizontal jump, vertical jump and skip incorporated also. 	<ul style="list-style-type: none"> • Target throwing: students have choice to use underarm or over arm throw to hit target on wall. Teacher promotes use of over arm throw for power and precision. Arm extension focus. • FMS Skills: Over arm throw skill addressed in this lesson. Components of balance and catch incorporated also.
<p><u>Teacher Reflection:</u> Crouch skill addressed in this unit? Students aware of the 60 minute guideline?</p>	<p><u>Teacher Reflection:</u> Landing on balls of the feet addressed in this unit? Students aware of individual and partner activities?</p>	<p><u>Teacher Reflection:</u> Arm extension addressed in this unit? Element of choice in physical activity?</p>



YOUTH -PATH

Youth – Physical Activity Towards Health



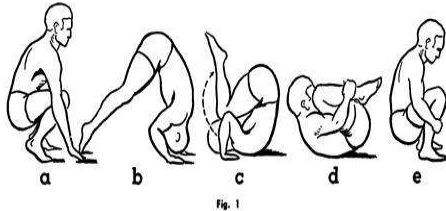
GYMNASTICS
INTEGRATING HRA & FMS IN UNIT
 School of Health & Human Performance Dublin City University

Health Related Activity Focus

- | | | |
|------------------------------|-----------------|--|
| 1. Cardiovascular Endurance; | 2. Flexibility; | 3. Choice in the physical activity environment |
|------------------------------|-----------------|--|

Fundamental Movement Skill Focus

- | | | |
|---------------------------------|--|--|
| 1. Improving ability to crouch; | 2. Improving ability to land on the balls of feet; | 3. Improving leg/eye and arm/leg co-ordination |
|---------------------------------|--|--|



Example of activity 1: <i>CVE and ability to crouch</i> <i>90 second gymnastics routine</i>	Example of activity 2: <i>Flexibility and landing on the balls of feet</i> <i>Springboard Landing</i>	Example of activity 3: <i>Choice in physical activity and co-ordination</i> <i>Balance on beam/bench</i>
<ul style="list-style-type: none"> • Gymnastics routine: Students work in groups and conduct a continuous 90 second gymnastics routine. Forward roll emphasis in routine performance (encourages pupils to conduct crouching action in starting position.) • FMS Skills: Balance, skip and run addressed in the routine performance. Components of horizontal and vertical jump incorporated also. <p><u>Teacher Reflection:</u> Crouch skill addressed in this unit? Students aware of cardiovascular endurance?</p>	<ul style="list-style-type: none"> • Springboard: Teacher introduces springboards to gymnastics lesson. All students opportunity to use equipment in class – landing on the balls of the feet from the spring. Flexibility addressed during warm up and cool down. • FMS Skills: Run, vertical and horizontal jump addressed in this activity. Components of balance and skip incorporated also. <p><u>Teacher Reflection:</u> Landing on balls of the feet addressed in this unit? Students conscious of flexibility component?</p>	<ul style="list-style-type: none"> • Beam/bench: Students have the option to walk, crawl, skip or jump etc on beam or bench. Use of beam and bench improves co-ordination of leg/eye when landing and opposite arm/leg when moving. • FMS Skills: Balance, run and skip addressed in this activity. Components of horizontal and vertical jump incorporated also. <p><u>Teacher Reflection:</u> Leg/eye and arm/leg co-ordination addressed in this unit? Element of choice in physical activity?</p>

Appendix C

Teacher Charter Physical Activity Promotion

Y-PATH

Coláiste Cill Mhantáin Physical Activity Promotion

In Ireland, **25%** of children are now classified as **overweight / obese**.

*In August 2011, **teachers** at Coláiste Cill Mhantáin identified **9 strategies** to increase physical activity amongst **students**:*

- Promote active commuting to and from Coláiste Cill Mhantáin: New **cycle track** in Wicklow Town for students.
- Use **pedometers** to record student daily and weekly step counts. These devices are available in the PE department.
- Implement and sustain fun physical activity **challenges** between **1st year** class groups.
- Use **physical activity** to enhance learning both within and outside the classroom (active **lesson** planning).
- Use of **stretching** during class time particularly during the intermittent period of a double class.
- Participate in school **hikes**: teachers can lead these excursions.
- Organise mini **physical activity tournaments** outside of school hours including both teacher and student participation.
- Encourage students to get involved in as many physical activities as possible. See the local **“directory”** in student journals, school posters or **online**.
- Staff involvement in physical activity during **lunch time**.



Appendix D

Teacher Questionnaire

Y-PATH

Y-PATH Questionnaire

Dear participant,

The following questionnaire is designed to gather information on the Y-PATH intervention. It is important to try to answer **ALL** 4 questions. Your answers are anonymous and confidential so try to answer all questions as honestly as you can. The questionnaire is easy to complete and takes about 5 minutes to complete.

Question 1:

Have you heard of the *Youth Physical Activity Towards Health* (Y-PATH) intervention programme?

Yes / No

If yes, can you tell me what you know of it:

.....
.....
.....

Question 2:

In the past 5 months at Coláiste Cill Mhantáin, have you in any way contributed to increasing physical activity amongst students?

Yes / No

If so, can you give some examples:

.....
.....
.....

Question 3:

Do you think teachers can play a role in increasing a student's physical activity behaviour?

If yes, what might this be:

.....
.....

If no, who might you recommend for this role:

.....
.....

Question 4:

In August 2011, the Y-PATH research team met with staff members and discussed strategies for teachers to increase physical activity amongst students. Can you list any of these strategies and possible actions taken?

List of strategies discussed	Actions taken
•	•
•	•
•	•
•	•
•	•
•	•

Appendix E

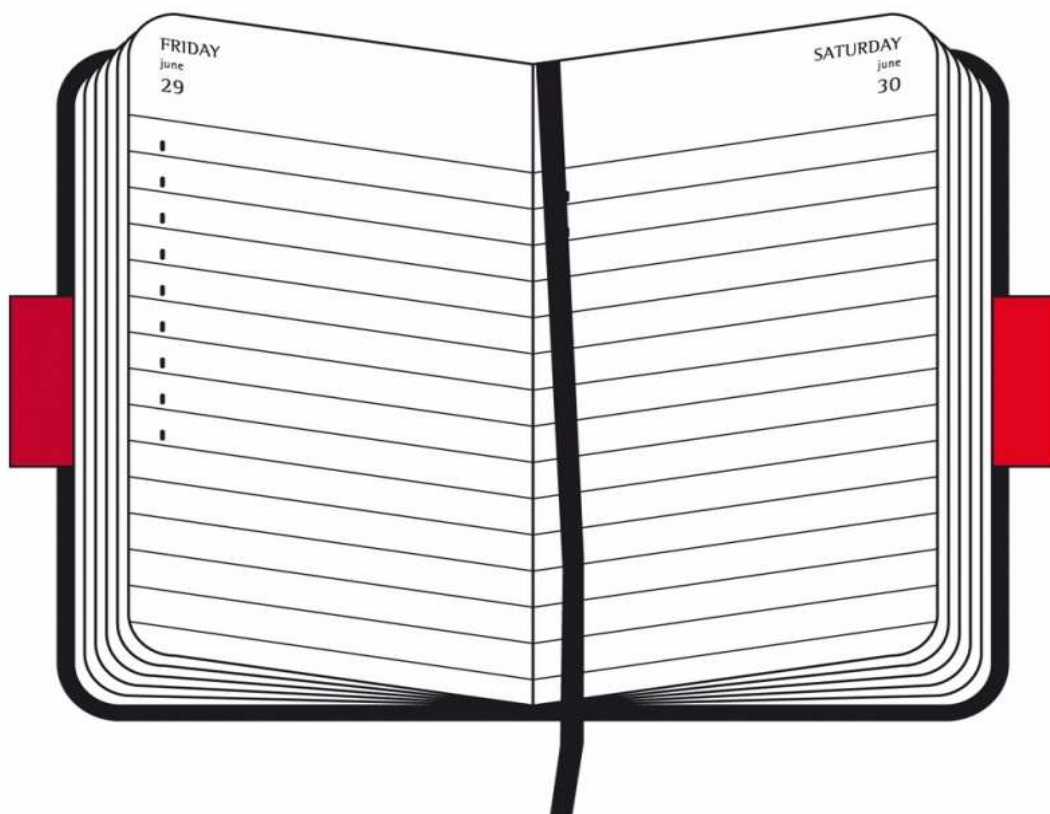
Student Physical Activity Journal

Y-PATH

Y-PATH

Youth – Physical Activity Towards Health

**1st Year Physical Activity Journal
September 2011 – May 2012
Coláiste Chill Mhantain**



Keep the journal in a safe and secure place



County Wicklow
Vocational Education Committee





Youth – Physical Activity Towards Health

Student Name:

1st Year Class:

Physical Activity Journal 1st Year

Each student is responsible for his/her own physical activity journal.

Write your name and class on the inside of this physical activity journal.

Remember fill in the physical activity journal when your PE teacher tells you to.

Content:

1. Health Related Activity PE: Weeks 1 – 6 (Sept-Oct)
2. November Physical Activity Journal
3. December Physical Activity Journal
4. January Physical Activity Journal
5. February Physical Activity Journal
6. March Physical Activity Journal
7. April Physical Activity Journal
8. May Physical Activity Journal
9. Physical Activity Directory
10. Physical Activity Advice

Sample Week: physical activity journal for the last 7 days

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
8:00am-9:00am	**Before School Walk to school 15 minutes	**Before School	**Before School Walk School 15 minutes	**Before School	**Before School Cycle School 10 minutes	**Weekend	**Weekend
9:00am-11:00am	School	School	School	School	School		
11:00am-11:15am	**Small Break	**Small Break	**Small Break Play basketball in yard with friends 10 minutes	**Small Break	**Small Break		
11:15am-13:00pm	School	School	School	School	School		Wash and Hoover the car 30 minutes
13:00pm-13:30pm	**Lunch Walk with friends 20 minutes	**Lunch Play football in yard 20 minutes	**Lunch	**Lunch Indoor school rugby training 25 minutes	**Lunch		
13:30pm-16:00pm	School	School	School	School	School	Rugby Match 70 minutes	
16:00pm-18:00pm	** After School Rugby training school 60 minutes	** After School	** After School Walk home from school 15 minutes	** After School	** After School Cycle home from school 10 minutes		
18:00pm-19:00pm		Wicklow U – 14's rugby training 60 minutes		Wicklow U – 14's rugby training 60 minutes		Cycle with friends around Wicklow 45 minutes	
19:00pm-20:00pm			Walk the dog with father 35 minutes		Cut the grass and hedges with brother 45 minutes		Walk the dog with father 35 minutes
20:00pm-21:00pm							

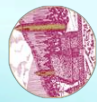
Week 1: Fill in your physical activity journal for the last 7 days

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
8:00am-9:00am	**Before School	**Before School	**Before School	**Before School	**Before School	**Weekend	**Weekend
9:00am-11:00am	School	School	School	School	School		
11:00am-11:15am	**Small Break	**Small Break	**Small Break	**Small Break	**Small Break		
11:15am-13:00pm	School	School	School	School	School		
13:00pm-13:30pm	**Lunch	**Lunch	**Lunch	**Lunch	**Lunch		
13:30pm-16:00pm	School	School	School	School	School		
16:00pm-18:00pm	** After School	** After School	** After School	** After School	** After School		
18:00pm-19:00pm							
19:00pm-20:00pm							
20:00pm-21:00pm							

Appendix F

Physical Activity Advocacy Posters

Y-PATH



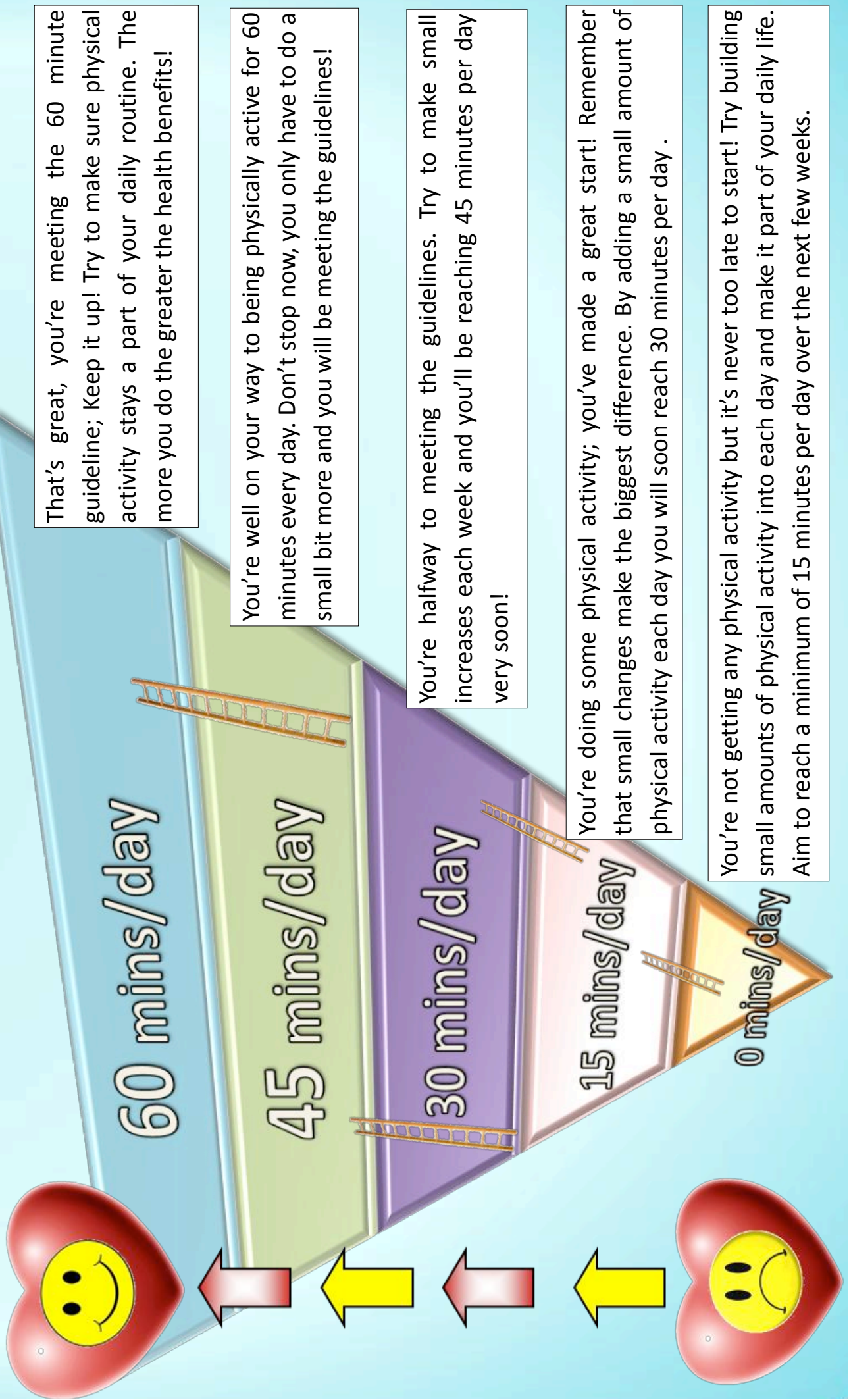
County Wicklow
Vocational Education Committee



Steps To Physical Activity: Step it Up Wicklow!



How much Physical Activity are YOU doing?



Appendix G

Pathways to Activity Inventory

Y-PATH



Arklow

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Athletics	St Benedict's Athletics Club	St Mary's Hall, Arklow, Co. Wicklow		Patricia Rice 0402 22000 ricepatricia70@yahoo.ie	
Boxing	Arklow Boxing Club	Emoclew Road	Arklow Boxing Club	June Manley/ Jackie Manley 0402 31463	From 11years+ Tracksuit/shorts and runner reqd. for training
Camogie	Arklow Rocks Parnell	Emoclew Road	www.arklowrocks.com Arklow Rocks Camogie	Monica Jameson camogie@arklowrocks.com	
Community Games	Arklow Community Games (Gymnastics and Athletics, depending on demand)	St Mary's College Sports Hall	Arklowcg.org	Jim O'Reilly 0402 91085	
GAA	Aughrim GAA Club		Aughrim GAA Club		
	Arklow GeraldinesBallymoney GAA Club	The Vale Road, Arklow, Shelton, Arklow	www.arklowgaa.com Arklow GeraldinesBallymoney GAA Club	Darren Magee 0879152070 info@arklowgaa.ie	Astroturf pitchavailable for booking; Football, hockey, all weather pitch (Contact George Byrne:087 2023534)
	Arklow Rocks Parnell	Emoclew Road	www.arklowrocks.com arklow rocks parnellsgaa club	Bryan O'Leary 0863844546 secretary@arklowrocks.com info@arklowrocks.com	
Golf	Arklow Golf Club	Abbeylands, Arklow, Co.Wicklow	www.arklowgolflinks.com	0402 32492/ 0402 91604 arklowgolflinks@eircom.net	
	Woodenbridge Golf Club	Vale of Avoca, Arklow	www.woodenbridge.ie	0402 35202 reception@woodenbridge.ie	
Gymnastics	Arklow Gymnastics Club	St Mary's College Sports Hall	www.arklowgymclub.com Arklow Gym Club	Michael Kenny/Susan Kenny 040239177 Sara Kenny- 085 - 1615973	

Handball	Arklow Handball Club	Vale Road, Arklow, Co. Wicklow		Eamon Rice 087 219 7144	
Rugby	Arklow Rugby Club	Ballyrichard, Old Dublin Road	Arklow Rugby Club	Barney Hynes 0862309921 hynes.bernard@yahoo.com	Indoor multi purpose hall, fully equipped gym, 2 indoor squash courts.
Racquetball	Arklow Racquetball Club	Coral Leisure Sports Centre, Arklow		Michael Barnes 0402 39592	
Rowing	Arklow Rowing Club	Arklow	Arklow Rowing Club	Ken Tancred 087-9683795 arklowrowingclub@yahoo.ie	Ages 12 years and up
Soccer	Arklow Celtic Soccer Club	Celtic Park, Coolgraney Road, Arklow	Arklow Celtic	Peter Walker 086 8795080 hunterwalker@eircom.net	
	Arklow Town Soccer Club	Bridgewater Centre Park, Lambertton, Arklow	www.arklowtownfc.com Arklow Town F.C.	Jackie Doyle 0402 31900	
	Arklow United Football Club	Ferndale Park, Arklow, Co. Wicklow	www.arklowunited.com Arklow United FC	Neil McAnaspie 086 1539941 secretary@arklowunited.com	
Swimming	Asgard Swimming Club	Coral Leisure Centre, Seaview Avenue, Arklow, Co. Wicklow	www.asgardsc.ie	Nicole McInerney 087 8175850 asgard.swimmingclub@gmail.com	Competitive Swimming, The club doesn't provide lessons Ages 7+
Tennis	Arklow Lawn Tennis Club	Coolgreaney Road, Arklow, Co. Wicklow	www.altc.ie	087 2904472 f.dennehy@svuh.ie	



Ashford

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional info
GAA	Ashford GAA Club	Ashford	Ashfordgaa.com Ashford Gaa-Club	Mick Purcell0876107945 (mp30@eircom.net) Pat Lawless087 2540550 (lawlesspat@eircom.net)	
Social Horse riding		Ashford		Derek O'Callaghan 0872595325	Must have own horse. Saturdays at 10am, followed by picnic

Aughrim

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Camogie	AnnacurraCamogie Club	Annacurra, Aughrim	AnnacurraCamogie	Kathleen McAllister 0402 36195 kathleenmcallister@o2.ie	
Angling	National Disabled Angling Facility (Angling for All)	Rednagh Road, Aughrim, Co. Wicklow	www.aughrim.ie/thingstodo	0402 36552 bkeating@tinet.ie	Fully accessible. Open to general public of any age or ability. Rods available for hire and bait for purchase. Rates by the hour or day.
Rugby	Aughrim Rugby	Aughrim Community & Sports Complex, Rednagh Road, Aughrim	www.aughrimrugby.ie Aughrim Rugby	Derek McAllister 086 047 5996 info@aughrimrugby.ie	
Community Hall	Aughrim Community Hall	Aughrim		Parish Priest 0402 36298	Irish Dancing, G.A.A. Club, Drama Classes, Set Dancing, Martial Arts, Tae-Kwon-Do. Phone for information.



Glenealy

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Badminton	Glenealy Badminton Club	Glenealy Village Hall		Brona Sutton 0404 44550	
Camogie	Glenealy Camogie Club	Glenealy, Co. Wicklow	Glenealycamogie u-13 Glenealy Senior Camogie Club	Anne Hogan 087 676 8071 annehgn@gmail.com	
GAA	Glenealy GAA Club	Glenealy, Co. Wicklow		Peter King 0404 44612 (King's Pub) secretary.glenealy.wicklow@gaa.ie	
Community Centre	Glenealy Village Hall			Sheila 0404 44808 0404-44040 glenealyvillagehall@eircom.net	Badminton , Ballroom dancing, Latin dancing, Indoor hurling, Tennis, Drama, Community Games activities -Contact for details



Greystones

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Angling	Greystones Ridge	North Beach, Greystones, Co. Wicklow		Michael Quinn 086 267 5382 Info@mitchellquinn.ie	Juniors need to have parent member of the club.
Athletics	Gresystones and District Athletics Club	Shoreline Sports Park, (Charlesland Sport and Recreation Park)	www.greystonesac.com Greystones AC	Theresa Kinane 086 863 5797 Theresa.kinane@gmail.com	
Badminton	St Killian's Badminton Club	St. David's School, Greystones		Kevin Hardiman 01-286 4145	Over 16 only. No youth division.
Baseball	Greystones Mariners Baseball Club	Charlesland Sport and Recreation Park	www.greystonesbaseball.org Greystones Mariners Baseball Club	Paul Murray 0863675056 mariners@greystonesbaseball.org	
Bowling	Gresytones Bowling Club	Burnaby Park, Greystones, Co. Wicklow	www.Greystoneslawnbowling.org	Sean Maxwell 012877533 seanmaxwell60@yahoo.ie	
Cricket	Wicklow County Cricket Club	Gresystones Rugby Club (and other locations)	Wicklowcountycricketclub.com / info@wicklowcountycricketclub.com	Tony Buck (H)0404 46676/(W) 0404 43572 info@wicklowcountycricketclub.com	Amalgamation of Avondale Cricket Club and North Wicklow Cricket Club
GAA	Eire og GAA Club	Off Mill Rd.	www.eireoggreystones.com	Carmel Deeney 086 162 1651	

Golf	Charlesland Golf Club	Greystones	www.charlesland.com	01 287 8200 info@charlesland.com golf@charlesland.com	
Karate	Greystones Karate Club	Eire Og GAA Clubhouse	Greystones Karate Club	Ken Loftus 086 3892294 Kenloftus@gmail.com	
Rugby	Greystones Rugby Club	Dr. Hickey Park, Delgany Road, Greystones, Co. Wicklow	www.greystonesrfc.ie Greystones RFC Greystones RFC Junior Section	Club phone: 01 287 4640 manager@greystonesrfc.ie	
Soccer	Greystones United FC	Woodlands, Greystones	www.gufc.ie Greystones United Soccer Club	Kevin O'Mahony0876373930 Michael Browne0876229333 football@gufc.ie	Full size all weather pitch Full size grass soccer pitch 2 small 7 aside courts
Table Tennis	Greystones Table Tennis Club	St. David's School Hall Greystones (Seafront Entrance)		Ms. Toni Massey 086 6821453 Paul Corcoran087 2575278 greystonestabletennisclub@gmail.com	Ages 14+
Sports Park	Charlesland Sports Recreation Park		www.shorelineleisure.ie/shorelinecharlesland	01 201 6145 shorelinesportpark@gmail.com	Astro turf, athletics track, baseball pitch and skate park.
Community Centre	Kilian House Family Centre			Tom Hillery 01 201 7896	
	St Patrick's Church and Parish Centre		www.stpatricksgreystones.ie	Joanne Douglas 01 201 0648 Phone +Fax stpatricksparish@eircom.net	Ballet, speech and drama, yoga, girls' brigade and boys' brigade (See website for details)



Kilcoole

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Athletics	Kilcoole Athletics Club	Charlesland		John O'Toole 087-2353373 jrootoole@gmail.com	
Basketball	Kilcoole Kings Basketball Club				
Camogie	Kilcoole Camogie Club	Newcastle Road, Kilcoole, Co. Wicklow	Kilcoolecamogie.com	Breda Donnelly 087 699 8536	
GAA	Kilcoole GAA Club	South Kilcoole, Newcastle Road	www.kilcoolegaa.ie	Colm Hatton 087 947 3164	
Golf	Kilcoole Golf Club	Kilcoole	www.kilcoolegolfclub.com	01 287 2066 / 01 2010497	
Soccer	St. Anthony's Kilcoole Soccer Club	FinnPark, Kilcoole	www.kilcoole.net	Tony Farrell 087 2745398	
Community Centre	St Patrick's Hall			Andrew Kenna 01 287 5418	Kickboxing, bowling, ballet , hip-hop, youth club and Irish Dancing. Ring for details.



Newcastle

Sport	Club/facility	Location	Website/Facebook	Contact Details
GAA	Newcastle GAA Club			Eddie Farrel 087 271 2698
Judo	Bray Judo Club	Newcastle Community Centre		Derek O'Callaghan 087 259 5325 / 01 287 4810
Community Centre	Newcastle Community Centre			Catherine Carey 01 2810528

Newtownmountkennedy

Sport	Club/facility	Location	Website/Facebook	Contact Details
GAA	Newtown GAA Club	Newtownmountkennedy, Ballinahinch		Robert Nolan & Pat Doyle 01 281 9100 plmdoyle@yahoo.ie
Golf	Druid's Glen Golf Club		www.druidsglen.ie	01 287 3600 info@druidsglen.ie
Tae Kwon Do	East Coast Tae Kwon Do	Newtown Community Centre	www.eastcoasttkd.org	Michael Whelan 087 989 7217
Community Centre	Newtown Community Centre			Noel Gregory



Rathdrum

Sport	Club/facility	Location	Website/Facebook	Contact Details
Athletics	Parnell Athletics Club	Rathdrum Rugby Club	www.parnellac.com	Billy Porter 087 292 8660
Camogie	Avondale Camogie Club	Avondale, Rathdrum		0831125861 (club phone) Donna Olanhan 0861246490 Donna.olahan@travelcounsellors.com
GAA	Avondale GAA Club	Corballis, Rathdrum	Avondale GAA Club	Brendan Brady 0868112763
Gymnastics	Rathdrum Gymnastics Club (Gymnastics and Trampolining)	Avondale GAA Community Hall, Avoca Road	www.rathdrumgymclub.ie	Mary Burke 086 321 2213 info@rathdrumgymclub.ie
Rugby	Rathdrum Rugby Club		www.rathdrumrugby.ie	Johnny Conway 0876627572
Soccer	Avonmore FC			Michael Farrell 086 2042795

Rathnew

Sport	Club/facility	Location	Website/Facebook	Contact Details
GAA (No junior club at present)				Yvonne Kelly 086 169 0628
Soccer				Declan Earls 0866028687 decearls@hotmail.com
Community Centre	St Brigid's Hall (Currently being refurbished; hoping to open again in March 2012)		Rathnew Community Centre Limited - St Brigid's Hall	Evelyn Kinsella 087 926 1899



Roundwood

Sport	Club/facility	Location	Website/Facebook	Contact Details
Athletics	Roundwood and District Club	An Tochar GAA Club	Roundwood & District Athletic Club	Louise Kenna 086 316 1027
Badminton	Roundwood Badminton Club	An Tochar GAA Club		Liz Belton 0863636157
GAA	An Tochar GAA Club	Roundwood, Co.Wicklow		Paul Brady 0863180014 pbrady68@hotmail.com
Golf	Djouce Golf Club			01 281 8585
Community Centre	An Tochar GAA Club and Community Centre	An Tochar GAA Club		Paul Brady 086 318 0014 pbrady68@hotmail.com



Wicklow Town

Sport	Club/facility	Location	Website/Facebook	Contact Details	Additional Info
Angling	Wicklow Bay Angling	Wicklow Town	www.wicklowbaysac.com	Kit Dunne 0876832179 wicklowbaysac@eircom.net	Under 16s welcome if with parent member
Athletics	Inbhearr Dee	Wicklow Town	Inbhear Dee Athletic Club	Geraldine Mooney 087-6557199 mooneygeraldine@gmail.com	
	Slicualann	Phone for details	Slicualann.com Slicualann Athletics Club	Tony Collins 087 988 4039 admin@slicualann.com	Amalgamation of: Bray Runners AC, Greystones& District AC, Inbhear Dee AC - Wicklow Town, Lake Shore Striders AC - Blessington, Roundwood& District AC, Parnell AC - Rathdrum. .
Badminton	St Patrick's Badminton Club	St. Patricks GAA Club, Dunbur Rd.		Philomena Curley 087 2067607	7 Years to adult
Basketball	Wicklow Town Basketball Club			Mick Larkin 0862693351	
Boxing	Our Lady Of Fatima	Hillview Community Centre , Hillview,	www.olofboxingclub.co.cc OurladyoffatimaBoxingclub Wicklow	Piaras O'Sullivan 087 6590722 olofboxingclub@hotmail.com	
GAA	St Patrick's GAA Club	Dunbur Road, Wicklow Town	www.stpatrickswicklow.ie	John Smith 086 8130477 chairperson.stpatricks.wicklow@gaa.ie	

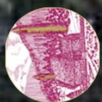
Golf	Blainroe Golf Club	Blainroe (3 miles South of Wicklow Town)	www.blainroe.com	0404 68168 info@blainroe.com	
	Wicklow Golf Club	Dunbur Road	www.wicklowgolfclub.ie	Joe Kelly 0404 67379 info@wicklowgolfclub.ie	
Hockey	Wicklow Hockey Club	Dominican Convent, Wicklow Town	www.wicklowhockey.com Wicklow Hockey Club	Richard Woodroffe 086 1973547 secretary@wicklowhockey.com info@wicklowhockey.com	
Martial Arts	Uplift Gym and Martial Arts (Kickboxing classes)	The Murrough, Wicklow Town	www.wicklowmartialarts.com	0404 64786 Simon Alvey 085 145 3582 simonlalvey@gmail.com	Beginner kickboxing class for 12 years+
Tae Kwon Do	East Coast Tae Kwon Do	De la Salle School Hall	www.eastcoasttkd.org	Mr. James Whelan 087 1346168	Saturday afternoons All ages
Rowing	Wicklow Rowing Club	Seafront, Wicklow Town	Wicklow Rowing Club	Bernice Murphy 086 8797621 bernicedunne@eircom.net	Season starts in March and ends in mid August 10 years+
Rugby	Wicklow RFC	Ashtown Lane, Wicklow Town,	www.wicklowrfc.com	087 205 1659 info@wicklowrfc.ie	
Sailing	Wicklow Sailing Club	South Quay, Wicklow Harbour	www.wicklowsailingclub.com	John Harte 086 3155818 Clubhouse: 0404 67526 info@wicklowsailingclub.com	ISA approved sailing courses for juniors in summer. Must be confident in water.
Snooker	The Q Club	The Mall Centre, Main Street, Wicklow Town		0404 68975	Weekly tournaments for under-18s
Soccer	Wicklow Rovers AFC	Whitegates, Wicklow Town	www.wicklowrovers.com Wicklow Rovers AFC	Gerry Doyle 0861692163	
	Wicklow Town AFC	Finley Park, Wicklow Town	Wicklow Town A.F.C	Mary Dickenson 086 8737664 mdickenson@eircom.net	
Special Olympics	Blue Dolphins	Wicklow Town	www.wicklowbluedolphins.com	Pam Beacom 086 2893946	
Swimming	Wicklow Swimming Club	Wicklow Harbour, Wicklow Town	www.wicklowsc.com	Sandra Nolan 087 2490044 sandranolan@eircom.net	Summer sea races and winter pool training.

Tennis	Wicklow Tennis Club	The Glebe, Main Street, Wicklow Town	www.wicklowtennisclub.ie	Sinead Nolan 0404 68666	Club membership required. Junior, family and Student membership available.
Triathlon	Wicklow Triathlon Club	Various Training sessions around Wicklow— check website	www.wicklowtri.com	Dermot Hickey, Youth Officer info@wicklowtri.com	Full Time Student / Junior membership per annum - €30
Leisure Centres and Gyms	Coral Leisure	Station Road, Wicklow Town, Co. Wicklow	www.coralleisure.ie	0404 66831 0404 66832	Pay as you go rates available. Swimming lessons and lane swimming
	Uplift Gym and Martial Arts	The Murrough, Wicklow Town	www.wicklowmartialarts.com	0404 64786 Simon Alvey085 145 3582 simonlalvey@gmail.com	

Appendix H

Inventory Poster

Y-PATH



What Can I Do in Wicklow Town?

Athletics

Inbhear Dee Athletics Club
Wicklow Town

Cross Country and Track

	Geraldine Mooney: 0876557199
	Inbheardeeac@gmail.com
	Inbhear Dee Athletic Club

Badminton

St Patrick's Badminton Club
St Patrick's GAA Club, Dunbur Rd.

Training from 9 years old and up

	Philomena Curley: 087 2067607
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Boxing

Our Lady of Fatima Boxing Club
Hillview Community Centre

Training from 9 years old and up

	Piarras O'Sullivan: 087 6590722
	http://www.olofboxingclub.co.cc
	olofboxingclub@hotmail.com
	Ourladyoffatima Boxingclub Wicklow

Dancing

Rising Star Performing Arts School

Fatima Hall, Dominican College
Dance (hip hop, jazz and musical theatre),
Drama and Singing

	Lindsey 0868461559
	Ann 0868227244
	lindseyaherne@hotmail.com
	mcintyreanne@eircom.net
	"Rising Star" Performing Arts School Wicklow Town

GAA

St Patrick's GAA Club
Dunbur Road, Wicklow Town

Gaelic football, hurling and ladies football

	John Smith: 086 8130477
	www.stpatrickswicklow.ie
	chairperson.stpatricks.wicklow@gaa.ie
	St Patrick's Gaa

Golf

Blainroe Golf Club
Blainroe

	0404 68168
	www.blainroe.com
	info@blainroe.com

Wicklow Golf Club
Dunbur Road

	Joe Kelly 0404 67379
	www.wicklowgolfclub.ie

Hockey

Wicklow Hockey Club
Dominican College, Wicklow Town

	Peter (PRO): 087 4166242
	Richard (Secretary): 086 1973547
	www.wicklowhockey.com
	info@wicklowhockey.com
	secretary@wicklowhockey.com
	Wicklow Hockey Club

Martial Arts

Uplift Gym and Martial Arts
The Murrrough, Wicklow Town

Beginner kickboxing training (12 years old+)

	0404 64786
	Simon Alvey: 085 145 3582
	www.wicklowmartialarts.com
	UPLIFT GYM WICKLOW

Rowing

Wicklow Rowing Club
East pier, Wicklow Harbour

Training every night from April to
September
(weather permitting)

	Bernice Murphy 086 8797621
	BerniceDunne@eircom.net
	Wicklow Rowing Club

Rugby

Wicklow Rugby Club
Ashtown Lane (Off Marlton Road)

	Stephen Clarke : 087 2051659
	www.wicklowrfc.com
	info@wicklowrfc.ie
	Wicklow RFC

Sailing

Wicklow Sailing Club
South Quay, Wicklow Harbour

	Clubhouse: 0404 67526
	John (Commodore): 086 3155818
	www.wicklowsailingclub.com
	info@wicklowsailingclub.ie

Snooker

The Q Club
The Mall Centre, Main St, Wicklow
Town

Weekly tournaments for u-18s

	0404 68975
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Soccer

Wicklow Rovers AFC
Whitegates, Wicklow Town

	Paul (Chairman): 0870566848
	Gerry (Secretary): 0861692163
	www.wicklowrovers.com
	Wicklow Rovers AFC

Wicklow Town AFC
Finley Park, Wicklow Town

	Mary Dickenson: 086 8737664
	mdickenson@eircom.net
	Wicklow Town A.F.C

Special Olympics

Blue Dolphins

	Pam Beacom 086 2893946
	www.wicklowbluedolphins.com
	BLUE DOLPHINS SPECIAL OLYMPICS CLUB, WICKLOW TOWN

Tennis

Wicklow Tennis Club
The Glebe, Main St.

	Sinead Nolan 0404 68666
	www.wicklowtennisclub.com
	info@wicklowtennisclub.com

Other Facilities

Coral Leisure Centre
Station Road

Pay as you go rates available for pool and gym
(must be 16+ to use gym)
Swimming lessons and lane swimming available

	0404 66831
	0404 66832
	www.coralleisure.ie
	Coral Leisure Wicklow

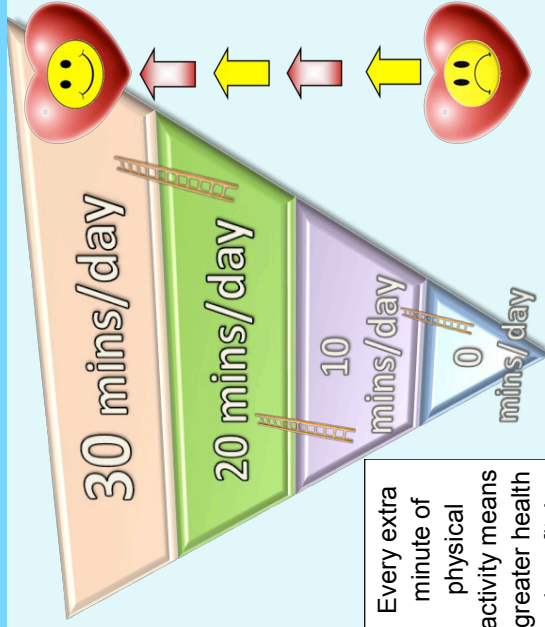
Appendix I

Physical Activity Parent Leaflets

Y-PATH

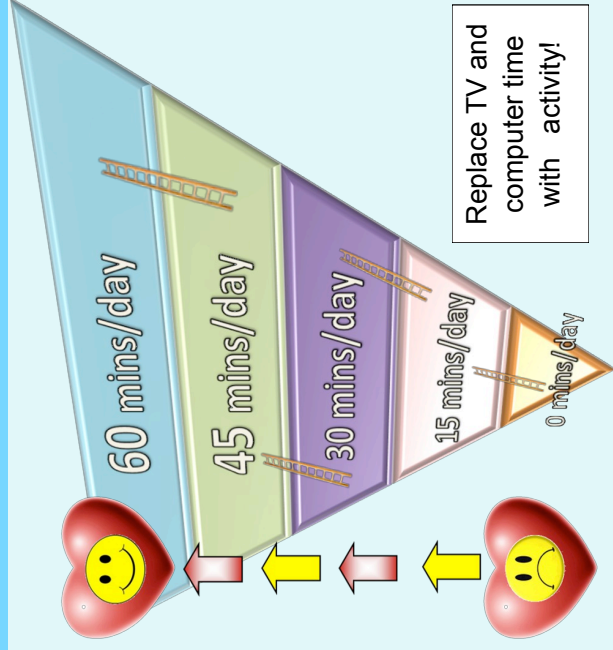
How can I work towards meeting the recommendations?

Adults



Every extra minute of physical activity means greater health benefits!

Children and Youth



Replace TV and computer time with activity!

County Wicklow Vocational Education Committee

Y-PATH

Youth – Physical Activity Towards Health

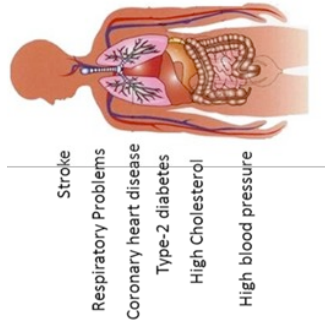


Y-PATH Research Team,
 Physical Activity Research Unit,
 School of Health and Human Performance,
 Dublin City University,
 Dublin 9.

Phone: 01-700-7393
 E-mail: Sarahjane.Belton@dcu.ie
 Web: www.dcu.ie/shhp/ly_path

Why is physical activity important?

The World Health Organisation identifies physical inactivity as the fourth leading risk factor of global mortality, causing an estimated **3 million deaths** globally (WHO, 2010)



Most common diseases and conditions can be prevented through regular physical activity

Making physical activity a part of everyday life can have enormous physical and emotional benefits which are especially important for youth

Reduced anxiety and stress
Interaction with new people
Better concentration
Self-discipline
Positive self-image
Greater confidence



Healthy weight

Better sleep

What is Physical Activity?

Physical activity is any body movement that results in energy expenditure. As well as sport and structured exercise, this includes day to day activities that get you moving.

Walking

DIY



Dancing

Circuit training

Climbing the stairs

Household chores

Fitness classes

Going to the gym

Horse riding

Rollerblading/skating

Carrying grocery bags

Swimming

Weight Training

What are the recommendations for physical activity?

The National Physical Activity Guidelines for Ireland are:

At least **30 minutes** a day of **moderate activity** on **5 days a week**

Adults
(aged 18-65)

Moderate intensity activity

Breathing is harder

Heart rate is slightly increased

Warm and sweating slightly

Still able to carry on a conversation

Vigorous intensity activity

Breathing is heavy

Heart rate is significantly increased

Sweating a lot

Difficult to carry on a conversation

At least

60 minutes of

moderate to vigorous activity

every day

This can be accumulated throughout the day in smaller blocks of physical activity.

Children & Youth
(aged 2-18)



Results from **Y-PATH** research conducted in September and October 2010 indicate that **only 1 in 5 children** in Wicklow Town are meeting the 60 minute physical activity recommendation for health on all 7 days.

Remember, these guidelines are minimum recommendations; the more physical activity you do the greater the health benefits!

How can I encourage my child to be more physically active?

Two things you can do to increase your child's participation in physical activity and therefore contribute to their overall good health and wellbeing are:

- 1) Facilitate and encourage
- 2) Be an active role model and take part in physical activity with your child

Research has shown that parents who facilitate and encourage physical activity can greatly influence increased participation in physical activity. (Ornelas et al, 2007)

Facilitate and Encourage

- Take on a committee position for your child's team or volunteer to help out at matches and events.
- Encourage your child to try new sports and activities
- Praise and reward effort
- Remember that there is more to physical activity than sport
- Encourage your child to try the extra curricular activities available in school
- If transport is an issue, try organising a car pool with other families in the area.

Active Role Model

- Cut down on sedentary activities such as TV and using the computer; research shows that children are up to ten times more likely to watch excessive amounts of TV if their parents watch 2-4 hours per day (Jago, 2010).
- Take up a new sport or start a new exercise regime
- Look in your local area or the Y-PATH online directory to find facilities and clubs that might interest you and your child
- Make it a family tradition to go for a walk together once a week
- Walk or cycle where possible instead of taking the car.

For more tips and advice go to www.GetIrelandActive.ie

Appendix J

Walk/Step Pedometer Challenge

Y-PATH

RECORD SHEET

Walk Challenge - record your minutes
Step Challenge - record your steps

Week	1	2	3	4
Mon				
Tue				
Wed				
Thur				
Fri				
Sat				
Sun				
Total				

Start date

Finish date

If you are very inactive, have a health problem, or are worried about any aspect of your health, you should consult your doctor before undertaking this activity challenge.

CONVERTING your step

If you take part in vigorous activity such as team sport, dancing or jogging you can convert your vigorous activity by using the formula below.

10 minutes of moderate intensity activity = 1,000 steps

10 minutes of vigorous intensity activity = 2,000 steps

Moderate Intensity	Vigorous Intensity
Causes a slight but noticeable increase in your breathing and heart rate. You should be able to maintain a conversation.	Makes you "huff and puff", conversation is difficult.
Brisk walking, swimming, cycling, rowing, dancing	Aerobics, brisk rowing, fast cycling, jogging, competitive sport - squash, football, tennis

DONATE Have a Heart

Nearly 27 lives are lost in Ireland every day to heart disease and stroke. Please make a donation today so our charity can continue its work to prevent more people dying from this disease. Donate now online at www.irishheart.ie or send a cheque or postal order to:

Irish Heart Foundation
4 Clyde Road, Ballsbridge, Dublin 4

T: 01-6685001

F: 01-6685896

Helpline 1890 432 787
email: info@irishheart.ie



Additional Walk or Step Challenge cards can be downloaded from

www.irishheart.ie/heartweek

Supported by



Walk for Heart

Walk or Step Challenge

Young People (12-18 years)

www.irishheart.ie

Walk for Heart



The Irish Heart Foundation is calling on as many young people as possible to Walk for Heart – Your Heart.

Take up the Walk or Step Challenge on your own or with a group of friends over 4 weeks, at a date that suits you.

Being active regularly is one of the best ways to keep your heart healthy and help prevent health problems.

Doing the 4-week challenge will make you aware of how much activity you do and the amount you need to do to enjoy the positive benefits for your health and wellbeing.



IRISH HEART FOUNDATION

Young people (up to 18 years) need at least 60 minutes of moderate intensity activity everyday. Moderate activity causes an increase in your breathing and heart rate, similar to a brisk walk. The good news is that this activity can be done over several sessions, very often as part of your everyday activity, and each session must last for at least 10 minutes or longer to get the health benefits.

WALK Challenge

Your goal is at least 30 minutes of walking at a brisk pace five days a week or about 150 minutes over the week for 4 consecutive weeks. This is in addition to your regular leisure activity, sport and PE to make up your 60 minutes of activity everyday. The Walk Challenge can be part of your travel to and from school or to the shops. It's up to you how you accumulate the 150 minutes. For example you might walk 20 minutes every day or you might prefer to get in two or three longer sessions (e.g. 50 minutes each). And you don't have to do your daily walking all at once. Consider taking 10 minutes in the morning, 15 minutes walking home from school and the rest later in the day. In this way you'll be surprised at how many minutes you clock up.

Record the dates and minutes of your walks in the record sheet on reverse.

STEP Challenge

Using a pedometer aim to build up to 10,000 steps per day for good health. Walking 10,000 steps includes your regular routine activities, such as general walking to the shops or to friends after school. Many people, however, only take between 3,000 and 5,000 steps a day. How many do you think you take?

DOING the Step Challenge

Record the number of steps you take daily and progress gradually towards achieving 10,000 steps by adding 300-500 steps each day. If you are inactive at the moment (less than 3,000 steps a day), it will take you at least 3 weeks to reach the 10,000 target. And if you are fairly active (more than 7,000 steps per day) you will achieve your target in one week.



Using the pedometer

A **pedometer** is a device which counts steps and is also called a step-o-meter or step counter. The pedometer has a built in pendulum which moves as you walk and counts these as steps. It is best to wear your pedometer on the top of your waistband or on a belt around your hip, in line with your knee.



You can buy a reliable **Irish Heart Foundation pedometer** online for €10 (at cost price) with free delivery at www.irishheart.ie/shop

FREE Prizes

Once you have completed the 4-week challenge, don't miss your chance to register for our FREE prize draw for a chance to win great prizes to keep you active such as bikes, sports vouchers, pedometers and much more!

Just log on to our website www.irishheart.ie/heartweek

Appendix K

Research Paper: Patterns of Non-Compliance in Adolescent Field Based Accelerometer Research

Y-PATH

Note: This article will be published in a forthcoming issue of the *Journal of Physical Activity & Health*. This article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copy edited, proofed, or formatted by the publisher.

Section: Original Research

Article Title: Patterns of Non-Compliance in Adolescent Field Based Accelerometer Research

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Key Words: physical activity, day period, compliance, strategies

Number of words, tables, figures:

Abstract - 184

Main text - 3,506

Tables - 2

Figure – 1

Abstract

Background. The primary purpose of this study was to investigate patterns of non-compliance in an adolescent field based accelerometer study. A further purpose was to investigate the effect of a cost efficient strategy (SMS reminder message) on the compliance of adolescents.

Method. The research carried out in 2010 involved 117 second level students ($12.41 \pm .53$ yrs) from four schools in a rural Irish town. The Actigraph accelerometer data was processed over 7 days to determine compliance level.

Results. Students were more likely to remove their monitor in the evening period than at any other time, however if students removed their monitor after school it remained unworn for a significantly longer duration than in any other time period. Students who received a SMS message were significantly more likely ($p = 0.008$) to wear their monitor in the morning than those that did not.

Conclusions. Sending an SMS message each morning is effective for improving the number of students wearing monitors to school. The after school period is a critical period for non-wear time and should be targeted in future studies wishing to improve compliance.

Key Words: physical activity, day period, compliance, strategies

Introduction

One of the greatest difficulties in using accelerometers to measure levels of free living physical activity is getting participants to comply with research conditions. Generally in field based accelerometer research, participants are asked to wear the monitor during all waking hours (except while bathing or swimming) across several days¹. Compliance difficulties arise when participants forget to put the monitor on first thing in the morning, or when they forget to put the monitor on after certain activities. When an accelerometer is not being worn the output will show consecutive zero counts for each epoch for the duration of non wear time. Sirard and Slater² reported on the difficulties inherent in the accelerometer data reduction process when the monitor has not been worn for a certain period. Masse et al.¹ highlighted the range of criteria researchers have employed when trying to ascertain non-wear periods from 10 minutes of consecutive zero's to 30 minutes. Though 10 minute³⁻⁶ and 20 minute criterions⁷⁻¹⁰ are more prevalent in youth accelerometer studies, durations as long as 60 minutes have also been employed in some studies.¹¹⁻¹³ The choice of criterion in a given study will have implications for deciding on whether or not a participant has met the criteria for minimal wear time, and thereby inclusion of their data set in analysis.

Trost et al.¹⁴ discussed several strategies to improve monitor wearing compliance: activity monitoring log, reminder phone call or flyer, information sheets for participants on wearing accelerometers, notifying teachers/parents of the protocol, showing participants non wear output, or providing incentives contingent on compliance (e.g. money, gift cards); however, the effectiveness of these strategies in field-based work is unclear, specifically among youth.¹⁵ Among high school aged students (15 – 18 years), Sirard and Slater² examined the effect of different strategies on compliance with wearing accelerometers. Three compliance strategies - 1) receiving three phone calls over the data collection period, 2) completing a daily journal, and 3) monetary compensation contingent on number of complete

days were compared with a control condition. The authors reported that the monetary compensation strategy resulted in significantly greater compliance than the other conditions examined.

There is a definite need for standardisation of criteria for deciding upon non-wear time, and minimal wear time ¹, however as highlighted by Sirard and Slater ² if researchers can reduce the amount of missing data then less burden will be placed on these factors in the data reduction process. This point was also highlighted by Rowlands et al. ¹⁵, who noted that if participants do not wear the monitors consistently during the measurement period then questions relating to epoch length, data reduction processes or intensity cut points are of little consequence. The purpose of this research was to investigate whether there were patterns of non-compliance within the data, and to build upon the work of Sirard and Slater ² by carrying out an investigation into the effect of a cost efficient SMS strategy on the compliance of adolescents in field based accelerometer research.

Methods

Participants

A convenience sample of 134 first year students from all four second level schools in a rural Irish town were invited to participate in this study. Students were invited to participate in the study by way of an information leaflet and an informed consent form which was distributed to parents/guardians through the school PE teacher. A total of 117 students assented (with parents consent) to participate in the study. This compliance study was part of a larger study measuring the physical activity levels of students in these schools. As such the purpose of the overall study was communicated to the students (measuring physical activity levels of youth), but we did not risk influencing students' compliance by telling them the further purpose of the study which is being presented in this paper. This study was approved by the Dublin City University Research Ethics Committee.

Design

As part of the study protocol, an investigator checked in school each morning between 9:00am – 10:00am to ensure participants were wearing monitors correctly. In the event that a child forgot to wear his/her device, their parents/guardians were contacted to drop in the device within the first two hours of school. The compliance strategy employed was to send an SMS reminder message before 8 am each weekday morning (9.30 am on weekend days). Due to ethical restrictions students self selected whether or not to provide their mobile number in order to receive the reminder SMS strategy. Subsequently, 67.5% participants consented to provide their mobile number leaving 32.5% participants acting as a control group.

Measures

Actigraph GT1M and GT3X accelerometers were used to determine periods of the day when the monitor was worn and when it was not. Both devices have similar dimensions (3.8cm x 3.7cm x 1.8cm) and are capable of producing comparable activity counts for the vertical axis.¹⁶ As such, only activity counts from the vertical axis were used in the study. Detailed specifications of the hardware and a full description of how the monitor acquires and filters data is available from the manufacturers website (www.theactigraph.com).

Procedures

All data were collected during a four week period from September to October 2010. Accelerometers were distributed to students in their PE classes following a strict overview and protocol. In line with other studies^{17,18}, students were instructed to wear the monitors above the iliac crest of the right hip with an elastic belt and adjustable buckle. The same research investigator led the distribution and explanation process throughout the four schools, five research assistants were also present at each school to assist in showing students how to attach the monitor and adjust the elastic waist band to ensure a snug fit. Monitors were collected from the students on the morning of the final day of monitoring.

Data reduction

Data in relation to accelerometer compliance was available for all 117 participants. Due to a malfunction with Actigraph software (Version 4.4.1), data from 52 of the 117 participants failed to download correctly resulting in a remaining sample size of 65 participants with valid accelerometer recorded data. Actigraph data were reduced using a custom software programme developed for this study. The first and last days of monitoring were excluded from analysis to allow provision for subject reactivity.¹⁹ The processing was then conducted on participants with data from 7 days.

Consistent with previous studies a valid day was determined as having greater than 600 minutes of wear time.^{1,2,12} Strings of 20 consecutive minutes of zero counts were considered to be times when the monitor was not being worn.¹⁹ The Troiano et al.¹³ model of allowing for short (1 min max) interruptions of small values between 0 and 100 was employed in the processing of non-wear time. Waking hours in this study were considered to be between 8 am and 10 pm- i.e. a string of zero counts was only categorised as non-compliance if it occurred during this period. Non-wear time each day was calculated as the number of minutes of non-wear events recorded between 8 am and 10pm. Once data had been processed through the inclusion criteria detailed above, the number of ‘valid’ days of data each participant had recorded was calculated.

Statistical analysis

Preliminary statistics were conducted between the four schools to identify if potential differences in age and non-wear time occurred. A chi-square test for independence identified if percentage differences in the number of days meeting the minimum wear requirement existed across schools. A one way between-groups ANOVA was conducted to explore the impact of both age and non wear time in the morning across the four schools. An independent

sample t-test was conducted to compare differences in overall non wear time per day between those who wore their device in the morning and those who forgot¹.

Time of day was broken down into four day periods – morning (8am – noon), afternoon (noon – 4pm), after school (4pm – 6pm) and evening (6pm – 10pm). Because three of the day periods were four hours in duration with the after school period being just two hours, data were standardised by computing a new variable to illustrate average non wear time per hour for each of the four time periods. Descriptive statistics were calculated from the data. Based on the receipt of SMS or non-receipt of SMS, independent sample t-tests were used to investigate 1) differences in percentage of days wearing monitor to school, and 2) minutes of non-wear time overall, on weekdays/weekend days, and in each of the four day periods. A 2 (gender) x 4 (day period) ANOVA was used to investigate the effect of gender and day period on hourly minutes of non wear time. A two way between groups ANOVA was conducted to explore the impact of gender and removal of monitor during a particular day period on non wear time per hour. The alpha level for analysis was set at $p < 0.05$.

Results

The mean age of the participants was 12.41 (± 0.51) years with no significant differences across the four schools ($F(3,113)=1.144$, $p>0.05$). Using a Chi-square test for independence, no significant association was found between school attended and the number of days meeting minimum wear requirement ($\chi^2=19.745$, $p>0.05$). There was no statistically significant difference in morning non wear time for the four schools ($F(3,41)=0.143$, $p>0.05$). On average 9% of participants forgot to wear their monitor to school in the morning. An independent t-test confirmed that there was no significant differences ($t(43)=-0.679$, $p>0.05$) in overall non-wear time per day between those who wore and forgot their devices (see

¹ The purpose of this independent t-test was to ensure that those participants who forgot their monitor in the morning compared to those who wore monitors were not statistically different in terms of overall non-wear time.

footnote 1). The remaining analysis was carried out with data collapsed across the four schools. Participant characteristics are presented in Table 1.

Patterns of non-compliance

Overall 15.4% of participants met the minimum wear requirement (>600 minutes) on all seven days, 50.8% met the requirement on six days, with 63.1% meeting it on five days. While 80% of the sample met the minimum wear requirement on at least four days, if three weekdays and one weekend day was to be taken as a minimum requirement for inclusion in analysis of physical activity levels of this group^{12,13}, 70% would meet the requirement. 84.6% of the sample met the minimum requirement of 600 minutes on at least three days.

On average participants recorded 240.6 (± 225.1) minutes of non wear time per day; 225.3 (± 262.4) minutes on a weekday and 285.3 (± 368.1) minutes on a weekend day. The difference in non-wear duration on a weekday versus a weekend day was not significant. All participants recorded at least one non-wear event (period during waking hours with 20 consecutive minutes of zero counts); on average participants removed their device 9.05 times over 7 days of monitoring (1.29 times per day). Figure 1 displays the percentage of participants with frequency of non-wear events over the seven day period. The number of times participants removed their monitors within each day period over the 7 days are shown in Table 2, the percentage of participants that removed their monitors during these periods are also shown. Students were twice as likely to remove their monitor in the evening period than at any other time.

Further analysis investigated the average duration of non-wear events per hour during each of the four day periods. Results of this analysis are also shown in Table 2. Results of a two way between groups ANOVA (exploring the impact of gender and removal during a particular day period on non wear time per hour) showed that the interaction effect between day period and gender was not significant. There was a statistically significant main effect for

day period ($F(2, 184) = 5.643, p = 0.001$), with a medium effect size (partial eta squared = .084). There was no significant main effect for gender. Post hoc comparisons using the Tukey HSD indicated that the mean hourly minutes for the after school period was significantly higher than the other three day periods. If students removed their monitor during the after school time period it would remain removed for 44.1 minutes per hour, compared with 12.7, 11.2, and 14.4 minutes for the morning, afternoon and evening periods respectively.

Impact of compliance strategies

Overall 69% of the participants wore their monitor into school every morning, 23% wore the monitor on four mornings, 7% on three mornings, and 1% on just two mornings. Results of an independent sample t-test showed that students who received the reminder SMS were significantly more likely ($p = 0.008$) to wear their monitor in the morning than those that did not receive the SMS.

When the Actigraph data was considered ($n = 65$) it was found (using a one-way ANOVA) that the number of days students remembered to wear monitor to school in the morning did not significantly influence overall average non-wear time. An independent samples t-test showed no significant differences in average duration of total non-wear, weekday non-wear, weekend day non-wear, morning non-wear, afternoon non-wear, after school non-wear or evening non-wear based on receipt of the different support strategies.

Discussion

Compliance of participants engaging within this study protocol are in some ways comparable to that reported in other studies carried out with similar age groups. Overall 84.6% of the sample in the current study met the 600 minute minimum criterion on at least three days. This is in line with the findings of Ness et al.²⁰ who reported 85% compliance, but is slightly lower than that reported by Van Coevering et al.²¹ who reported 92%. Troiano et al.¹³ reported that 71% of their sample provided four or more valid days of data – this

compares to 80% in the current study. It must be noted however that only 15.4% of the sample in the current study met the minimum wear criterion on all 7 days monitored; this is in contrast to the figures of 50% and 45% reported by Van Coevering et al.²¹ and Sirard et al.²² respectively. These differences can possibly be explained by a much longer non-wear criteria time employed in the Van Coevering et al.²¹ study (180 mins of consecutive zero's), and the older age group sampled in the Sirard et al.²² study (16.7 ± 1.34 years).

It was found in this study that participants were almost twice as likely to remove their monitor in the evening period (between 6 and 10 pm) than at any other time. On average participants removed their monitors 3.58 times in the evening over the 7 day period, and just 1.65 times in the after-school period. The interesting thing however is that while the students removed their monitors less often in the after-school period, if they did remove it they left it removed for a significantly greater period of time (44.1 minutes for each hour) than if they removed it in any of the other three day periods. This identifies the after school period as a particularly critical period in terms of compliance reduction.

Sirard and Slater² found that providing a monetary incentive contingent on the number of valid days of data a participant recorded, significantly influenced compliance in their cohort of 15 – 18 year old youth. In the current study, both ethical and monetary restrictions meant that this strategy was not an option. Results from the present study indicate that students who received an SMS reminder message were significantly more likely to remember to wear their monitor first thing in the morning than those that those who did not receive the compliance SMS strategy. Interestingly, however this did not significantly influence overall compliance in terms of either valid days of data or minutes of non-wear. Having an investigator present each morning increased wear time compliance and thus increased the number of children adhering to the minimum wear time criteria (> 600 mins per day). Subsequently, having this investigator present each morning in schools supported

accelerometer compliance providing a representative insight into the habitual physical activity behaviour amongst rural adolescent youth.

Conclusion

Sending an SMS reminder message each morning appeared to influence the likelihood of students wearing the monitor to school each morning. Even allowing for the number of data sets lost due to software malfunction, the remaining sample used in this study means that important conclusions can be drawn. Based on our findings we would strongly recommend sending an SMS reminder message each morning to participants for future field based accelerometer studies. In addition findings in relation to patterns of non-compliance indicate that an additional SMS reminder each day during the period immediately after school may significantly improve minutes of wear time. While we would tentatively recommend this as an additional strategy to aid compliance in future studies, there is a need for further research to investigate the significance of any impact this strategy may have on overall minutes of non-wear.

Conflict of interest

The authors declare that there are no conflicts of interest. The funding sources listed below had no involvement in the conduct of the research.

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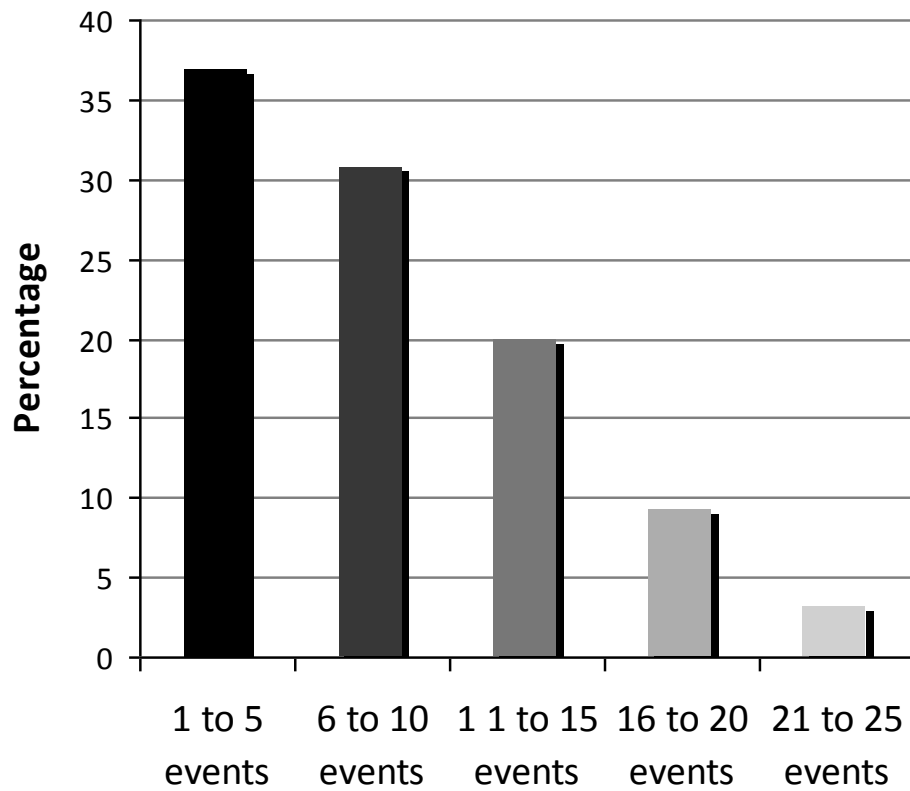


Figure 1. Percentage of Irish adolescents in 2010 with frequency of non-wear events over 7 days (n = 65)

Table 1. School and participant characteristics of Irish adolescents in 2010 including compliance strategies (n = 117)

n	Age (mean (SD))	No SMS	SMS
Full cohort 117 (64 male)	12.41 (.51)	38 (32%)	79 (68%)
Reduced cohort 65 (43 male)	12.41 (.53)	20 (31%)	45 (69%)

Table 2. Patterns of compliance of Irish adolescents in 2010 across day periods (n = 65)

Day period	Morning	Afternoon	After School	Evening
Number of times monitor removed over 7 days	1.88	1.94	1.65	3.58
% of participants that removed monitor at least once over 7 days	67.7%	63.1%	67.7%	95.4%
Duration of non-wear (mins/hr) if monitor removed	12.7	11.2	44.1	14.4