Active Classrooms: Development and evaluation of a movement integration intervention to increase physical activity levels of primary school children

by

Rosemarie Martin

Department of Arts Education and Physical Education

A thesis submitted in fulfilment of the requirements

for the degree of Doctor of Philosophy

Submitted to

Mary Immaculate College

-University of Limerick-

May 2017

Supervised by **Dr. Elaine Murtagh**

Abstract

Active Classrooms: Development and evaluation of a movement integration intervention to increase physical activity levels of primary school children

Rosemarie Martin

Physical inactivity is recognised as an international public health issue with less than 20% of children globally achieving the recommended 60 minutes of moderate-to-vigorous physical activity (MVPA) per day for health benefits (WHO 2010). School-based physical activity (PA) interventions have been acknowledged as a key strategy for reaching the majority of children (WHO 2010). The five articles presented in this thesis explore the design, implementation and evaluation of a movement integration (MI) intervention (incorporation of PA into academic lessons) on the MVPA levels of primary school children. The acceptability of this teaching method by teachers and students is also assessed.

A systematic literature review was conducted to assess the effectiveness of MI interventions on PA, learning, facilitators of learning and health outcomes. Fifteen studies met the inclusion criteria. Six studies that reported PA levels were found to have medium-to-large effect sizes. All four studies reporting learning outcomes reported positive effects. Teachers and students were pleased with the programmes and enhanced on-task-behaviour was identified (n=3). Positive effects were also reported on students' BMI levels (n=3). These findings informed the development of a behaviour change intervention for teachers guided by the Behaviour Change Wheel (BCW) framework (Michie *et al.* 2011). A pilot study was conducted with one classroom teacher and her students (n=28) to evaluate the effectiveness of MI lessons on students' MVPA levels. The teacher taught one active Maths lesson and one active English lesson each day for a week. Usual classroom lessons served as a control. Teacher and student satisfaction were also evaluated. Results demonstrated that MI lessons were effective in eliciting time in MVPA ($p<.01$) (mean 8 minutes daily) as well as being well received by the students and the teacher.

These findings from the pilot study then informed the refinement of the 'Active Classrooms' protocol and conduct of a cluster randomised controlled trial to assess the effectiveness of the programme on the MVPA levels of students during class-time and throughout the school day. Ten teachers in randomly selected schools and their students (n=248) agreed to participate. The intervention group participated in two MI lessons daily (one Maths and one English) taught by the classroom teacher for 8 weeks. PA was measured using accelerometers at baseline, during the final week of the intervention and at follow-up after 4 months. A repeated measures ANCOVA identified a significant difference for change in daily class time MVPA between the intervention group and control group from pre- to post- intervention ($p<.001$) and this difference was maintained at follow-up ($p<.001$). No significant difference emerged for change in school day MVPA between the groups from pre- to post- intervention ($p=.52$) or follow-up ($p=.09$). Teachers' (n=5) perceptions of the effectiveness and use of the intervention were assessed using questionnaire data, and students' enjoyment of the programme was evaluated using a draw-and-write technique (n=129) and focus group discussions (n=20) post-intervention. Teachers and students were highly satisfied with the programme emphasising enjoyment, health benefits and enhanced teaching and learning as contributing to its success. Since teachers are central change agents their acceptability of the programme is key to its effectiveness.

The focus on teacher behaviour through the BCW framework (Michie *et al* 2011) in the design of a MI intervention contributes to the uniqueness of the study. While the limitations of this study must be taken into consideration, these findings provide evidence for MI as an effective and implementable strategy to increase MVPA which has important implications for the health of primary school children.

Keywords: movement integration, physical activity, accelerometer, draw and write, enjoyment, teacher approval, randomised controlled trial

Declaration

I hereby declare that:

This thesis is my own work. All quotations from other sources are duly acknowledged and referenced. This document as a whole is not the same as any that I have previously submitted or am currently submitting, whether in published or unpublished form, for a degree, diploma, or similar qualification at any university or third level institution. I am the author of this thesis and the principal author of the five articles which form its core.

Signature: ___________________________

Rosemarie Martin

Date: ___________________

Acknowledgements

"At times our own light goes out and is rekindled by a spark from another person. Each of us has cause to think with deep gratitude of those who have lighted the flame within us." Albert Schweitzer

Many people have helped along my Ph.D journey to keep my flame alight and to those people I am forever grateful.

To my supervisor, Dr. Elaine Murtagh I would like to express the deepest appreciation for everything over the past four years. Without all of your time, dedication, help, guidance and encouragement over the past few years my dream of completing this thesis would not have been possible. I would also like to thank other members of staff in Mary Immaculate College for their help along the way.

I am indebted to the students, teachers and principals who participated in the 'Active Classrooms' programme. This study would not have been possible without your willingness to participate and your openness in sharing your thoughts and drawings. Thank you!

To all my friends, thank you for your patience, encouragement, support and understanding especially to Louise Purcell, Georgina Condon, Anne Hogan and Lucy Sheehy for your "corrections". Thank you to my team mates and management of Mungret/St.Paul's and Limerick Ladies football teams for the study breaks over the years! To the Board of Management and Staff of Donoughmore National School, thank you for your encouragement and support throughout the process.

To my parents, Thomas and Marie Giltenane for all your love, help, support and encouragement not only during this process but throughout my life. You have been my inspiration and my motivation. You have always encouraged us to achieve to our highest potential, reach for the stars and follow our dreams. Thank you! My sisters, Martina and Olivia deserve my wholehearted thanks for the coffee dates, 'brain dumping' and resources shared! Thanks also to my brothers Thomas, Denis and Brendan for your moral support.

Finally, and most importantly to my own little family. Seamus, thank you for your patience, technical assistance, support, encouragement and everything you have done to help me get through this! When times were tough, you never let me give up. To my beautiful sons, Jason and Ivan, thank you for being my motivation and being with me throughout the journey! I love you both to infinity and beyond!

Dedication

"In life, one has a choice to take one of two paths: to wait for some special day—or to celebrate each special day"
Rasheed Ogunlaru

This thesis is dedicated to:

My parents, Thomas and Marie,

My husband, Seamus

and

My two beautiful boys, Jason and Ivan.

For their unconditional love, support and encouragement.

I am truly thankful for having you all in my life.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BCT	Behaviour Change Techniques
BCW	Behaviour Change Wheel
BMI	Body Mass Index
C	Control
CDC	Centers for Disease Control and Prevention
CHAM JAM	Children's Hospital at Montefiore Joining Academics and Movement
COM-B	Capability, Opportunity & Motivation to performing a Behaviour
CONSORT	Consolidated Standards of Reporting Trials
COREQ	Consolidated Criteria for Reporting Qualitative Research
CPM	Counts per minute
CSPAP	Comprehensive School Physical Activity Programme
CSPPA	Children’s Sport Participation and Physical Activity study
DALY	Disability Adjusted Life Years
DCYA	Department of Children and Youth Affairs
DES	Department of Education and Skills
EASY Minds	Encouraging Activity to Stimulate Young Minds
EMBASE	Excerpta Medica database
ERIC	Education Resources Information Center
ES	Effect Size
F & V	Fit en Vaardig op school’ (Fit and academically proficient at school)
GAPA	Global Advocacy for Physical Activity
GUI	Growing up in Ireland
HBSC	Health Behaviours in School Children
HSE	Health Service Executive
I	Intervention
ICMJE	International Committee of Medical Journal Editors
ILSI	International Life Sciences Institute
IOM	Institute of Medicine

LPA	Light Physical Activity
MET	Metabolic Equivalent
MI	Movement Integration
MIREC	Mary Immaculate College Research Ethics Committee
MRC	Medical Research Council
MVPA	Moderate-to-vigorous physical activity
NCCA	National Council for Curriculum and Assessment
NCD	Non-Communicable Disease
NPAP	National Physical Activity Plan
PA	Physical Activity
PAAC	Physical Activity Across the Curriculum
PAD	Physical Activity Data
PDPAR	Previous Day Physical Activity Recall
PE	Physical Education
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
QIF	Quality Implementation Framework
RCT	Randomised Controlled Trial
RE-AIM	Reach, Effectiveness, Adoption, Implementation, and Maintenance
SD	Standard Deviation
SOFIT	System for Observing Fitness Instructional Time
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
UKHEA	United Kingdom Health Education Authority
US	United States
WHO	World Health Organisation

Research Communications

Publications:

- **Martin, R**., and Murtagh, E. M. (2015) 'Preliminary findings of *Active Classrooms*: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127 (impact factor 1.82).
- **Martin, R.** and Murtagh E.M. (2015) 'An intervention to improve the physical activity levels of children: Design and rationale of the *'Active Classrooms'* cluster randomised controlled trial', *Contemporary Clinical Trials*, 40, 180-191 (impact factor 2.05).
- **Martin, R.** and Murtagh, E.M. (2017) 'An evaluation of teacher and student perceptions of participating in the *Active Classrooms* programme', *Teaching and Teacher Education*, 63, 218-230 (impact factor 1.82).
- **Martin, R.** and Murtagh, E.M. (2017) 'Active Classrooms': A Cluster Randomised Controlled Trial Evaluating the Effects of a Movement Integration Intervention on the Physical Activity Levels of Primary School Children', *Journal of Physical Activity and Health*, 14, 290-300 (impact factor 1.88).
- **Martin, R.** and Murtagh, E.M. (2017) 'Effect of active lessons on physical activity, academic and health outcomes: A systematic review', *Research Quarterly for Exercise and Sport*, 1-20 (impact factor 1.702).

Conference Presentations:

- **Martin, R.** (2014) '*Active Classrooms*: A Classroom Intervention to Improve the Physical Activity Levels of Primary School Children'. International Research Methods Summer School. Mary Immaculate College, 6th – 8th June.
- **Martin, R.** & Murtagh E.M. (2014) 'The Active Classrooms study protocol: an intervention to improve the physical activity levels of children by teaching literacy and numeracy using physically active methodologies'. PEPAYS-Ireland Annual Research Forum. Waterford Institute of Technology, 5th-6th June.
- **Martin, R.** (2015) 'The Active Classrooms pilot study: an intervention to increase physical activity levels of primary school children during class time'. All Ireland Postgraduate Conference in Sport Sciences and Physical Education. University of Limerick, 23rd Jan.

- **Martin, R.** & Murtagh E.M. (2015) 'From sedentary classrooms to active classrooms as teachers transition to a new method of teaching: integrating physical activity and academic content. Educational Studies Association of Ireland Conference'. Maynooth University & Carton House, 9th -11th April.
- **Martin, R.** & Murtagh E.M. (2015) 'The impact of physically active teaching methods on students' MVPA levels'. PEPAYS-Ireland Annual Research Forum. University of Limerick & Mary Immaculate College, 9th June.
- **Martin, R.** & Murtagh E.M. (2016) 'The effects of a classroom-based physical activity intervention, '*Active Classrooms*', on the moderate-to-vigorous physical activity levels of primary school children'. PEPAYS-Ireland Annual Research Forum. Tralee Institute of Technology, 30th May.
- **Martin, R.** & Murtagh E.M. (2017) 'An intervention to improve the physical activity levels of primary school children'. Psychology Health and Medicine Conference. Royal College of Surgeons, 3rd March.

CHAPTER 1

INTRODUCTION

Chapter 1: Introduction

1.1 Introduction

This thesis explores the development of a classroom-based physical activity (PA) intervention and evaluates its effects on the PA levels of primary school children. Chapter 1 places this thesis in context by outlining background information of the problem being explored. In doing so, a rationale underpinning the overall research project is outlined. Research objectives undertaken and reported in the thesis are set out. The structure of the thesis and its integral components are also outlined.

1.2 Rationale for the research

There is increasing research evidence of the declining daily PA levels of children throughout the world. It has been reported that less than 20% of children globally are achieving the recommended 60 minutes of moderate-to-vigorous physical activity (MVPA) per day for health benefits (WHO 2010). In most European countries, PA begins to decline significantly in children between the ages of 11-15 years (WHO 2016). This decline has been identified particularly in girls with more than 86% of 15-year-old girls considered to be physically inactive (Currie 2008, WHO 2016). These high levels of physical inactivity track across phases of life into adulthood (Twisk *et al.* 2000), are linked to obesity, cardiovascular disease, coronary heart disease, hypertension, type 2 diabetes, and cancer and have resulted in higher rates of morbidity and mortality throughout the world (Naylor and McKay 2009, WHO 2010). These high rates of inactivity are also particularly true to Ireland with 70% of boys and 84% of girls aged 9-18 years not achieving 60 mins of PA daily (Inchley *et al.* 2016). Increasingly sedentary living and school environments are thought to have contributed to physically inactive lifestyles with children spending more time engaging with technology and screen-based activities than engaging in PA (Hamilton *et al.* 2008).

Schools internationally have been recognised as a key location to intervene as the majority of children attend school and targeting this age group may encourage physically active behaviours to continue into adulthood (Twisk *et al.* 2000, GAPA 2010, WHO 2016). However, ironically schools have been identified as significant sedentary environments with children spending the majority of their day seated to receive instruction (Nettlefold *et al.* 2011, Hegarty *et al.* 2013). Therefore, in an effort to combat inactivity amongst children in schools the Institute of Medicine has recommended that children accumulate at least 30 minutes of MVPA during school hours (Kohl and Cook 2013). The Department of Education and Skills in Ireland (Curriculum and Assessment Policy Unit 2016) recently released a circular (0013/2016) recommending that all primary schools develop a formal plan to promote PA outside of the Physical Education (PE) curriculum. However, with an already over-crowded curriculum, assessment pressures and emphasis on general academic subjects such as literacy and numeracy, teachers face a lack of time for PA breaks. Therefore, methods of integrating PA into the academic curriculum are necessary.

The Centers for Disease Control and Prevention (2013) supports the Comprehensive School Physical Activity Programme (CSPAP) which provides guidelines to schools to enable all students to accumulate 60 minutes of MVPA during the school day. It suggests that students must be provided with multiple opportunities to access PA throughout the school day. One component of the programme includes the integration of PA into classroom lessons. This infusion of PA into general education lessons has been termed movement integration (IOM 2013). Unlike PA breaks which provide active breaks throughout the day, movement integration intends to engage students in PA during instruction of the existing curriculum (Martin and Murtagh 2015; McMullen *et al.* 2016). Two previous systematic literature reviews identified 16 published interventions which integrate PA into academic lessons (Norris *et al.* 2015, Webster *et al.* 2015). These existing interventions have illustrated that academic lessons which integrate movement not only positively impact students' PA levels but also improve their health, academic achievement, concentration, classroom behaviour and time-on-task (Norris *et al.* 2015, de Greeff *et al.* 2016). These findings stand in contrast to some teachers' beliefs that lessons integrating movement reduce academic teaching time and interrupt learning (Morgan and Hansen 2008). It is also apparent that opportunities to increase the PA levels of a large population of children can be provided by altering teaching methods to those requiring students to be more physically active as part of the academic curriculum, since the students are under the instruction of the teacher. By integrating PA and curricular content, teachers can focus on academic teaching objectives while also providing greater opportunities for their students to engage in additional PA. This method also contributes to experiential/kinaesthetic learning which emphasises involving students for effective learning (Lengel and Kuczala 2010). Therefore, there is strong evidence to support the CSPAP (Centers for Disease Control and Prevention 2013) recommendation of integrating PA into academic lessons in the classroom.

While the literature referred to above highlights the need for increased PA during school time and supports the concept of movement integration as an effective means to improve PA levels of children, a systematic review of movement integration interventions (Chapter 2: Part B) identified many specific research gaps which motivate the research undertaken in this thesis:

- It has been recognised that many movement integration interventions have not considered theory in their development or analysis (Norris *et al.* 2015). Such interventions have been criticised as lacking theoretical grounding and valid basis for their development (Michie *et al.* 2009). Implementation Science encourages the scientific development and reporting of behaviour change interventions which allow specific functional components responsible for observed changes to be clearly identified and replicated (Dombrowski *et al.* 2007). The Behaviour Change Wheel (Michie *et al.* 2011a) framework outlines a systematic process to intervention development which is based on an initial evaluation of the target behaviour in context, then identification of specific evidence-based behaviour change techniques. The use of this framework in the development of the current intervention intends to enhance replication, implementation and evidence synthesis.
- The need to undertake robust research studies to evaluate the effects of movement integration interventions has been highlighted in the literature (Chapter 2: Part B). Few movement integration studies evaluated their primary outcomes using randomised controlled trials or cluster randomised controlled trials. Since these are regarded as the most rigorous methods of determining the effectiveness of an intervention (Moher *et al.* 2010) a cluster randomised controlled trial has been employed in the current study.
- To ensure effective implementation of interventions it has been emphasised that the needs of their primary implementers and key stakeholders should be central to their development (Meyers *et al.* 2012, Michie *et al.* 2014). Teachers and students are the primary stakeholders of classroom-based interventions. Failure to identify and overcome barriers for teachers to implement such interventions results in implementation failure (Han and Weiss 2005) and enjoyment experienced by students has been found to influence effectiveness of PA interventions. Presenting students with programmes they enjoy results in high participation and positive results (Dishman *et al.* 2005). This enjoyment also

influences teacher approval of classroom-based PA interventions (McMullen *et al.* 2016). Despite this evidence few existing movement integration interventions evaluate teacher and student perceptions. Therefore, teacher approval and student enjoyment are outcomes which will be evaluated in the current study.

1.3 Research aims

The overall research aim is to design a movement integration intervention linked to the academic content of the Irish Primary School curriculum and evaluate its effects on the MVPA levels of primary school children. The primary outcome is change in minutes of MVPA measured using accelerometers. Secondary outcomes are teacher and student satisfaction with the programme and its implementation. Teacher satisfaction will be evaluated through open-ended and closed questionnaire items. The write and draw technique and focus group discussions will be used to evaluate student enjoyment of the programme.

1.4 Thesis Structure and Objectives

This thesis is presented in the form of an article-based thesis. Five peer-reviewed journal articles which have either been published or accepted for publication in international peer-reviewed journals form the core of this thesis. The full references and specific research objectives addressed in each of these articles are outlined below:

Chapter 2: Part B:

Martin, R. and Murtagh, E. M. (2017) 'Effect of active lessons on physical activity, academic, and health outcomes: A systematic review', *Research Quarterly for Exercise and Sport,* (accepted for publication, 3.2.2017, See Appendix Q), http://dx.doi.org/10.1080/02701367.2017.1294244

Objectives:

- to identify existing classroom-based PA interventions which integrate academic content
- to assess the effect of the interventions on PA, learning, facilitators of learning, and health outcomes
- to identify research gaps in the literature

Chapter 3:

Martin, R. and Murtagh, E. M. (2015) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127. ISSN: 0742-051X, http://dx.doi.org/10.1016/j.tate.2015.09.007

Objectives:

- to evaluate the MVPA levels of the participants during the intervention lessons
- to evaluate teacher and student acceptability of the intervention programme

Chapter 4:

Martin, R. and Murtagh, E. M. (2015) 'An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191. ISSN: 1551-7144, http://dx.doi.org/10.1016/j.cct.2015.01.019

Objective:

- to describe and provide a rationale for the methodological procedures used to design, implement and evaluate the effectiveness of the 'Active Classrooms' intervention

Chapter 5:

Martin, R. and Murtagh, E. M. (2017) 'Active Classrooms: A cluster randomised controlled trial evaluating the effects of a movement integration intervention on the physical activity levels of primary school children', *Journal of Physical Activity and Health*, 14, 290-300, http://dx.doi.org/10.1123/jpah.2016-0358

Objectives:

- to integrate PA into the teaching of English and Mathematics academic content of the Irish Primary School Curriculum
- to evaluate the effectiveness of the programme on students' minutes in MVPA by obtaining objective accelerometer data
- to evaluate teacher acceptability of the programme and teacher ratings of their students' engagement in the programme

Chapter 6:

Martin, R. and Murtagh, E. M. (2017) 'Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme', *Teaching and Teacher Education*, 63, 218-230, http://dx.doi.org/10.1016/j.tate.2017.01.002

Objective:

- to evaluate student enjoyment and explore teacher insights of their experiences of participating in the programme

1.5 Thesis Outline

This thesis is presented as follows: Chapter 2 comprises two parts. Part-A situates the topic under investigation within PA and health literature. A rationale for improving PA levels for the health benefits of children is presented and the concept of movement integration is broadly defined. Part B presents a peer-reviewed and published systematic literature review of movement integration interventions and identifies limitations in the existing studies. Chapter 3 is a peer-reviewed and published article which describes the pilot study undertaken to determine the effectiveness of the intervention lessons on the MVPA levels of the participants. Teacher acceptability and student enjoyment of the lessons are also evaluated. Chapter 4 is a peer-reviewed and published article which outlines and rationalises the methods employed to address the research aims of this thesis. Chapter 5 is a peer-reviewed and published article which presents results of the cluster randomised controlled trial and relates these findings to previous similar studies. Chapter 6 is also a peer-reviewed and published article, which gives teachers and students a voice by describing their perspectives of participating in the programme. Finally, Chapter 7 synthesises the findings of the previous chapters and discusses them in light of the research objectives. The contribution of the study to the broader existent literature is emphasised. In addition, this chapter presents the overall conclusions of this thesis and suggests a series of future research recommendations.

CHAPTER 2

LITERATURE REVIEW

Chapter 2: Literature Review

Part A: Physical Activity for Health in Children

2.1 Introduction

The following literature review describes the health benefits of PA with an emphasis on the health benefits for children. It considers the current international and Irish PA recommendations for children and it looks at the levels of PA children are presently achieving. This will be considered as a rationale for the importance of increasing children's PA levels and using the school as a place for intervention. PA levels of children during the school day are considered and will be used to justify the importance of integrating PA into the classroom ensuring that PA levels during class time are increased. Existing school- and classroom-based PA interventions and their effectiveness are presented, and the barriers preventing them from occurring are discussed.

2.2 Physical Activity and Health

With many innovations in technologies in the 21st century, everyday life offers fewer opportunities for PA compared to that of our pre-technology predecessors. There is much data available to indicate that many children in westernised societies are not participating in sufficient PA due to societal changes in lifestyle. Much responsibility has been placed on the exposure of children to sedentary environments and their increased use of technology (Holt *et al.* 2013). This decline in PA participation is resulting in a large section of society being insufficiently active for health gain which has serious consequences for public health (Oliver *et al.* 2006, Duncan *et al.* 2012). Several studies have emphasised the health benefits of PA and the negative consequences of physical inactivity and prolonged sedentary behaviour. The World Health Organisation (WHO) (2016) has highlighted the need to increase PA levels in children and adolescents as a means to curb the alarming increases in childhood and adolescent obesity, and a range of preventable and lifestyle related diseases which have emerged in the last 30 years in this young population.

Physical inactivity is a contributor to a number of diseases including coronary heart disease (CHD), cardiovascular disease, obesity and its co-morbidities, many cancers and Type II diabetes among others (Hamilton *et al.* 2008). It has been reported that 6-10% of all deaths from these major non-communicable diseases have been caused by physical inactivity (Lee *et al.* 2012).

An alarming estimate of 1.9 million deaths (WHO 2010) throughout the world are as a result of physical inactivity which makes it the fourth leading cause of death worldwide, with tobacco, alcohol and diet being the other leading causes (Bull *et al.* 2010, Kohl *et al.* 2012). However, despite the effects it has on health, physical inactivity still receives less emphasis than alcohol, tobacco, and diet in combatting health issues (GAPA 2010). PA is a 'basic human right' and it has been argued that to reduce the risk of the many adverse health conditions inactivity causes, PA should be defined as a stand-alone public health issue (Kohl *et al.* 2012).

Longer life duration and increased physical and mental health have been directly associated with increased regular PA (Hallal *et al.* 2012, Dobbins *et al.* 2013). The WHO (2010) reports the health benefits of PA, some of which include the reduction of blood pressure, improvement in cholesterol levels, reduction in the risk of cancer and improvement in the control of blood glucose levels in overweight people. The U.S Dept. of Health and Human Services (2012) also attributes improved cardiovascular endurance and a decreased risk of depression and heart attack to physical activity. Other positive outcomes of PA that have been reported include a sense of purpose and value for the individual, a better quality of life, reduced stress, better sleeping patterns, stronger relationships and a greater sense of social connectedness (Das and Horton 2012, Heath *et al.* 2012). These health enhancing properties of PA are evidence based and widely accepted (Woods *et al.* 2012) thus, emphasising the need to actively promote it.

The promotion of PA is highly recommended throughout the world to improve the health of individuals and populations. It has been suggested by Hallal *et al*. (2012) that for health improvements to occur PA should be made a global public health priority. It has also been argued that for population level changes to occur PA interventions need to be implemented in systems across society (Kohl *et al*. 2012), including the education system, rather than focusing on individual behaviour. The WHO emphasises the Health in All Policies approach (Ståhl *et al.* 2006) which involves the whole of government and the whole of society taking responsibility for improving health outcomes. In activity similar vein the Toronto Charter (Bull *et al.* 2010) highlights the importance of PA for the health of all and it outlines actions required to prioritise PA across different sectors of society including education. Similarly, in Ireland the Department of Health (2013) published Healthy Ireland: A Framework for Improved Health and Wellbeing 2013-2025. This framework emphasises the importance of developing a national plan to increase PA levels across the population in an effort to prioritise the improvement of health and wellbeing of the whole society. This has now been produced (Department of Health 2013) and acknowledges the education/health partnership and whole systems approach to promoting PA. The National Physical Activity Plan for Ireland aims to increase the proportion of children taking at least 60 minutes of daily MVPA by at least 1% per annum (National Physical Activity Guidelines Steering Group 2014). School has been identified as a primary setting in which children can gain the knowledge and positive experiences of PA to enable them to live physically active lives (National Physical Activity Guidelines Steering Group 2014). The Department of Education and Skills (DES) has therefore responsibility to contribute towards this target. Extending the number of schools participating in the Active School Flag programme to 500 further schools by 2020 is a specific action which contributes to the DES role in fulfilling the national PA plan's goal (National Physical Activity Guidelines Steering Group 2014). This action can only be achieved if PA interventions and policies are introduced into schools in Ireland which ensure that children are provided with multiple opportunities to be physically active throughout the school day.

2.3 Physical Activity and Health of Children

PA is vitally important for children's health and physical inactivity has serious consequences on their wellbeing which have been found to track into their future lives (Twisk *et al.* 2000). Participating in PA has been linked to reduced stress and anxiety, enhanced self-esteem and reduced risk of coronary disease, type 2 diabetes, obesity and cardiovascular disease among children (Fahey *et al.* 2005, Hamilton *et al.* 2008). It has also been found to have beneficial effects on children's body fat composition, aerobic fitness, cardiovascular performance, bone health, musculoskeletal system and psychological well-being (WHO 2010). Many of the benefits to participating in PA are discussed in more detail in the following sections:

2.3.1 Metabolic Health

PA has often been coupled with diet to address the problem of obesity. Eating a healthy diet and regular physical exercise ensures a balance between energy uptake and energy expenditure resulting in a healthy weight. However, it has been reported that as children require considerable nutritional intake for growth and development, weight is more effectively controlled through increased PA than diet alone (Baranowski *et al.* 2000). It is well documented that PA is essential to achieve and maintain BMI levels within the healthy range, preventing overweight and obesity (Kimm *et al.* 2005, Doak *et al.* 2006). PA contributes to the body's energy expenditure which must balance its food energy intake if a healthy weight and BMI are to be established. PA has also been reported to increase metabolic rate and reduce risks for metabolic syndrome (Ferguson *et al.* 1999, Andersen *et al.* 2006). Given the many health effects of PA, it is argued that coupling PA with diet weakens efforts to develop approaches to tackle the pandemic of physical inactivity in children because it confines opportunities for action and hinders the development of holistic approaches to address PA and inactivity (Kohl *et al.* 2012). Therefore, where children are concerned PA should be a distinct public health issue.

Given the well-established link between PA and weight control, Hardman et al. (2009) claim that many children are not engaging in sufficient PA and are thus contributing to the prevalence of overweight and obesity. This is evident internationally and has also been found to be true to Ireland. In comparison to a number of European and developed countries, Ireland has one of the highest occurrences of overweight children (24.7%) along with Israel and Portugal (Lissau *et al.* 2004). The Growing up in Ireland Survey (Layte and McCrory 2011) recognises childhood overweight and obesity as a public health problem. The high level of overweight and obese children in Ireland may have a significant impact on the development of chronic diseases in the future Irish population. It is recognised that obesity and heart disease lay their roots in childhood, making the levels of PA in this group particularly important to the long-term impact on public health (Waring *et al.* 2007). Many studies have shown that PA interventions can improve obesity levels and childhood is a critical time to intervene (Ferguson *et al.* 1999, Owens *et al.* 1999, Livingstone 2001). Therefore, to ensure the health of our children and future generations, children of all ages must engage in PA and interventions are required to make this happen.

2.3.2 Cardiorespiratory Health

Engaging in PA has been found to contribute to improvements in the health of both the cardiovascular system and the respiratory system. This is significant since total and abdominal adiposity and cardiovascular disease risk factors are influenced by the fitness levels of these systems (Ortega *et al*. 2007). Children's engagement in endurance activities such as aerobics, walking, running, cycling, stair climbing, basketball etc. is reported to increase their cardiorespiratory fitness in a range from 5% to 15%, and the higher their PA levels the higher their cardiorespiratory fitness levels (Physical Activity Guidelines Advisory Committee 2008). Improvements in cardiorespiratory fitness have been found to positively affect anxiety, depression, self-esteem, mood status, as well as being associated with higher academic achievement (Ortega *et al*. 2007). Although it is acknowledged that engaging in any PA has health benefits (Janssen and LeBlanc 2010), the dose of exercise found to improve cardiorespiratory fitness has been outlined as an intensity between 70-90% of maximal heart rate (MVPA) for 20-60 minutes, 3-4 days per week over a duration of 1 to 3 months (Baquet *et al.* 2003, Physical Activity Guidelines Advisory Committee 2008). Therefore, school PA programmes could contribute to the improvement of cardiorespiratory fitness levels of students if implemented often with emphasis on intensity, over a sustained period.

2.3.3 Musculoskeletal Health

PA has also been identified as a vital component for healthy skeletal development of children. Positive associations have been identified between bone mineral density and engagement in high impact or weight bearing PA during childhood (Physical Activity Guidelines Advisory Committee 2008). This has important implications for the healthy development and maintenance of skeletal mass, preventing osteoporosis. Accidental fractures have occurred more frequently in children who have lower bone densities than similar aged children with greater bone densities (Hind and Burrows 2007). The fractures and disability as a result of brittle and porous bones cause complications later in life such as morbidity and mortality, prolonged hospitalisation, loss of independence, feelings of depression and reduced quality of life (Iqbal 2000), which take a vast personal and economic toll. Preventing osteoporosis by ensuring that children and youth develop strong high density bones has been emphasised as far superior to any treatment for older individuals (Iqbal 2000). Therefore, since engaging in PA encourages bone development, it is a key WHO (2003) recommendation for the prevention of osteoporosis.

2.3.4 Mental Health

In addition to physical health, PA also has an influential role in mental health and wellbeing. Mental illness is a serious public health issue which can affect people irrespective of age, gender or socio-economic status. Eating disorders, suicide, depression and anxiety are some of the dominant conditions which affect more young people globally than any other age profile (Biddle and Asare 2011). It is projected that unless drastic measures are taken, mental illness will compose 15% of the global burden of disease by 2020 (Biddle and Mutrie 2007). Self-esteem is highlighted as a key indicator of positive mental health and well-being with improvements in self-esteem leading to improvements in mental health. Participation in regular PA improves skills, knowledge, fitness, health and social factors which are associated with enhanced self-perceptions. Positive self-perceptions then stimulate positive views about oneself resulting in an improved self-esteem and sense of well-being (Duncan and Eyre 2008). A meta-analysis in children and young people (aged 3-20 years) revealed that engaging in PA has indeed beneficial effects on children's self-esteem (Ekeland *et al.* 2005). Additional studies have also demonstrated that engaging in regular PA has positive effects on depression and feelings of anxiety in children and young people (Larun *et al.* 2006, Biddle and Asare 2011). Considering these beneficial effects on mental health, it is not surprising that participation in PA is a strategy recommended by the WHO (2010) to protect the psychological well-being of young people.

2.3.5 Cognitive Functioning and Academic Achievement

Engaging in PA is reported to increase circulation to areas of the brain which initiate learning (Blakemore 2003). Many studies and systematic reviews have been conducted to evaluate the effects of PA on academic performance and cognitive functioning (Tomporowski *et al.* 2008, Trudeau and Shephard 2008, Centers for Disease Control and Prevention 2010). Results have demonstrated that routine PA can be linked to improved academic achievement and cognitive functioning in children. Positive associations were also reported for classroom behaviours such as time-on-task, concentration and attention. Moreover, reviews have demonstrated that reducing curricular time to incorporate PA into the school day does not negatively impact students' learning (Keeley and Fox 2009). These findings lend support to the idea that PA should be emphasised in childhood as a means to support and facilitate cognitive development, learning and academic achievement.

Given the plethora of physical, psychological, and economic benefits of PA outlined in this section there is no doubt that children should be facilitated to participate in as much PA as possible daily.

2.4 Current Physical Activity Recommendations for Children

WHO (2010) recommendations state that children aged 6-17 years should participate in at least 60 minutes of MVPA every day, and perform vigorous, high-intensity PA, muscle strengthening and bone strengthening physical activities on at least three days per week. To develop these recommendations a global group with expertise in PA, policy development and implementation was established. This expert group compiled and assessed the scientific evidence relevant to PA in the prevention of non-communicable diseases among children. The evidence used is published in the Physical Activity Guidelines Advisory Committee (2008) report. The suggested guidelines were reviewed by the WHO Guideline Review Committee, peer reviewed and published. An additional independent review also confirms the validity of these recommendations. In their review of health benefits of PA for children, Janssen and LeBlanc (2010) report that some health benefits can be achieved through an average of 30 mins of PA per day. However, they recommend that children should accumulate 'an average' of at least 60 mins per day, and to elicit more health benefits for children who are already somewhat active, higher targets of up to several hours of at least moderate intensity PA should be set.

Intensity thresholds have been defined in terms of multiples of resting energy expenditure (METs) (Saint-Maurice *et al.* 2016). There is consensus in the literature that for children the threshold for moderate intensity PA is activity that is executed at 4 times the intensity of rest (i.e. ≥ 4 METs) and vigorous intensity PA is defined as activity that is executed at 6 times the intensity of rest (i.e. ≥ 6 METs) (Trost *et al.* 2011). For children, moderate intensity activities include hiking, skateboarding, rollerblading, brisk walking, and cycling. Vigorous intensity activities include running and chasing games, skipping, martial arts, running, cycling, swimming and other sports such as Gaelic football, hurling, tennis, soccer, rugby and basketball. Aerobic activity is the movement of the body's large muscles in a rhythmic manner for a sustained period of time. It has 3 components- intensity, frequency and duration. Research has shown that the total amount of PA (minutes of moderate intensity PA) is more important for achieving health benefits than any one component (frequency, intensity or duration) (US Department of Health and Human Services 2012). Muscle-strengthening activities include resistance training and weight lifting. Bone- strengthening activity is when force is placed on the bones promoting growth and strength e.g. jumping jacks, running, brisk walking, weight lifting etc. Many of these activities can serve multiple purposes as they are also aerobic and muscle-strengthening activities (Health Service Executive and Department of Health and Children 2009, US Department of Health and Human Services 2012). Since children can use their own body weight for resistance and weight exercises, these guidelines can be achieved without the use of specialised equipment.

The PA guidelines suggest that time in PA can be accumulated in bouts throughout the day (National Physical Activity Guidelines Steering Group 2014, World Health Organization 2016). In 1998 the UKHEA Conference's primary recommendation shifted the emphasis from sustained periods of activity to activity accumulated over a day and also removed the emphasis from vigorous intensity to moderate intensity PA for all young people (Armstrong and Welsman 2006). This is important since it makes the target of 60 minutes more achievable, especially for those least motivated to engage in PA. Out of reach targets have been found to undermine PA participation (Janssen and LeBlanc 2010) and accumulating moderate PA throughout the day is a goal deemed easier to achieve.

Although all children may not meet the recommendations, some PA is better than none, especially for those most at risk (Barr-Anderson *et al.* 2011) and it may be easier to encourage them to participate in short bouts rather than extended periods.

Irish guidelines reflect international recommendations and emphasise that while incorporating exercises, activities for children and young people should be fun, match their age, skill level and maturity (Health Service Executive and Department of Health and Children 2009). As stated in much of the literature, the 'Get Ireland Active' (National Physical Activity Guidelines Steering Group 2014) report also acknowledges that activity, no matter how short, counts towards children's 60 minutes and that sedentary behaviour should be replaced by active time to increase children's PA.

The public health guidelines outlined above state that for health benefits to occur PA must be of at least moderate intensity and the more vigorous the activity the greater the health benefits (WHO 2010). However, it must be noted that light intensity PA has also been found to have health benefits particularly when replacing or interrupting sedentary behaviour (Healy *et al.* 2008b). In their systematic review, Janssen and LeBlanc (2010) observed a dose-response relationship between PA and health benefits for children. Similar to the findings of Healy *et al.* (2008) they also report that even small amounts of PA can have benefits for children, especially those in high-risk categories. Aerobic activities are reported to bring about greatest health benefits for children as they enhance the cardiovascular and respiratory systems (Janssen and LeBlanc 2010). Participating in physical activities such as walking, running, swimming, climbing, jumping, resistance exercises etc. have also been shown to improve other physical elements in children such as their fitness, flexibility, muscular strength, mobility, balance, control, body awareness and energy levels. These improvements have been found in healthy children and in children with movement disorders such as cerebral palsy (Payne *et al.* 1997, Strong *et al.* 2005, Scholtes *et al.* 2010). PA and health status are directly related, such that further increases in PA lead to additional improvements in health status and that some PA is better than none. This is true for all children even those with physical disabilities who should be encouraged to be as active as their ability allows (National Physical Activity Guidelines Steering Group 2014) by participating in some form of PA, which is suitable to their needs and abilities. Therefore, the development of interventions, to ensure that daily PA recommendations are being met, is critical for the current and future health of all children.

2.5 Current Levels of Physical Activity Among Children

Despite the well documented benefits of PA and clear guidelines for volume of participation needed for health, PA and inactivity remain a cause for concern. The Global Matrix 2.0 (Tremblay *et al.* 2016), which consolidated the findings of 38 international report cards on the PA of children and youth, reports that average grades for overall PA globally is D (low/poor). This is also true to Ireland which scored a D for overall PA (Harrington *et al.* 2016). Self- report data from the HBSC studies (Callaghan *et al.* 2015, Inchley *et al.* 2016) found that only 23% of children in Ireland meet the PA recommendations. Results from the Growing Up in Ireland Study (Smyth *et al.* 2009) also reported that only 25% of 9 year olds met the recommendations in the previous 7 days and 4% of the children reported that they did not achieve 60 minutes of MVPA on any of the previous 7 days. It must be acknowledged that discrepancies have been identified in the literature between self-report and objectively measured estimates of PA. The CSPPA study (Woods *et al.* 2010) found that 19% of primary school children meet the PA recommendations of at least 60 minutes of MVPA per day. The latter findings may be more accurate since accelerometers and pedometers were used to collect the data and these are regarded as more accurate measures of PA (Dollman *et al.* 2009). The disparity in PA data coupled with reports that the majority of young children cannot accurately recall activities or quantify their duration (Baranowski *et al.* 1984), emphasise the need to use objective measures such as accelerometers and pedometers in such research.

Waring *et al.* (2007) caution that care must be taken when interpreting PA reports since, despite current trends, they found that a wide range in activity levels appears to be common in children, with groups that are very active and very inactive. This is clear in Riddoch *et al.* (2004) where the researchers found significant differences in PA between the genders, with boys being far more active than girls. Their findings suggest that at 9 years of age boys are 21% more active than girls and at 15 years of age boys are 26% more active than girls. They also found that significant declines in PA levels occur as children get older. Nine-year-old boys were found to be 27% more active than 15-year-old boys and 9-year-old girls were 32% more active than 15-year-old girls. On examining the PA patterns of European youth, Armstrong and Welsman (2006) confirmed that international reports with findings stating that PA declines with age and that girls are less likely to be physically active than boys, are consistent across European countries. Therefore, much consideration must be given to engaging girls in PA and of sustaining the PA levels of all children as they grow older.

2.6 Childhood as an Essential Time for Intervention

Many studies have indicated that the age-related decline in PA levels begins during late primary school years (van Sluijs *et al.* 2008). Sherar *et al.* (2007) found that the greatest decrease in MVPA and vigorous PA was in children between the ages of 8 and 9 years (pre-adolescence) for both boys and girls. Given the well-established age-related decline in PA which appears to start before puberty, reaching children before this critical developmental phase is crucial. It is widely accepted that childhood provides a great opportunity to positively influence children's attitudes and encourage participation in PA (Twisk *et al.* 2000, Woods *et al.* 2010). Many studies have suggested that children who learn to love being active are more likely to grow up to be active adults (Twisk *et al.* 2000) thus, highlighting the need to prioritise and invest resources in encouraging PA among children in an effort to sustain these good habits throughout life (Twisk *et al.* 2000, Naylor and McKay 2009, Belton *et al.* 2010, MacCallum *et al.* 2012, Woods *et al.* 2012). Therefore, childhood is a critical period for health promotion interventions in order to break the cycle of physical inactivity. Since schools have been targeted as a key location to reach the majority of children as early as possible (World Health Organization 2016), focusing on children in primary school could change the path of inactivity for the next generation (Riddoch *et al.* 2004).

2.7 School as a Place for Intervention

The school has been identified as a primary location to promote PA among children since most communities have schools and the majority of youth across the full socioeconomic spectrum attend school on a regular basis for a substantial number of their waking hours during the week, for 6-12 years of their lives (Pate *et al.* 2006, Waring *et al.* 2007, Huberty *et al.* 2011, Erwin *et al.* 2012, Murtagh *et al.* 2013). The WHO (2016) and the Global Advocacy for Physical Activity (GAPA) specifically identified schools as a target setting for the promotion of PA among children and youth (GAPA 2010). However, despite this recognition of the central role of schools in promoting health, it has been reported that the primary school is not delivering on its potential to be a good setting for the promotion of PA (Waring *et al.* 2007). Many school environments are reported to contribute to the promotion of poor exercise habits (Colin-Ramirez *et al.* 2010) with children spending the majority of their time in school engaged in physically inactive classroom behaviour (Fairclough *et al.* 2012, Holt *et al.* 2013). Reduced sitting time and increased MVPA have been linked to increased health benefits (Biddle *et al.* 2004, Healy *et al.* 2008b). Therefore, it is recommended that extended sitting time should be limited throughout the day and broken up with MVPA as often as possible (Tremblay *et al.* 2011, National Physical Activity Guidelines Steering Group 2014).

In the United States the problem of childhood inactivity has long been recognised and although schools have been identified as a primary location to reverse this problem, the introduction of the 'No Child Left Behind' policy with its emphasis on academics has considerably reduced time given to PE and PA breaks in school (Opitz 2011). This trend has also been observed in other countries, with reports that children in Australia spend 48% of their time (176 ± 46 minutes/day) across the entire school day being sedentary (Telford *et al.* 2005, Jackson *et al.* 2008, Salmon *et al.* 2010). Unfortunately, a similar trend of emphasising academic subjects has also been identified in Ireland as the DES increased the primary school time allocation for literacy and numeracy by 60 and 70 minutes respectively and emphasise the safeguarding of time spent teaching these subjects (DES 2011). It is recommended that this be achieved by integrating literacy and numeracy into other subjects and reallocating discretionary time and time spent on other subjects to literacy and numeracy. As a result, opportunities for PA during school time are limited.

Break time, lunch time and PE lessons are the traditional ways for students to access PA during the school day. However, many studies have indicated that not all children choose to be physically active during break and lunch time, with much research indicating that boys are much more active than girls during the school period (Riddoch *et al.* 2004, Belton *et al.* 2010, Knowles *et al.* 2013). PE alone cannot provide sufficient activity to help students meet recommended levels of PA to achieve health benefits (Huberty *et al.* 2011). PE as a subject occurs too infrequently (30-60 minute sessions x 1-3 days per week) and provides limited amounts of MVPA due to lack of space and equipment, large class sizes, and in some cases inadequate teacher training (McKenzie *et al.* 1998, Morgan and Hansen 2008, European Commission 2013, Donnelly *et al.* 2013). Cale and Harris (2006) observed it cannot be assumed that children will make the time or find suitable opportunities for one hour of PA daily when left to their own devices. Therefore, it is necessary to implement interventions which provide multiple opportunities for PA throughout the school day (Centers for Disease Control and Prevention 2013). While, it is recognised that schools alone cannot solve the physical inactivity epidemic (GAPA 2010), strong school-based policies and programs, along with the influence of schools on the family and community, can help fight the problem (Wechsler *et al.* 2000, World Health Organization 2010, World Health Organization 2016).

In order to facilitate implementation, introducing PA interventions into schools must consider school budget constraints, limited resources, time and an already existing heavy workload on teachers (Erwin *et al.* 2012, Murtagh *et al*. 2013). Interventions developed to promote the integration of PA into the school day have previously been evaluated (Salmon *et al.* 2007, Ward *et al.* 2007, Erwin *et al.* 2012, Dobbins *et al.* 2013, Norris *et al.* 2015) and reports have determined this instructional strategy to be an inexpensive and effective means of improving PA outcomes for all students (Erwin *et al*. 2012). Additionally, from a public health perspective, school-based programmes which promote PA for children are considered to be the most effective approaches for reducing the risk of chronic diseases associated with inactive lifestyles (Colin-Ramirez *et al.* 2010).

2.8 Interventions in the Primary School

School-based interventions are initiatives undertaken within the school to promote PA during the school day. This is achieved by creating a school environment that is more suitable to attaining higher rates of PA among youth as well as increasing the time students spend engaged in MVPA (Dobbins *et al.* 2009). Significant changes need to be made to the school curriculum to support increased time for PA (Dobbins *et al.* 2009). School-based interventions to promote PA include activity breaks (Mahar *et al.* 2006, Murtagh *et al.* 2013), active lessons (Liu *et al.* 2008, Donnelly *et al.* 2009, Finn and McInnis 2014, Riley *et al.* 2016), active homework (Lubans and Morgan 2008), PE lessons (McKenzie *et al.* 1996, Sallis *et al.* 1997, Eather *et al.* 2013), playground markings and equipment (Huberty *et al.* 2011), health education classes (Eather *et al.* 2013) and changes to the classroom environment (Cardon *et al.* 2004). To the author's knowledge 78 studies have been published to date which report primary school-based interventions with PA outcomes (see Appendix A).

2.8.1 Existing Classroom-based Interventions

For the purposes of this thesis a classroom-based intervention is defined as an intervention designed to reach children directly in the classroom setting, during the normal school day. Many studies have found that children's activity levels are largely restricted during the school day, apart from break time and PE lessons (Tudor-Locke *et al.* 2006, Belton *et al.* 2010). It has been suggested that children should accumulate at least 30 minutes of MVPA within the school day (Pate *et al.* 2006). Much needs be done to provide children with opportunities to meet this goal outside of the traditional occasions such as PE and break time. Classroom-based PA interventions have been identified as a means to increase the PA levels of all students, regardless of gender, especially the low-active groups of children who need more opportunities to be active (Cardon *et al.* 2004, Mahar *et al.* 2006, Oliver *et al.* 2006, Gibson *et al.* 2008, Donnelly *et al.* 2009, Erwin *et al.* 2011a).

To the author's knowledge 63 primary school-based interventions have been published which include components that are delivered at the classroom level. This includes teaching health lessons with (n=12) and without (n=10) PA breaks or PE, PE lessons only (n=7), classroom PA breaks (n=18), movement integration (n=13), changes to the classroom environment (n=2) and having a PA specialist in the classroom (n=1). In the following section classroom-based interventions in primary schools are reviewed. These include activity permissible classroom, health/ PA themed lessons, active breaks and movement integration. A systematic review was conducted to evaluate the effectiveness of movement integration, i.e. those that integrate movement into academic content, and is reported in Part B of this chapter.

2.8.1.1 Activity permissible classroom

Activity permissible classrooms facilitate the creation of more active and engaging teaching and learning areas through the use of exercise stability balls, stand- up desks, node chairs[1] and buoy chairs[2] instead of fixed desks and chairs (Kilbourne 2013). The aim is to promote more active teaching and learning areas. Kilbourne (2013) claims that activity permissible classrooms create opportunities to promote life-long movement and good health. Two studies compared an activity permissive classroom in which sitting was replaced with dynamic sitting, standing and walking around to a traditional classroom with 8 and 10-year-old students (Cardon *et al.* 2004, Lanningham-Foster *et al.* 2008)[3]. Lanningham-Foster *et al.* (2008) reported a 50% increase in accelerometer measured movements (acceleration: m/s^2) in the activity permissive classroom over a 12-week period compared to the traditional classroom setting (n = 24 students). Similarly, accelerometer data showed significantly more lesson-time counts per min during the "Moving School" lessons (n = 25 students) compared to the traditional setting (n = 22 students) over an 18-month period (+404 counts/min, $p<.001$). However, since this intervention involves replacing all existing school furniture with exercise stability balls, stand-up desks, node chairs and buoy chairs it has been argued (Salmon 2010) that it would be very cost-prohibitive to create these types of schools on a large scale.

[1] A free-wheeling chair with a seat that swivels and a swing-out desk
[2] Seat with a contoured base which tilts and swivels to engage the core muscles
[3] Although many interventions of this kind exist to reduce sedentary behaviour (Hegarty *et al.* 2016), this considers interventions that aim to increase PA

2.8.1.2 Health/ activity themed lessons

Health/ PA themed lessons consist of lessons taught by the classroom teacher or by specialists that emphasise the importance of PA to the students. Twenty-two studies incorporated this element into the classroom either as a stand-alone element (n=12) or in conjunction with PE lessons, PA breaks or home activity components to promote PA (n=10). Switch Off- Get Active! (Harrison *et al.* 2006) aimed to reduce screen time and increase children's PA levels by providing them with a 16-week teacher-led health education intervention. While this study did not incorporate a PA component, results of a self-report questionnaire demonstrated that although the health education lessons did not reduce television viewing, they did increase 30 min blocks in MVPA per day (+ .84 30 min blocks/day, $p < .05$) in primary school children. Two multi-component school-based interventions also incorporated health-related lessons in their classroom components (Colin-Ramirez *et al.* 2010, Eather *et al.* 2013). The lessons were delivered by trained specialists and both interventions included daily PA programmes either in the classroom (Colin-Ramirez *et al.* 2010) or during break time and at home (Eather *et al.* 2013). The outcomes of the RESCATE study (Colin-Ramirez *et al.* 2010) were assessed by the Student Physical Activity and Nutrition (SPAN) questionnaire and pedometers measured students' steps/day in the Australian Fit-4-Fun study (Eather *et al.* 2013). Results showed significant improvements in MPA levels of RESCATE students (Colin-Ramirez *et al.* 2010) and in steps/day of Fit-4-Fun students (Eather *et al.* 2013).

Although these health themed lessons seem to be effective in improving PA levels, many are delivered by the researchers/specialists for a specified duration of time and are not sustained beyond the period of the study (Salmon *et al.* 2007, Eather *et al.* 2013). Where classroom teachers are involved in delivering the programmes, finding time to teach these additional lessons as well as incorporating the PA element has been recognised in the literature as an issue (Cothran *et al.* 2010) and a reason for poor or no implementation.

2.8.1.3 Active breaks

Active breaks are breaks in regular classroom instruction to perform physical exercise which may or may not relate to curricular content. Incorporating short bouts of activity during instructional time through active breaks has been highlighted as a means of accumulating PA during the school day (Erwin *et al.* 2011b). Belton et al. (2010) state that such interventions could have the additional benefit of increasing PA levels of lesser active children and girls who are often shown to be less active than males, especially during school. Twenty-five studies identified in Appendix A incorporate PA breaks in primary school. In some of these studies the breaks are delivered by the classroom teacher (Erwin *et al.* 2011b, Murtagh *et al.* 2013) and in others they are delivered by specialists/researchers (Salmon *et al.* 2007). Many interventions aimed to incorporate between 5 and 15 minutes of physically active breaks in the classroom throughout the school day (Naylor *et al.* 2006, Erwin *et al.* 2011b, Murtagh *et al.* 2013). Aside from activity cards, few of the interventions required any additional equipment making them inexpensive and convenient to implement. Some of the studies provided training for teachers to support implementation of the active breaks (Naylor *et al.* 2006, Erwin *et al.* 2011b, Mitchell *et al.* 2013). Pedometers and self-report measures such as activity logs were predominantly used to gather student PA data (see Appendix A). One study reported no significant difference for accelerometer measured average vector magnitude/min between the intervention and control group (Caballero *et al.* 2003) and another reported no significant effect for overall accelerometer measured counts/min (de Meij *et al.* 2011) however, it must be noted that both studies reported positive effects on other outcomes such as fat intake and organised sports participation. All twenty-three remaining interventions reported positive effects on PA outcomes demonstrating that incorporating PA breaks into the classroom could significantly increase the number of steps, counts or minutes in PA children achieve per day. This strategy has been reported to improve PA levels of all children regardless of their gender and it is particularly effective for those in the high risk, low-active groups who need more opportunities to be active (Pangrazi *et al.* 2003, Erwin *et al.* 2011b).

2.9 Movement Integration

Despite evidence of the effectiveness of active breaks in improving PA levels for all children, priority given to academic subjects such as Literacy and Numeracy, in an already overloaded curriculum has resulted in a lack of emphasis on PE and insufficient time for activity breaks in the primary school classroom (Mahar *et al.* 2006, Cothran *et al.* 2010, McMullen *et al.* 2014). In order to resolve this problem which sacrifices PA and instead prioritises academic content, methods of successfully integrating movement into academic lessons in the classroom are necessary (Heidorn *et al.* 2010). Movement integration activities strive to infuse PA into general education lessons (Kohl and Cook 2013). Few school or classroom-based interventions focus on integrating PA into academic lessons (Oliver *et al.* 2006, Donnelly *et al.* 2009, Bartholomew and Jowers 2011, Finn and McInnis 2014, Riley *et al.* 2016). Teaching academic content using physically active methods could be a way of coping with the barriers to increase PA and reduce sedentary behaviour in primary school children.

Take 10! was one of the first programmes designed to integrate movement and academic learning objectives (Peregrin 2001). The initial version was designed by a group of health, education and PA experts within the International Life Sciences Institute (ILSI) Research Foundation in 1999 to promote PA in childhood. Take10! was designed to be implemented in the classroom setting with the aim of integrating 10-minute physically active academic lessons throughout the school day. The programme intended to get students moving without sacrificing academic teaching and learning time (Peregrin 2001). The expert group anticipated that children would gain health and learning benefits from these short bouts of PA. This US-based programme has been implemented, evaluated, refined and disseminated in the US and internationally since 2002 (Kibbe *et al.* 2011). Take 10!, adaptations of the programme and other movement integration interventions have since been implemented in the US, Australia and other countries such as China and the Netherlands (Liu *et al.* 2007, Donnelly *et al.* 2009, Li *et al.* 2010, Kibbe *et al.* 2011, Donnelly *et al.* 2013, Mullender-Wijnsma *et al.* 2015, Riley *et al.* 2016). This instructional strategy is gaining attention in health and PA promotion literature (Norris *et al.* 2015, Webster *et al.* 2015). It has also been recommended in recent national (National Physical Activity Guidelines Steering Group 2014) and international (World Health Organisation 2008, Centers for Disease Control and Prevention 2013, Kohl and Cook 2013) policies as a population-level means to improve PA levels of children. A detailed systematic review was conducted to evaluate existing movement integration studies and is reported in the following Part B of this chapter.

2.10 Summary of Classroom-based Interventions

Integrating PA into the classroom has been an effective approach to improve PA levels among children and it is believed to be an important aspect of school-based health and wellness policies (Erwin *et al.* 2012). The review presented above has illustrated that there are various modes of integrating PA into the classroom. The Activity Permissible Classroom has been shown to be effective in improving students' PA levels but cost-prohibitive to implement on a large scale (Salmon 2010). Health/ PA themes lessons have also been shown to provide students with the knowledge required to improve their PA levels however, most of these interventions were multi-component incorporating activity breaks or additional PE classes. The health lessons were often delivered by the researchers/specialists and may not be sustained beyond the intervention period (Eather *et al.* 2013). Active breaks have also been found to improve students' PA levels. However, teachers have reported that time is a barrier to implementing these additional sessions during class time (Cothran *et al.* 2010, McMullen *et al.* 2014). A recent review of the literature noted that meaningfully integrating PA into academic lessons may be a way of overcoming the barriers to improve students' physical activity levels during class time (Norris *et al.* 2015). However, to date few studies have adopted such an approach and further investigation is needed to confirm the effectiveness of this strategy. Part B of this chapter further evaluates movement integration interventions with regard to health, education and PA outcomes.

Part B: Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review

Preamble

The following article reports a systematic literature review of movement integration interventions. The effect of the interventions on PA, academic and health outcomes of students are examined. This is an Accepted Manuscript of an article which has been peer reviewed and published in *Research Quarterly for Exercise and Sport* online [March 22, 2017], impact factor 2015: 1.702 (Thomson Reuters Journal Citation Reports 2016). It has been reprinted by permission of the Society of Health and Physical Educators, (http://www.shapeamerica.org) (see Appendix S for ©Taylor and Francis copyright permissions). The following is the citation for this article:

Martin, R. and Murtagh, E.M. (2017) 'Effect of active lessons on physical activity, academic and health outcomes: A systematic review', *Research Quarterly for Exercise and Sport*, 1-20 (accepted for publication 3.02.2017, See Appendix Q), http://dx.doi.org/10.1080/02701367.2017.1294244

Statement of authorship:

I hereby declare that I, Rosemarie Martin am the principal author of this article. The following statements outline my contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

(See Appendix R)

2.11 Abstract

Purpose. To conduct a systematic review of classroom-based PA interventions which integrate academic content and assess the effectiveness of the interventions on PA, learning, facilitators of learning, and health outcomes. **Method**. Six electronic databases (ERIC; PubMed; Google Scholar; Science Direct; Cochrane Library, and EMBASE) and reference lists were searched for English language articles, published January 1990 - March 2015, reporting classroom-based interventions which deliberately taught academic content using physically active teaching methods, > 1 week duration, with PA, health, learning or facilitators of learning outcomes. Full text articles were reviewed by two authors. Data was extracted onto an Excel spreadsheet and authors were contacted to confirm accuracy of information presented. **Results.** Fifteen studies met the inclusion criteria. Six studies reporting on PA levels were found to have medium-to-large effect sizes. All four studies reporting learning outcomes reported positive effects of intervention lessons. Teachers and students were pleased with the programmes and enhanced on-task-behavior was identified (n = 3). Positive effects were also reported on students' BMI levels (n = 3). **Conclusions.** Physically active academic lessons increase PA levels and may benefit learning and health outcomes. These teaching methods are also positively received and enjoyed by both students and teachers. These findings emphasize the need for such interventions to contribute towards public health policy.

Keywords: classroom, academic content, movement integration

2.12 Introduction

Recent evidence has shown that since the 1990's an increasing number of primary school aged children are inactive (Holt *et al.* 2013, Metcalf *et al.* 2002). The World Health Organization (WHO) (2010) recommends that school aged children should accumulate at least 60 min of MVPA per day for health benefits. However, less than 20% of children worldwide are achieving these recommendations (WHO 2010). Children who participate in high levels of PA are less likely to develop cardiovascular disease, type 2 diabetes, cancer, and other chronic illnesses (Hamilton *et al.* 2008). For health improvements to occur, it has been proposed that PA should be made a public health priority throughout the world (WHO 2010).

Schools have been targeted to implement PA interventions as they are prime locations to reach the majority of children (Martin and Murtagh 2015b). However, ironically, as children are often required to remain seated to receive instruction, class time represents a significant sedentary period of their day (Holt *et al.* 2013). Globally it is recommended that all schools develop policies to address PA during the school day and not just in PE or active travel (WHO 2010). Previous reviews illustrate that there is evidence of the success of these school-based programmes (Barr-Anderson *et al.* 2011, Dobbins *et al.* 2013). However, emphasis on Literacy and Numeracy has resulted in reduced time for activity breaks and little emphasis on PE (Erwin *et al.* 2012). Therefore, in an effort to overcome these barriers it has specifically been recommended by the CDC (2010) that PA should be integrated into academic lessons since movement has been found to enhance learning while also improving students' PA levels. These physically active academic lessons intend to teach academic content through the use of physically active teaching methods (Martin and Murtagh 2015b) and are distinct from PA breaks which may be unrelated to educational outcomes.

Previous systematic reviews of PA interventions in the classroom setting examined studies which incorporated PA breaks, active transitions, standalone physical activities, and active academic lessons (Erwin *et al.* 2012, Webster *et al.* 2015). These reviews evaluate the interventions with regard to the benefits of movement integration (Webster *et al.* 2015), PA, health outcomes, and educational outcomes (Erwin *et al.* 2012, Norris *et al.* 2015). Interventions evaluating the effect of classroom-based PA breaks on health outcomes- such as posture, bone strength, bone mineral content and stress- were previously reviewed and noted positive results (Erwin *et al.* 2012). However, the effect of classroom-based PA on students' BMI was not evaluated in this review. The relationship between PA and BMI is well documented with PA deemed to be essential to achieve BMI levels within the healthy range, preventing obesity (Doak *et al.* 2006, Kimm *et al.* 2005).

In their recent comprehensive review Norris and colleagues (Norris *et al.* 2015) concluded that all studies reported improved PA in intervention groups or in specific demographics, such as least active girls, as a result of the active academic lessons. Additionally, educational outcomes reported have shown either significant improvements or no difference compared to traditional teaching (Norris *et al.* 2015). This contributes to the growing evidence supporting the link between PA and learning outcomes (Tomporowski *et al.* 2008).

However, both teacher approval and student enjoyment, which have been shown to be essential for success, have not been reviewed previously in relation to such active academic lessons. Although teaching with a physically active academic curriculum has been identified as a way of coping with barriers such as time and assessment pressures (Cothran *et al.* 2010, Naylor *et al.* 2015), to improve PA levels and reduce sedentary behavior in primary school children (Bartholomew and Jowers 2011), teachers have a fundamental role in determining the effectiveness (Fullan 2007) of such interventions. The teacher largely influences what children do in the classroom, it is therefore crucial that teachers are satisfied with the programme. Teachers' opinions, views, and attitudes towards PA have been recognized as the greatest obstacles to PA promotion in the classroom (Morgan and Hansen 2008) and executing change is ultimately an individual decision by teachers (Martin and Murtagh 2015b). Therefore, behavioral change on the part of the teacher, as well as providing them with interventions that coincide with their curriculum, schedules, and their principles and beliefs about teaching (McMullen *et al.* 2014) are required to encourage classroom teachers to adopt responsibility for integrating PA into academic lessons. Student enjoyment has also been found to influence and control the effects of PA interventions (Howie *et al.* 2014). Enjoyment has been recognized as a key component of acceptability and a prevailing motivational element for children to engage in PA (Allender *et al.* 2006). Evidence illustrates that the beneficial effects of PA interventions are determined by levels of student enjoyment with increased PA resulting from greater enjoyment (Dishman *et al.* 2005, Schneider and Cooper 2011). Teacher approval of classroom-based interventions has also been found to rely on student enjoyment (McMullen *et al.* 2014). Therefore, it is essential to consider teacher approval and student enjoyment of PA interventions.

In their recent review Norris and colleagues (2015) identified a need for further, more rigorous research in order to firmly ascertain the effects of physically active lessons. Additionally, Webster *et al.* (2015) concluded that there is a need for research which demonstrates the contribution of physically active lessons towards students' positive dispositions towards PA. Therefore, the present systematic review intends to synthesize the existing evidence base by including BMI as a health outcome and facilitators of learning outcomes such as student enjoyment and teachers' approval, which have been deemed essential in determining the success or failure of such classroom-based PA interventions (Cothran *et al.* 2010, Howie *et al.* 2014).

This paper is the first review to consider the effects of physically active academic lessons on PA, learning, facilitators of learning (to include teacher approval, student enjoyment and on-task behavior), and health (BMI) outcomes. To inform future practice and present a strong case for schools to incorporate PA into academic lessons in the classroom it is important to provide a comprehensive summary of previous interventions with regard to these outcomes. Therefore, this systematic review aims to identify existing classroom-based PA interventions which integrate academic content and assess the effect of the interventions on PA, learning, facilitators of learning, and health outcomes.

2.13 Method

The PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) was followed in conducting and reporting this systematic literature review (Moher *et al.* 2009). A review protocol has not been published previously.

2.13.1 Criteria for Considering Studies for this Review

In this review the following conditions were used to select studies: (a) the intervention was applied in a school classroom setting; (b) study participants were school aged children (5-18 years) and included all children regardless of their body mass index category. Studies where PA interventions formed part of treatment programmes for participants with specific illnesses or multifactorial diseases (e.g. heart disease) were excluded; (c) interventions which deliberately taught academic content using physically active methods; (d) the intervention must be of at least one week duration; (e) one or more of the following outcomes reported: proportion of class time in moderate-to-vigorous physical activity (MVPA); duration of MVPA (time spent engaged in MVPA); learning outcomes (e.g. academic performance); facilitators of learning (e.g. behavior, enjoyment, concentration, attention); health outcomes (e.g. BMI); (f) English language articles published in peer-reviewed journals between January 1990 and March 2015. Articles reporting multicomponent interventions were excluded if the effects of the classroom-based intervention were not specified.

2.13.2 Search Methods for Identification of Studies

A systematic literature review was conducted to identify classroom-based PA interventions. This review places emphasis on the school classroom setting therefore the search focused on location (classroom-based), behavior (PA), and accumulation of PA, health benefits or educational benefits as outcome measures. A comprehensive search strategy was developed to coincide with the Cochrane Collaboration methodology for conducting literature searches (Higgins and Green 2011). The following data bases were searched ERIC; PubMed; Google Scholar; Science Direct; Cochrane Library, and EMBASE. English language studies only were included and date limits were set from January 1990 to March 2015. The search terms used to search titles/abstracts were (classroom AND (physical activity OR exercise OR physical inactivity OR sedentary) AND (school)). The search terms were slightly modified for certain databases such as Google Scholar and PubMed where the search terms were classroom AND physical activity AND school.

Papers in press were included. Where conference proceeding titles or abstracts were found authors were contacted for full-text papers. Reference lists from related review and original articles were also hand-searched for relevant papers.

2.13.3 Study Selection

The initial eligibility assessment was performed by one author who reviewed paper titles and abstracts. The full text versions of 63 articles were then reviewed independently by two authors. Where disagreements between reviewers occurred, consensus was achieved through discussion and reassessment of each of the eligibility criteria for the study. The study selection process is summarized in the PRISMA flow-chart below (Figure 2.1).

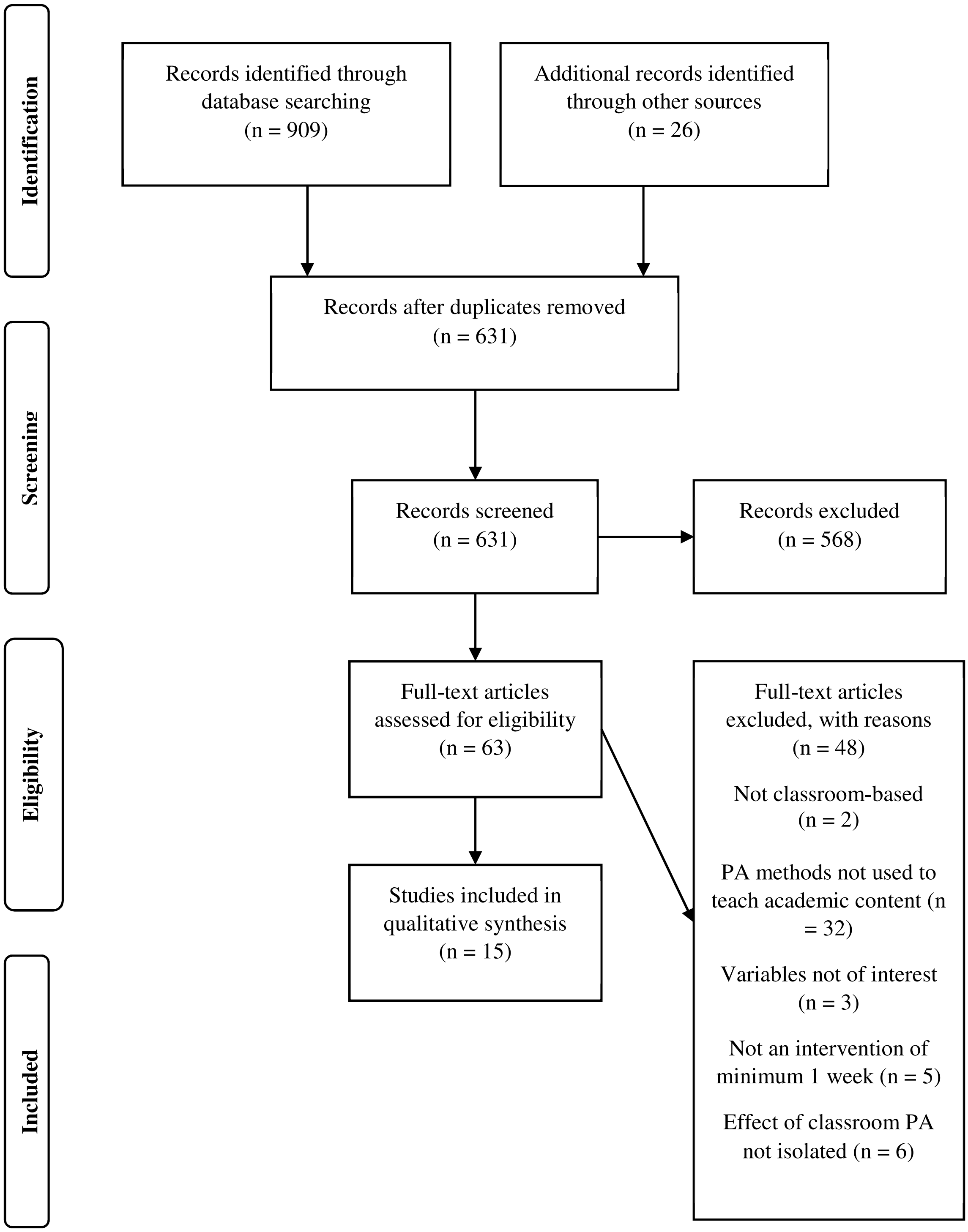


Figure 2.1 Study Selection Process and Flow of Systematic Review

2.13.4 Data Extraction

A data extraction sheet was created in Microsoft Excel to record the following characteristics of each included study: study location, duration, and design; participants' characteristics (age/grade level); intervention characteristics; MVPA, learning, health, and facilitators of learning outcomes. One author extracted the data from included studies.

The primary outcomes of interest are the effects of classroom-based PA intervention programmes which integrate academic content on the MVPA levels, health, learning, and/or facilitators of learning of children aged 5-18 years. The effect size (ES) for each outcome of interest was calculated using the method described in Zhu (2016) within each of the included studies and recorded in Table 2.3. Cohen's d index (ES) (Cohen 1988) was calculated as the difference between treatment and control group means divided by the pooled standard deviation. In studies where pre- and post- test means and standard deviations were reported for each group, ES was calculated by subtracting pre-test ES from post-test ES (Erwin *et al.* 2012). Difference between post-test and pre-test means divided by the pooled standard deviation was used to compute ES for pre/post-test designs (Cohen 1988). In studies which evaluated difference in effect between different grade levels ES was calculated by subtracting the lower grade mean from the upper grade mean (difference between the groups) and dividing by the pooled standard deviation (Cohen 1988). Reported results were assessed in terms of Cohen's effect size standard (≥ 0.8 = large; < 0.8 to > 0.2 = medium; ≤ 0.2 = small) (Cohen 1988). Studies with secondary outcomes received separate effect size scores for each outcome. Neither Liu *et al.* (2007) nor Reed *et al.* (2010) provided sufficient information to allow effect size calculation for PA outcomes. PA was a secondary outcome in the study by Reed *et al.* (2010).

All relevant information related to the outcomes of interest was extracted from each of the included studies and inserted into an Excel spreadsheet where it was collated and analyzed.

The studies were also grouped into those which presented PA outcomes only, learning, facilitators of learning or health outcomes only or those which presented a combination of these outcomes (See Appendix B, Appendix C, and Appendix D). Authors of all included articles were contacted via email and asked to confirm that the information outlined in the appendices accurately represents their study. Thirteen authors responded confirming the accuracy of the information presented (Donnelly *et al.* 2009, Donnelly and Lambourne 2011, Erwin *et al.* 2011a, Finn and McInnis 2014, Goh *et al.* 2014, Lee and Thomas 2011, Liu *et al.* 2007, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Oliver *et al.* 2006, Reznik *et al.* 2015, Riley *et al.* 2015, Li *et al.* 2010).

2.13.5 Risk of Bias Assessment

An evaluation of study merit was carried out using the Cochrane Collaboration 'risk of bias's assessment tool (Higgins *et al.* 2011). This seven-component rating scale for trials assesses randomization, allocation blinding, blinding of participants and researchers, incomplete outcome data, discriminatory reporting, and other potential biases. High, unclear or low risk of bias were awarded in each category. A summary of the assessment is outlined in Table 2.1.

2.14 Results

2.14.1 Study Selection

A total of 909 studies were identified through the electronic databases and an additional 26 articles through searching references of relevant papers and searching studies that have cited these papers. Three hundred and four duplicates were removed. Of the 631 titles and abstracts screened 568 were excluded as they did not meet the inclusion criteria. Sixty-three full text articles were then reviewed. Fifteen of these met the inclusion conditions and were examined in the systematic review. Two of these studies reported outcome measures from the same participants so they were combined in the analysis (Donnelly *et al.* 2009, Donnelly and Lambourne 2011). Figure 2.1 outlines further details including the reasons for exclusion of the full text articles reviewed.

Table 2.1 Risk of Bias Assessment of Identified Studies

	Random Sequence Generation	Allocation Concealment	Blinding of participants	Blinding of outcome assessment	Incomplete outcome data	Free of Selective Reporting	Other bias
Donnelly *et al.* (2009)	unclear	unclear	high	low	low	unclear	low
Donnelly and Lambourne (2011)	unclear	unclear	unclear	low	unclear	unclear	unclear
Dunn *et al.* (2012)	high	high	high	low	low	unclear	high
Erwin *et al.* (2011a)	high	high	unclear	unclear	high	unclear	high
Finn and McInnis (2014)	high	high	unclear	unclear	unclear	unclear	high
Goh *et al.* (2014)	high	high	unclear	unclear	low	unclear	high
Lee and Thomas (2011)	high	high	unclear	unclear	unclear	unclear	high
Li *et al.* (2010)	unclear	unclear	unclear	low	low	unclear	low
Liu *et al.* (2007)	high	high	unclear	unclear	unclear	high	high
Mahar *et al.* (2006)	unclear	unclear	high	high	unclear	unclear	high
Mullender-Wijnsma *et al.* (2015)	high	high	unclear	unclear	unclear	unclear	high
Oliver *et al.* (2006)	high	high	high	high	low	unclear	high
Reed *et al.* (2010)	unclear	unclear	unclear	unclear	high	unclear	high
Reznik *et al.* (2015)	unclear	unclear	high	high	low	unclear	low
Riley *et al.* (2015)	low	unclear	high	high	low	unclear	low

2.14.2 Study Characteristics

All 15 studies selected for this review are classroom-based interventions of at least 1 week duration which integrate PA and academic content. Study sizes ranged from n = 47 (Finn and McInnis 2014) to n = 4700 (Li *et al.* 2010). A total of 9,067 students were tested across included studies however, this does not include one study which reported the number of classrooms (n = 144) rather than the number of participants in the study (Dunn *et al.* 2012). Overall 2,554 students were assessed for MVPA outcomes, n = 2,173 for learning outcomes, n = 416 for facilitators of learning outcomes and n = 6,980 students were assessed for health outcomes. All participants were aged between 5 and 12 years with all studies taking place in primary schools. No intervention based in a secondary school setting met the inclusion criteria. One study had female participants only (Finn and McInnis 2014). Sex of participants ranged from 42.9% males (Donnelly *et al.* 2009) to 58.7% males (Erwin *et al.* 2011a). Three studies did not report participants' sex (Dunn *et al.* 2012, Lee and Thomas 2011, Mahar *et al.* 2006).

Nine studies took place in the U.S. with the remaining studies located in China, Netherlands, New Zealand, and Australia. Six studies conducted randomised controlled trials (Donnelly *et al.* 2009, Mahar *et al.* 2006, Reed *et al.* 2010, Reznik *et al.* 2015, Riley *et al.* 2015, Li *et al.* 2010) while the other studies used non-randomised controlled trials or employed pre/post-test designs with baseline, intervention, and post-intervention assessments. One study did not use a comparative group (Finn and McInnis 2014). The included studies evaluate a range of primary and secondary outcomes which are summarized in Table 2.2 along with the aforementioned study characteristics.

2.14.3 Intervention

To be included in this review, the intervention duration was set at a minimum of one week. This included interventions which took place on five consecutive weekdays. Table 2.2 outlines the intervention durations which ranged from 2 weeks (Lee and Thomas, 2011) to 3 academic years (Donnelly *et al.* 2009). The majority of studies (8) were in the range of 2 to 8 weeks. All included interventions were required to involve the teaching of academic lessons with the integration of PA. The classroom-based PA intervention was the sole intervention of all included studies. Five interventions were based on the principles of TAKE 10! which comprises 10 min of PA integrated into core academic lessons at least once a day (Donnelly *et al.* 2009, Goh *et al.* 2014, Liu *et al.* 2007, Mullender-Wijnsma *et al.* 2015, Li *et al.* 2010). Move-To-Improve (Dunn *et al.* 2012), Energizers (Mahar *et al.* 2006), the EASY Minds study (Riley *et al.* 2015), and the studies by Erwin *et al.* (2011a) and Reed *et al.* (2010) also involve the integration of PA into core curricular content from once a day to three times a week. Two interventions involved the use of PA data objectively collected from the students to teach math and science content (Finn and McInnis 2014, Lee and Thomas 2011). The CHAM JAM intervention consisted of educational focused aerobic activities taught through the use of a CD, for 10 min three times a day (Reznik *et al.* 2015). The final study involved virtually walking around New Zealand which integrated educational content and the tracking of steps taken by individual students to reach each destination city (Oliver *et al.* 2006). Tables 2.2 and 2.3 summarize the data which was extracted and present effect sizes for outcome measures. Appendix B, Appendix C and Appendix D provide more detailed information on the individual studies.

Implementation of the interventions varied with some research teams implementing the active lessons themselves (Riley *et al.* 2015), other research teams assisting teachers with design and execution of the lessons (Donnelly *et al.* 2009, Lee and Thomas 2011), specialist teachers were hired and trained to deliver the *F&V* programme (Mullender-Wijnsma *et al.* 2015) while classroom teachers implemented physically active lessons themselves in the eleven remaining studies. Seven studies provided classroom teachers with training on the intervention programmes (Donnelly *et al.* 2009, Dunn *et al.* 2012, Erwin *et al.* 2011a, Goh *et al.* 2014, Mahar *et al.* 2006, Reed *et al.* 2010, Li *et al.* 2010). This training varied in duration and frequency between the studies from 45 min of once off training (Mahar *et al.* 2006) to 6 hours at the beginning of each academic year (Donnelly *et al.* 2009). No teacher training was specified in the other studies. Resources provided to teachers also varied. Some studies did not provide any resources at all (Donnelly *et al.* 2009, Erwin *et al.* 2011a, Liu *et al.* 2007, Mullender-Wijnsma *et al.* 2015, Oliver *et al.* 2006, Reed *et al.* 2010, Riley *et al.* 2015) whereas 30 fitness breaks and equipment kits were provided to participating teachers in one study (Dunn *et al.* 2012). Lee and Thomas (2011) supplied Physical Activity Data (PAD) technologies for student use and many studies supplied teachers with lesson plans and web links to their respective programmes (Finn and McInnis 2014, Goh *et al.* 2014, Mahar *et al.* 2006, Reznik *et al.* 2015, Li *et al.* 2010). Incentives for participation in the PA intervention were provided in four studies. Two studies used tracking posters and stickers to motivate student participation (Liu *et al.* 2007, Li *et al.* 2010), a third study awarded students with sports center passes and teachers with an undisclosed payment for their participation and compliance with the programme (Erwin *et al.* 2011a) while the fourth study awarded teachers with a professional development stipend of \$68.14 (Dunn *et al.* 2012). Riley *et al.* (2015) specified that no incentives were used in their project. No other paper referred to whether incentives or rewards were used or not. Six studies outline the detail of intervention lessons (Erwin *et al.* 2011a, Oliver *et al.* 2006, Riley *et al.* 2015) or include web links to the lessons allowing them to be replicated (Goh *et al.* 2014, Mahar *et al.* 2006, Reznik *et al.* 2015). Only three studies mention that theoretical frameworks guide their intervention designs. Erwin *et al.* (2011a) discuss the Ecological Model with emphasis on the impact of community and surroundings on the behavior of individuals. Mullender-Wijnsma *et al.* (2015) describe the theory of 'brain-based learning' which places emphasis on grounding teaching methods in the neuroscience of learning and Reznik *et al.* (2015) use the RE-AIM framework to guide their design. This places emphasis on the "Reach, Effectiveness, Adoption, Implementation, and Maintenance" of an intervention programme.

Nine studies reported the use of subgroups for analysis of outcomes. Four of these included subgroups to assess PA levels (Donnelly *et al.* 2009, Erwin *et al.* 2011a, Goh *et al.* 2014) or energy expenditure (Liu *et al.* 2007) using PA monitors. Four studies observed on-task behavior of subgroups (Donnelly *et al.* 2009, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010) and two studies selected subgroups to participate in focus group or individual interviews to assess learning and enjoyment (Finn and McInnis 2014, Lee and Thomas 2011). Of the studies which featured subgroups, only one (Mahar *et al.* 2006) described the selection of participants by randomization. All other subgroups were preferentially selected by teachers or researchers or by means not specified in the study.

2.14.4 Intervention Fidelity and Implementation

Direct observation by the researchers and teacher self-report records were used to evaluate intervention fidelity and/ or teacher compliance in six studies (Donnelly *et al.* 2009, Goh *et al.* 2014, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010, Reznik *et al.* 2015). Teacher self-report questionnaires revealed that PAAC schools achieved 50-83% of the target 90 minutes of MVPA (Donnelly *et al.* 2009). Teachers reported that an average of one ten minute TAKE 10! activity per school day can be successfully implemented (Goh *et al.* 2014). Eighty nine percent of teachers were found to comply with performing Energizers activities once a day (Mahar *et al.* 2006). Implementation and fidelity of the F&V (Mullender-Wijnsma *et al.* 2015) programme was assessed using observations, teacher-reports and heart rate monitors. Results indicate lessons lasted close to the intended 20-30 minutes, 98% of the lesson content was discussed, on-task behaviour was above 70%, and the students were moderate-to-vigorous physically active for 64% of the lesson time. Similar process measures from the CHAM JAM study report that teachers implemented an average of 60-83% of the target activities at Time 2. Finally, to monitor fidelity of their intervention delivery Reed *et al.* (2010) state that random audits by direct observation were carried out, however, they do not provide a report of these observations.

Table 2.2 Summary of Characteristics of Included Studies

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Donnelly et al. (2009), Donnelly and Lambourne (2011)	USA	3 years	x	x		cluster	BMI	PA (mins/day) Academic Achievement Process Measures: (Delivery, intensity & modelling)
Dunn et al. (2012)	USA	6 months			CT		PA daily	
Erwin et al. (2011)	USA	13 days		x			school day PA math class PA	math class PA intensity
Finn and McInnis (2014)	USA	7 weeks			Explor		Teachers' perceptions Students' perceptions	Feasibility of movement integration into science lessons
Goh et al. (2014)	USA	12 weeks (4 B, 8 I)		x		no control	school day PA (steps & intensity/day)	Teacher fidelity

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Lee and Thomas (2011)	USA	2 weeks		x	DTCT		student knowledge	
Li et al. (2010)	China	1 year, 1 year FU	x	x		cluster	BMI	Weight, height, BMI z scores, fat free mass, fat mass, % body fat
Liu et al. (2007)	China	1 year		x	CT		EE, PA (duration &intensity/day)	Height, weight & BMI Prevalence of overweight & obesity EE & PA intensity per session
Mahar et al. (2006)	USA	4 & 8 weeks	x	x		cluster multi-b (TOT)	PA levels (steps/school day)	On-task behaviour

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Mullender-Wijnsma et al. (2015)	Netherlands	21 weeks		x	Q-Exp	with control	academic achievement	Implementation measures: On-task behaviour MVPA levels of lessons
Oliver et al. (2006)	New Zealand	4 weeks		x		no control	PA levels (steps/day)	
Reed et al. (2010)	USA	3 months	x	x		cluster	Fluid Intelligence Academic Achievement	PA (steps/day) PA between groups Fitness performance
Reznik et al. (2015)	USA	8 weeks	x	x		cluster	school day PA (steps/day)	Anthropometric assessment PE class, trip, recess frequency Intervention implementation & process measures

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Riley et al. (2014)	Australia	6 weeks	x				school day PA (% time/day) math class PA (% time/day)	On-task behaviour Teacher & Student Satisfaction (Feasibility)

Abbreviations: Add. Info. Additional Information; B Baseline; Conv Convenience Sample; CT Controlled Trial; DTCT Delayed Treatment Controlled Trial; EE energy Expenditure; Explor Exploratory; FU Follow-up; I Intervention; multi-B Multiple Baseline; PA physical activity; PE Physical Education; P&PT Pre- & post-test; Q-Exp Quazi Experiment; TOT time-on-task

Table 2.3 Summary of Classroom-Based PA Interventions and their Overall Effects on PA, BMI and Academic Outcomes

Study	Classroom-based PA intervention elements		Outcomes (Effect Size Reported as Cohen's d)			
	PA integrated into core academic subjects	Active learning & using PA data	PA	BMI	Learning	Facilitators of Learning
Donnelly et al. (2009), Donnelly & Lambourne (2011)	x		0.65 ↑	0.01 • ↔	[a]↑	
Dunn et al. (2012)	x		1.24 • ↑			
Erwin et al. (2011)	x		1.84[b] • ↑ 0.54[c] • ↑			
Finn and McInnis (2014)		x				q/d [d] •
Goh et al. (2014)	x		- 0.11[e] • ↔ 0.24[f] • ↑			
Lee and Thomas (2011)		x			0.48[g] • ↔ 1.51[h] • ↑	
Li et al. (2010)	x			- 0.13 • ↓		
Liu et al. (2007)	x		• ↑[a]	↓[a]		
Mahar et al. (2006)	x		0.49 • ↑			0.6 ↑

Table 2.3 Summary of Classroom-Based PA Interventions and their Overall Effects on PA, BMI and Academic Outcomes (cont'd)

Study	Classroom-based PA intervention elements		Outcomes (Effect Size Reported as Cohen's d)			
	PA integrated into core academic subjects	Active learning & using PA data	PA	BMI	Learning	Facilitators of Learning
Mullender-Wijnsma et al. (2015)	x				i- 0.66, 0.7 [j] - 0.16, 0.53 • ~	
Oliver et al. (2006)		x[k]	0.09 • ↔			
Reed et al. (2010)	x		↔ [a]		0.3[l] ↑ [a] ↑[m], ↔[n] • ~	
Reznik et al. (2015)	x		0.16 • ↑			
Riley et al. (2014)	x		2.48[b] • ↑ 1.62[c] • ↑			0.9 ↑

Note. • = primary outcome; ↑ = reported as statistically significant increase; ↓ = reported as statistically significant decrease; ↔ = no significant change; ~ = mixed results; q/d = qualitative data

[a] not enough information provided to calculate; [b] Math class; [c] whole school day; [d] no comparative group; [e] change in daily steps; [f] change in intensity; [g] learning; [h] reasoning; [i] Maths grade 2, grade 3; [j] Reading grade 2, grade 3; [k] virtual walk; [l] fluid intelligence; [m] Social Studies; [n]Maths, Science & English

2.15 Outcomes

2.15.1 Physical Activity

As illustrated in Table 2.3 ten studies reported the effects of interventions on PA outcomes. Accelerometers (Donnelly *et al.* 2009, Riley *et al.* 2015), pedometers (Mahar *et al.* 2006, Oliver *et al.* 2006, Reed *et al.* 2010, Reznik *et al.* 2015), and both accelerometers and pedometers (Erwin *et al.* 2011a, Goh *et al.* 2014) were used to evaluate PA intensity levels and step counts in eight studies. Dunn *et al.* (2012) used observation to evaluate minutes spent in PA per day. Donnelly *et al.* (2009) used the System for Observing Fitness Instructional Time (SOFIT) to evaluate the intensity of classroom PA. Energy expenditure was assessed using Zhi-Ji UX-01 PA monitors and time spent in PA was evaluated using a self-report questionnaire completed by students in one study (Liu *et al.* 2007). In addition to using pedometers, Reed *et al.* (2010) also used the Previous Day Physical Activity Recall (PDPAR) questionnaire to evaluate students' PA levels. Two additional studies incorporated the use of heart rate monitors and pedometers to collect PA data however, the data was used for educational purposes within the classroom and was not evaluated by the researchers (Finn and McInnis 2014, Lee and Thomas 2011).

Of the ten studies reporting PA outcomes for physically active academic lesson interventions on students' daily PA levels, three were found to exceed Cohen's convention for a large effect (Cohen's $d \geq 0.8$) (Dunn *et al.* 2012, Erwin *et al.* 2011a, Riley *et al.* 2015). Effect sizes for all ten studies are outlined in Table 2.3.

2.15.2 Learning Outcomes

Four studies assessed the effect of physically active academic lessons on academic attainment (Donnelly *et al.* 2009, Lee and Thomas 2011, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010). Standardized assessments were used in three of these studies. Donnelly *et al.* (2009) used the Wechsler Individual Achievement Test-2nd Edition (WIAT-II-A; The Psychological Corporation 2001) to assess achievement in literacy skills and math. Reed *et al.* (2010) evaluated student achievement using the Palmetto Achievement Challenge Test (PACT) authorized by the South Carolina Education Accountability Act of 1998 and the U.S. government No Child Left Behind Act of 2001. Mullender-Wijnsma *et al.* (2015) assessed academic achievement in math through the use of a Tempo-Test-Rekenen (Speed Test Arithmetic), and the E´en-Minuut-Test (1-Minute Test) assessed the students' reading ability. Lee and Thomas (2011) alternatively used a researcher and teacher designed written test and structured interviews to evaluate the students' learning of math and science topics.

Effect sizes for the studies reporting learning outcomes are outlined in Table 2.3. The PAAC study did not provide sufficient information to calculate effect size for active academic lessons on student's academic achievement however, the authors report a statistically significant improvement (Donnelly *et al.* 2009, Donnelly and Lambourne 2011).

2.15.3 Facilitators of Learning Outcomes

Three of the included studies evaluated facilitators of learning. Three main facilitators were considered: teacher approval (Finn and McInnis 2014, Riley *et al.* 2015), student enjoyment (Finn and McInnis 2014, Riley *et al.* 2015), and on-task behavior (Mahar *et al.* 2006, Riley *et al.* 2015). The nature of qualitative data collected for these outcomes did not allow for effect size calculations.

Teacher approval was evaluated using survey (Riley *et al.* 2015) and interview techniques (Finn and McInnis, 2014). Two teachers completed a 5-point Likert scale to evaluate the timing, instructor quality, appropriateness of programme content, and programme impact of the EASY Minds study (Riley *et al.* 2015). It was revealed that teachers were highly satisfied with the EASY Minds programme and its impact. They also indicated that the programme was well received by the children and that they would feel comfortable teaching the programme. Two teachers participated in semi structured interviews to evaluate the feasibility and teacher approval of the Active Science Curriculum (Finn and McInnis, 2014). They reported that the programme improved students' science inquiry skills, promoted enjoyment of PA, provided opportunities to use technology, and provided opportunities to incorporate PA into academic lessons.

Both studies (Finn and McInnis 2014, Riley *et al.* 2015) which evaluated student enjoyment of active academic lessons used student questionnaires. Finn and McInnis (2014) adapted the Physical Activity Enjoyment Scales (PACES) questionnaire (Kendzierski and DeCarlo 1991) and also conducted focus group discussions with a sub-sample of students. They reported that students enjoyed the integration of PA into science lessons and that the students felt they gained academically from the active lessons. The evaluation questions in the EASY Minds study (Riley *et al.* 2015) applied a 5 point Likert scale ordered from 1 (strongly disagree) to 5 (strongly agree). Results revealed that students were highly satisfied with the programme, that they found the programme highly enjoyable, and enjoyed engaging in PA during their lessons.

Both studies (Mahar *et al.* 2006, Riley *et al.* 2015) which evaluated on-task behavior used momentary time sampling procedures to observe a sub-sample of students. Both studies also assigned two trained observers to simultaneously observe 6 students at a time on a rotational basis. Students were observed at 15 second intervals over a 30 min period (Mahar *et al.* 2006, Riley *et al.* 2015). Periods the students were observed varied between the studies. Students were observed in a 1 hour time slot at baseline, midpoint, and post-test during the EASY Minds study (Riley *et al.* 2015). Intervention lessons were taking place within this observational time at midpoint and post-test. Alternatively, on-task behavior was evaluated for 30 min during regular lessons directly pre and post student participation in *Energizers* activities (Mahar *et al.* 2006), by one observer throughout the *Energizers* study. However, the second observer only observed 40% of all classes. Both studies were found to have positive effects of physically active academic lessons on students' on-task behavior. The EASY Minds study (Riley *et al.* 2015) was found to have a large effect for change in students' on-task behavior between intervention and control groups from pre- to post- intervention. *Energizers* (Mahar *et al.* 2006) were found to have a medium effect on on-task behavior from pre- to post- *Energizers*, across all classes, during the study period.

2.15.4 Health Outcome (BMI)

Three studies included in this review evaluated health outcomes as a result of implementing physically active academic lessons in the classroom (Donnelly *et al.* 2009, Liu *et al.* 2007, Li *et al.* 2010). All three studies evaluated the intervention effect on students' BMI levels and defined BMI categories based on age- and sex-specific BMI calculations (Group of China Obesity Task Force 2004, Kuczmarski *et al.* 2002, Multicenter Growth Reference Study Group, World Health Organization 2006). Weight and height measurements were taken with stadiometers and digital scales. Donnelly *et al.* (2009) obtained height and weight measures at the beginning and end of each of their 3 intervention years. Liu *et al.* (2007) collected age, sex, height, and weight data pre- and post- intervention. Li *et al.* (2010) collected measures at baseline, 1 year later during the intervention and the following year at follow-up. Li *et al.* (2010) reported that students fasted the night before measurements took place.

All three studies evaluating BMI noted small effect sizes. Although no significant difference was identified in the prevalence of overweight and obesity between control and intervention groups in the Happy 10! studies (Li *et al.* 2010, Liu *et al.* 2007), a small effect size was calculated for change in both BMI and BMI z-scores between the groups in Li *et al.* (2010). In this report Happy 10! was found to have a similar effect on boys (-0.06) and girls (-0.08) with a more pronounced effect among obese children at baseline (-0.07) (Li *et al.* 2010). The Liu *et al.* (2007) report however, did not provide sufficient information to compute effect sizes. In the PAAC study (Donnelly *et al.* 2009) a small effect was found for change in BMI between PAAC and control schools from baseline to year three. However, change in BMI was influenced by exposure to PAAC, with a moderate correlation reported for BMI change and average weekly PAAC minutes. Schools that participated in ≥ 75 min of PAAC/week had statistically significant lower increases in BMI at 3 years in comparison to those that participated in < 75 min of PAAC/week ($r^2 = 0.42$, $p = .02$).

2.16 Discussion

This systematic literature review suggests that physically active academic lessons in the classroom can improve MVPA levels of children. There is also evidence that BMI, academic performance, and facilitators of learning may be improved by teaching academic content using physically active methods. Readers should be cognizant however of the great variances that were identified between the studies with regard to number of study participants, intervention duration, training and resources provided, implementation personnel, use of theoretical frameworks, and outcomes. With only six of the included studies using randomised controlled trials to evaluate their primary outcomes (See Table 2.2), this review demonstrates the need to undertake more robust research to evaluate the effects of physically active academic lessons on health and academic outcomes. Nevertheless, the body of evidence presented supports recommendations by the Comprehensive School Physical Activity Program (CSPAP) (Centers for Disease Control and Prevention 2010) to integrate PA into academic lessons since results indicate that improvements occurred in students' PA levels in addition to enhancing their learning. Suggestions that short stints of PA throughout the school day can contribute towards health benefits (Barr-Anderson *et al.* 2011) are also supported. This implies that if implemented long-term and widely, such interventions may result in health improvements reducing the risk of early death and the problem of non-communicable diseases (WHO 2010).

Of the ten studies reporting PA outcomes, six were found to have medium-to-large effects (Cohen 1988) of the physically active lessons on student PA levels. A variety of data collection instruments were used to gather PA data across the studies. These ranged from objective tools such as accelerometers, pedometers, heart rate and PA monitors, and direct observation (SOFIT) which provide measures of PA intensity and/or duration, to self-report questionnaires and Previous Day Physical Activity Recall questionnaires (PDPAR). It has been argued that each measurement tool has its strengths and limitations and that there will always be a compromise between "practicality and accuracy when it comes to… PA measurement… among children" (Trost 2007, p. 299). Baranowski *et al.* (1984) evaluated the use of self-report instruments with children and reported that children younger than 10 years were unable to accurately recall activities or quantify the duration of the activities. Nevertheless, self-report measures have been deemed valid and reliable instruments to observe changes in PA behavior in children (Pate *et al.* 2005) since they provide detailed information on the nature and circumstances of PA along with being inexpensive. Objective measures have been recommended (Trost 2007) as more acceptable for young children since they are unobtrusive and not subject to recall bias. However, they too have their limitations such as being expensive and logistically difficult to administer. Therefore, the positive results which have emerged, considering the strengths and limitations of the range of measurement tools used, demonstrate that there is potential in such interventions to improve the PA levels of primary school children.

Several reports have emphasized the importance that teacher and student attitudes play in determining the success or failure of classroom-based PA interventions (Cothran *et al.* 2010, Fullan 2007, McMullen *et al.* 2014). This review found that students enjoyed physically active lessons and that teachers expressed positive attitudes towards their implementation and outcomes (Finn and McInnis 2014, Riley *et al.* 2015). These findings are reconcilable with previous work which examined teacher approval and student enjoyment of school- and classroom-based PA programmes (Cothran *et al.* 2010, Dishman *et al.* 2005, McMullen *et al.* 2014, Schneider and Cooper 2011). Cothran *et al.* (2010) and McMullen *et al.* (2014) reported that teachers were most satisfied with PA breaks that incorporate academic content and support what they had planned to teach rather than being additional activities. Teachers approved lessons which were easy to implement, enhanced learning, and which lead to student enjoyment. Teachers in the Cothran *et al.* (2010) and McMullen *et al.* (2014) studies also reported that integrating PA increased attentiveness in academic lessons while also motivating and exciting students to participate academically. Schneider and Cooper (2011) and Dishman *et al.* (2005) previously emphasized that interventions should target student enjoyment and aim to promote successful PA experiences which incorporate small group interaction and deemphasize competition. This evidence (Allender *et al.* 2006, Cothran *et al.* 2010, Howie *et al.* 2014, McMullen *et al.* 2014) suggests that it is essential to evaluate teacher approval and student enjoyment with regard to PA interventions, however these outcomes have only been evaluated in two included studies. What children do in the classroom is mainly controlled by the teacher, as students cannot be physically active in the classroom without teacher approval (Martin and Murtagh 2015b). Therefore, teachers' behavior and attitudes play a fundamental role in influencing the effectiveness (Fullan 2007) of classroom-based interventions. Changing their teaching methods is a personal decision by the teacher and decisions to participate are influenced by their approval of intervention programmes (Cothran *et al.* 2010). Since student enjoyment has also been found to influence and control the effect of PA interventions (Howie *et al.* 2014), as well as being identified as a dominant motivational factor to participate in PA and the primary element of student acceptability of PA programmes (Allender *et al.* 2006), it is an outcome which should not be overlooked. Teacher approval of classroom-based PA interventions also relies on this enjoyment (McMullen *et al.* 2014, Martin and Murtagh 2015b). Therefore, to develop effective PA interventions it is essential that both teachers and students are satisfied with the programme and perhaps these are outcomes which should be considered in similar studies in the future.

Given that it is well documented that girls are much less active than boys (Riddoch *et al.* 2004, Sherar *et al.* 2007) it is quite surprising that only one study (Oliver *et al.* 2006) reported sex specific findings of PA data. In an evaluation of sedentary behavior and PA levels of 10 to 14-year-old children during the segmented school day, Bailey *et al.* (2012) reported that the least amount of MVPA was accumulated during class time (Boys 11.2%, Girls 10.2%) and the majority of class time was spent in sedentary (Boys 69.4%, Girls 71.2%) with no significant differences between the sexes for either. However, during their classroom-based intervention Oliver *et al.* (2006) reported that least active students, especially girls, significantly increased their PA levels. Similarly, in an evaluation of PA breaks in the classroom, Erwin *et al.* (2011b) found that the intervention was particularly effective for those in the high risk, low-active groups and had the same effect for boys and girls. Erwin *et al.* (2011b) concluded that the insignificant difference between the sexes may have been because the intervention was carried out in the confined space of the classroom where all children participated equally in the opportunities presented to them. Martin and Murtagh (2015b) also report no significant difference in the PA levels accumulated during intervention lessons between the sexes. It has been reported that in less structured school-based time periods such as recess and lunch, boys have been found to accumulate more MVPA (Bailey *et al.* 2012) therefore, under structured guidance such as during classroom interventions girls seem to be likely to make similar gains to their male counterparts. This indicates that classroom-based PA interventions hold great promise in increasing the PA levels of all students, regardless of sex. These interventions could also especially benefit least-active children who need to be facilitated with more structured opportunities to be active.

The extensiveness of childhood obesity has reached pandemic proportions in the US (Ogden *et al.* 2014), the UK (Stamatakis *et al.* 2010), and in European countries (Wang and Lobstein 2006) with over 22% of 7 to 17-year-old children now considered overweight/obese. This is also seen in Ireland with 26% of 9 and 13-year-old children considered overweight/obese (Layte and McCrory 2011). Since childhood obesity continues into adulthood and significantly increases the risk of disease and premature death, prevention has become a matter of urgency (WHO 2010). Increasing PA has been identified as an important strategy for the prevention of childhood obesity as it reduces BMI through increased energy expenditure and fat oxidation (Epstein and Goldfield 1999). The results presented in the current review indicate potential for classroom-based PA programmes in improving future public health. All three studies which examined intervention effects on students' BMI reported some positive results (Donnelly *et al.* 2009, Liu *et al.* 2007, Li *et al.* 2010). This can be supported by other investigations which examined the link between PA and BMI. Kimm *et al.* (2005) reported that increased PA is linked to decreased weight gain in adolescents and children. They found that children who engaged in more MVPA had a reduced risk of obesity than their sedentary peers. A systematic review of the literature by Doak *et al.* (2006) concluded that simple PA intervention programmes, such as incorporating daily PA into the school curriculum (Dwyer *et al.* 1983) and increasing PA during school break times (Sallis *et al.* 1993), are capable of preventing obesity in children. The evidence presented lends promise to the use of classroom-based PA interventions in contributing towards the improvement of children's health by striving to achieve BMI levels which are within the range for optimum health benefits.

With schools facing challenges in designating time for PA throughout the school day due to emphasis on core academic subjects, it is important to illustrate that incorporating PA into the classroom does not detract from academic performance but may enhance it. It has been proven that PA has a positive impact on cognitive development (Hillman *et al.* 2008), cognitive skills, attitudes, and academic behavior, such as memory and concentration which are all important elements of enhanced academic performance (Centers for Disease Control and Prevention 2010). Of the studies evaluating the impact of physically active academic lessons on student learning in the current review, all four studies reported some positive effects (Donnelly *et al.* 2009, Lee and Thomas 2011, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010). Students were examined mainly in math, reading, writing, and science. Lee and Thomas (2011) argue that the lack of difference in academic achievement between control and intervention groups in their study indicates that similar learning content was being covered in the traditional classroom and the classroom using PAD technologies. However, the authors claim that the PAD activities facilitate students to work with more complex data than their textbooks provide and consequently this intervention was found to have a large effect on reasoning tasks with contextualized data between the groups.

Of note is that all of the studies administered different assessments which limits comparability across interventions. Direct observation was used in both studies examining the relationship between the active lessons and time-on-task (Mahar *et al.* 2006, Riley *et al.* 2015). Medium and large effect sizes for behavior and time-on-task both during and following the active lessons were demonstrated in these studies. The findings presented support several previous publications which summarized the effect of active lessons on educational outcomes (Barr-Anderson *et al.* 2011, Bartholomew and Jowers 2011, Centers for Disease Control and Prevention 2010). Furthermore, implementing the interventions did not negatively affect students' learning, which provides counter-argument to some teachers' beliefs that increasing time spent teaching PA adversely affects students' academic achievements (Morgan and Hansen 2008).

The variances outlined across the studies with regard to duration of student exposure to physically active lessons, proportion of PA incorporated into lesson time, frequency of implementation, types of activities, teacher training, provision of resources and implementation personnel (teacher or researchers) highlights the need to rigorously examine and develop specific guidelines for teachers on how best physically active academic lessons should be implemented in the classroom in order to be effective in achieving health and educational gains.

2.17 Limitations

There are several limitations of note. First, the search strategy was limited to English-language publications. Second, no studies with children over 12 years old met the inclusion criteria so results are limited to interventions which took place in primary schools only. Third, there is a limited number of studies included in the review particularly for BMI, learning and/or facilitators of learning outcomes and consequently conclusions are drawn based on a small number of articles. Many of the included studies were assessed to be of high risk of bias in many areas according to the Cochrane Collaboration assessment tool (Higgins *et al.* 2011) or did not include sufficient information to make firm judgements about bias. Therefore, the results reported must be interpreted with caution since less rigorous studies may be biased toward overestimating or underestimating true intervention effects (Higgins *et al.* 2011). Fourth, as also noted in an earlier review (Norris *et al.* 2015), only three of the included studies considered theoretical frameworks in the development of their interventions (Erwin *et al.* 2011a, Mullender-Wijnsma *et al.* 2015, Reznik *et al.* 2015). There is evidence that PA interventions guided by behavior change theories are more effective and have more enduring results (Michie and Abraham 2004) than those that are not. Grounding future interventions in behavior change theories will ensure that they are provided with a valid foundation for their development (Norris *et al.* 2015). Fifth, only six studies provided detailed information regarding the active lessons implemented (Erwin *et al.* 2011a, Goh *et al.* 2014, Mahar *et al.* 2006, Oliver *et al.* 2006, Reznik *et al.* 2015, Riley *et al.* 2015) which limits the extent to which the components of the interventions can be fully examined or replicated. Variation in the duration of the interventions, which range from 1 week to 3 academic years, is an additional limitation. This great variance in student exposure to physically active academic lessons makes comparisons across the studies difficult since students received different total volume and frequency of active lessons. Sixth, not all of the authors contacted responded to confirm the accuracy of information presented regarding their studies. Seventh, since nine of the fourteen studies were carried out in the U.S. it may be problematic to generalize results to educational systems of other countries. Though it is worth noting that the US-based TAKE 10! programme was successfully adapted for China (Liu *et al.* 2007, Li *et al.* 2010) and Netherlands (Mullender-Wijnsma *et al.* 2015). Finally, we acknowledge that our findings are based on the published evidence available. It is possible that studies suggesting a beneficial intervention effect or a larger effect size are published, while a similar amount of data pointing in the other direction remains unpublished (Sterne *et al.* 2011). Such publication bias could overestimate the impact of classroom-based PA interventions on health and/or academic outcomes.

2.18 Conclusions

This review illustrates the important role that physically active academic lessons can play in increasing PA levels of schoolchildren. Additionally, potential benefits for education and health outcomes, and facilitators of learning were observed. Several recommendations with regard to study design and reporting have been identified. Specifically, this review demonstrates the need for future research to involve more robust designs, i.e. randomized controlled trials, and adhere to reporting standards, e.g. CONSORT (Schulz *et al.* 2010) so that conclusions can be drawn from well designed and reported, high quality studies. The results reported are of relevance for policy-makers, educational administrators, and teachers. Our findings provide evidence for the valuable contribution that physically active teaching methods can make to school-based health promotion.

2.19 What Does This Article Add?

This review evaluates existing classroom-based PA interventions which integrate academic content with respect to four major outcomes in this area. Although a previous review has been carried out which evaluates the effect of such interventions on PA levels and academic attainment, this is the first review to consider these outcomes as well as, health (BMI) and facilitators of learning outcomes. Facilitators of learning outcomes such as teacher approval and student enjoyment have previously been identified as essential in determining the success of classroom-based PA interventions and although a limited number of studies were available to assess this outcome in the current review, results support these previous findings and indicate that evaluations of teacher approval and student enjoyment should be included in future intervention studies. Results also indicate the potentially positive contribution accumulating PA through these interventions can make to the health of students. This review also demonstrates the need for researchers to undertake more robust research designs such as randomized controlled trials in their evaluation of such interventions to reduce the potential for bias and avoid misleading conclusions being drawn. Notwithstanding the aforementioned limitations regarding risk of bias in studies and the limited number of studies available, this review illustrates the positive effects physically active academic lessons can have on PA levels, health, learning, and facilitators of learning outcomes. It also highlights how such interventions can assist teachers in coping with barriers to improve PA levels of their students without negatively affecting academic teaching time. The evaluation of these outcomes in this review provides emerging evidence for the implementation of such interventions and makes a valuable contribution to the existing body of knowledge in this area.

2.20 Chapter Conclusion

Part A of this literature review highlights the health benefits of PA for primary school children and presents the important role schools can play in improving their current PA levels. The various ways PA is incorporated into the school and classroom environments are presented. Integrating PA into the academic content of the curriculum is highlighted as a means to overcome existing barriers to the implementation of PA interventions. The systematic review reported in Part B illustrates that movement integration is an effective strategy to improve PA levels, academic and health outcomes. No such programme which integrates movement into the academic content of the Irish Primary School Curriculum (NCCA 1999) has yet been developed. Therefore, this thesis study focuses on the development and evaluation of a PA intervention which integrates movement into the academic content of the Irish Primary School Curriculum and can be taught by classroom teachers, during class time. This thesis is also unique in that it evaluates teacher and student perceptions of participating in the programme, as well as the objectively measured PA data. This study intends to build on the design, implementation and evaluation limitations of previous movement integration studies by grounding the intervention in a behaviour change theory, using a cluster randomised controlled trial and adhering to the CONSORT (Schultz *et al.* 2010) guidelines. The following chapter outlines a pilot study to examine the preliminary efficacy of the 'Active Classrooms' study.

2.21 References

Allender, S., Cowburn, G., & Foster, C. (2006). 'Understanding participation in sport and physical activity among children and adults: A review of qualitative studies', *Health Education Research, 21*(6), 826-835. doi:10.1093/her/cyl063

Bailey, D. P., Fairclough, S., Savory, L., Denton, S., Pang, D., Deane, C., & Kerr, C. (2012). 'Accelerometry-assessed sedentary behavior and physical activity levels during the segmented school day in 10–14-year-old children: The HAPPY study', *European Journal of Pediatrics, 171*(12), 1805-1813. doi:10.1007/s00431-012-1827-0

Baranowski, T., Dworkin, R. J., Cieslik, C. J., Hooks, P., Clearman, D. R., Ray, L., . . . Nader, P. R. (1984). 'Reliability and validity of self-report of aerobic activity: Family Health Project', *Research Quarterly for Exercise and Sport, 55*(4), 309-317.

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A., & Yancey, A. K. (2011). 'Integration of short bouts of physical activity into organizational routine: A systematic review of the literature', *American Journal of Preventive Medicine, 40*(1), 76-93. doi:10.1016/j.amepre.2010.09.033

Bartholomew, J. B., & Jowers, E. M. (2011). 'Physically active academic lessons in elementary children', *Preventive Medicine, 52*(Suppl. 1), S51-54. doi:10.1016/j.ypmed.2011.01.017

Centers for Disease Control and Prevention [CDC]. (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York, NY: Psychology Press.

Cothran, D. J., Kulinna, P. H., & Garn, A. C. (2010). 'Classroom teachers and physical activity integration', *Teaching and Teacher Education, 26*(7), 1381-1388. doi:10.1016/j.tate.2010.04.003

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). 'Enjoyment mediates effects of a school-based physical-activity intervention', *Medicine and Science in Sports and Exercise, 37*(3), 478-487. doi:10.1249/01.MSS.0000155391.62733.A7

Doak, C., Visscher, T., Renders, C., & Seidell, J. (2006). 'The prevention of overweight and obesity in children and adolescents: A review of interventions and programmes', *Obesity Reviews, 7*(1), 111-136. doi:10.1111/j.1467-789X.2006.00234.x

Dobbins, M., Husson, H., DeCorby, K., & LaRocca, R. L. (2013). 'School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18', *Cochrane Database Systematic Review, 2*(2). CD007651. doi: 10.1002/14651858.CD007651.pub2

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., . . . Williams, S. (2009). 'Physical activity across the curriculum (PAAC): A randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine, 49*(4), 336-341. doi:10.1016/j.ypmed.2009.07.022

Donnelly, J. E., & Lambourne, K. (2011). 'Classroom-based physical activity, cognition, and academic achievement', *Preventive Medicine, 52*(Suppl. 1), S36-42. doi:10.1016/j.ypmed.2011.01.021

Dunn, L. L., Venturanza, J. A., Walsh, R. J., & Nonas, C. A. (2012). ‘An observational evaluation of Move-to-Improve, a classroom-based physical activity program, New York City schools, 2010’, *Preventing Chronic Disease, 9*(9), E146. doi:10.5888/pcd9.120072

Dwyer, T., Coonan, W. E., Leitch, D. R., Hetzel, B. S., & Baghurst, R. (1983). ‘An investigation of the effects of daily physical activity on the health of primary school students in South Australia’, *International Journal of Epidemiology, 12*(3), 308-313.

Eather, N., Morgan, P. J., & Lubans, D. R. (2013). ‘Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial’, *Preventive Medicine, 56*(1), 12-19. doi:10.1016/j.ypmed.2012.10.019

Epstein, L. H., & Goldfield, G. S. (1999). ‘Physical activity in the treatment of childhood overweight and obesity: Current evidence and research issues’, *Medicine and Science in Sports and Exercise, 31*(Suppl. 11), S553-559.

Erwin, H., Abel, M., Beighle, A., & Beets, M. (2011a). ‘Promoting children's health through physically active math classes: A pilot study’, *Health Promotion Practice, 12*(2), 244-251. doi:10.1177/1524839909331911

Erwin, H., Beighle, A., Morgan, C., & Noland, M. (2011b). ‘Effect of a low-cost, teacher-directed classroom intervention on elementary students' physical activity’, *Journal of School Health, 81*(8), 455-461. doi:10.1111/j.1746-1561.2011.00614.x

Erwin, H., Fedewa, A., Beighle, A., & Ahn, S. (2012). ‘A quantitative review of physical activity, health, and learning outcomes associated with classroom-based physical activity interventions’, *Journal of Applied School Psychology, 28*(1), 14-36. doi:10.1080/15377903.2012.643755

Finn, K. E., & McInnis, K. J. (2014). ‘Teachers' and students' perceptions of the active science curriculum: Incorporating physical activity into middle school science classrooms’, *Physical Educator, 71*(2), 234-253.

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). London, UK: Routledge.

Goh, T. L., Hannon, J., Webster, C. A., Podlog, L. W., Brusseau, T. A., & Newton, M. (2014). ‘Effects of a classroom-based physical activity program on children’s physical activity levels’, *Journal of Teaching in Physical Education, 33*(4), 558-772.

Group of China Obesity Task Force. (2004). ‘Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents’, *Zhonghua Liu Xing Bing Xue Za Zhi, 25*(2), 97-102.

Hamilton, M., Healy, G., Dunstan, D., Zderic, T., & Owen, N. (2008). ‘Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior’, *Current Cardiovascular Risk Reports, 2*(4), 292-298. doi:10.1007/s12170-008-0054-8

Higgins, J., & Green, S. (2011). ‘Cochrane handbook for systematic reviews of interventions Version 5.1. 0 [updated March 2011]’, *The Cochrane Collaboration, 5*(0). Retrieved from http://www.cochrane-handbook.org.

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., . . . Sterne, J. A. (2011). ‘The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials’, *The BMJ, 343*. doi: http://dx.doi.org/10.1136/bmj.d5928

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). ‘Science and society: Be smart, exercise your heart: Exercise effects on brain and cognition’, *Nature Reviews: Neuroscience, 9*(1), 58-65. doi:10.1038/nrn2298

Holt, E., Bartee, T., & Heelan, K. (2013). ‘Evaluation of a policy to integrate physical activity into the school day’, *Journal of Physical Activity & Health, 10*(4), 480-487.

Howie, E. K., Newman-Norlund, R. D., & Pate, R. R. (2014). ‘Smiles count but minutes matter: Responses to classroom exercise breaks’, *American Journal of Health Behavior, 38*(5), 681-689.

Kendzierski, D., & DeCarlo, K. J. (1991). ‘Physical Activity Enjoyment Scale: Two validation studies’, *Journal of Sport & Exercise Psychology, 13*(1), 50-64.

Kimm, S. Y., Glynn, N. W., Obarzanek, E., Kriska, A. M., Daniels, S. R., Barton, B. A., & Liu, K. (2005). ‘Relation between the changes in physical activity and body-mass index during adolescence: A multicenter longitudinal study’, *The Lancet, 366*(9482), 301-307. doi:10.1016/S0140-6736(05)66837-7

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., . . . Johnson, C. L. (2002). ‘2000 CDC Growth Charts for the United States: Methods and development’, *Vital and Health Statistics. Series 11, Data from the National Health Survey, 11*(246), 1-190.

Layte, R., & McCrory, C. (2011). *Growing up in Ireland: National longitudinal study of children: Overweight and obesity among 9-year-olds*. Dublin, Ireland: Government Publications.

Lee, V., & Thomas, J. (2011). ‘Integrating physical activity data technologies into elementary school classrooms’, *Educational Technology Research and Development, 59*(6), 865-884. doi:10.1007/s11423-011-9210-9

Li, Y. P., Hu, X. Q., Schouten, E. G., Liu, A. L., Du, S. M., Li, L. Z., . . . Ma, G. S. (2010). ‘Report on childhood obesity in China (8): Effects and sustainability of physical activity intervention on body composition of Chinese youth’, *Biomedical and Environmental Sciences, 23*(3), 180-187. doi:10.1016/s0895-3988(10)60050-5

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49): Sage publications Thousand Oaks, CA.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., . . . Chen, C. (2007). ‘Report on childhood obesity in China (6): Evaluation of a classroom-based physical activity promotion program’, *Biomedical and Environmental Sciences, 20*(1), 19-23.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). ‘Effects of a classroom-based program on physical activity and on-task behavior’, *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Martin, R. and Murtagh, E. M. (2015a) 'An intervention to improve the physical activity levels of children: Design and rationale of the ‘Active Classrooms’ cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191.

Martin, R. and Murtagh, E. M. (2015b) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). 'Physical activity opportunities during the school day: Classroom teachers' perceptions of using activity breaks in the classroom', *Journal of Teaching in Physical Education, 33*(4), 511-527.

Metcalf, B., Voss, L., & Wilkin, T. (2002). 'Accelerometers identify inactive and potentially obese children (EarlyBird 3)', *Archives of Disease in Childhood, 87*(2), 166-167. doi:10.1136/adc.87.2.166

Michie, S., & Abraham, C. (2004). 'Interventions to change health behaviors: Evidence-based or evidence-inspired?', *Psychology & Health, 19*(1), 29-49. doi:10.1080/0887044031000141199

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). 'Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement', *Annals of Internal Medicine, 151*(4), 264-269.

Morgan, P., & Hansen, V. (2008). 'Classroom teachers' perceptions of the impact of barriers to teaching physical education on the quality of physical education programs', *Research Quarterly for Exercise and Sport, 79*(4), 506-516.

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S., & Visscher, C. (2015). 'Improving academic performance of school-age children by physical activity in the classroom: 1-year program evaluation', *Journal of School Health, 85*(6), 365-371. doi:10.1111/josh.12259

Multicenter Growth Reference Study Group, World Health Organization. (2006). 'WHO Child Growth Standards based on length/height, weight and age', *Acta Paediatrica, 95*(Suppl. 450), 76-85. doi:10.1080/08035320500495548

Naylor, P., Nettlefold, L., Race, D., Hoy, C., Ashe, M., Wharf Higgins, J., & McKay, H. (2015). 'Implementation of school based physical activity interventions: A systematic review', *Preventive Medicine, 72*, 95-115. doi:10.1016/j.ypmed.2014.12.034

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O., & Stamatakis, E. (2015). 'Physically active lessons as physical activity and educational interventions: A systematic review of methods and results', *Preventive Medicine 72,* 116-125. doi:10.1016/j.ypmed.2014.12.027

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). 'Prevalence of childhood and adult obesity in the United States, 2011-2012', *Journal of the American Medical Association, 311*(8), 806-814.

Oliver, M., Schofield, G., & McEvoy, E. (2006). 'An integrated curriculum approach to increasing habitual physical activity in children: A feasibility study', *Journal of School Health, 76*(2), 74-79. doi:10.1111/j.1746-1561.2006.00071.x

Pate, R. R., Ward, D. S., Saunders, R. P., Felton, G., Dishman, R. K., & Dowda, M. (2005). 'Promotion of physical activity among high-school girls: A randomized controlled trial', *American Journal of Public Health, 95*(9), 1582-1587. doi:10.2105/AJPH.2004.045807

Raven, J. C., Raven, J. C., & De Lemos, M. M. (1958). *Standard progressive matrices*. London, UK: Lewis.

Reed, J. A., Einstein, G., Hahn, E., Hooker, S. P., Gross, V. P., & Kravitz, J. (2010). 'Examining the impact of integrating physical activity on fluid intelligence and academic performance in an elementary school setting: A preliminary investigation', *Journal of Physical Activity & Health, 7*(3), 343-351.

Schulz, K. F., Altman, D. G., & Moher, D. (2010). 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials, 11*, 32. doi:10.1186/1745-6215-11-32

Sterne, J. A., Egger, M., & Moher, D. (updated March 2011). Chapter 10: Addressing reporting biases. In: Higgins, J.P.T. & Green, S. (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0. The Cochrane Collaboration, 2011. Available from www.handbook.cochrane.org.

Reznik, M., Wylie-Rosett, J., Kim, M., & Ozuah, P. O. (2015). 'A classroom-based physical activity intervention for urban kindergarten and first-grade students: A feasibility study', *Childhood Obesity, 11*(3), *314-324.*

Riddoch, C., Bo, A., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L., . . . Ekelund, U. (2004). 'Physical activity levels and patterns of 9- and 15-year-old European children', *Medicine & Science in Sports & Exercise, 36*(1), 86-92.

Riley, N., Lubans, D. R., Morgan, P. J., & Young, M. (2015). 'Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomized controlled trial', *Journal of Science and Medicine in Sport, 18*(6), 656–661. doi:10.1016/j.jsams.2014.09.005

Sallis, J. F., McKenzie, T. L., Alcaraz, J. E., Kolody, B., Hovell, M. F., & Nader, P. R. (1993). 'Project SPARK. Effects of physical education on adiposity in children', *Annals of the New York Academy of Sciences, 699*(1), 127-136.

Schneider, M., & Cooper, D. M. (2011). 'Enjoyment of exercise moderates the impact of a school-based physical activity intervention', *International Journal of Behavioral Nutrition & Physical Activity, 8*(1), 64-64. doi:10.1186/1479-5868-8-64

Sherar, L. B., Esliger, D. W., Baxter-Jones, A. D., & Tremblay, M. S. (2007). 'Age and gender differences in youth physical activity: Does physical maturity matter?', *Medicine & Science in Sports & Exercise, 39*(5), 830-835. doi:10.1249/mss.0b013e3180335c3c

Stamatakis, E., Wardle, J., & Cole, T. J. (2010). 'Childhood obesity and overweight prevalence trends in England: Evidence for growing socioeconomic disparities', *International Journal of Obesity, 34*(1), 41-47. doi:10.1038/ijo.2009.217

Tomporowski, P., Davis, C., Miller, P., & Naglieri, J. (2008). 'Exercise and children's intelligence, cognition, and academic achievement', *Educational Psychology Review, 20*(2), 111-131. doi:10.1007/s10648-007-9057-0

Trost, S. G. (2007). 'State of the art reviews: Measurement of physical activity in children and adolescents', *American Journal of Lifestyle Medicine, 1*(4), 299-314. doi:10.1177/1559827607301686

Wang, Y., & Lobstein, T. (2006). 'Worldwide trends in childhood overweight and obesity', *International Journal of Pediatric Obesity, 1*(1), 11-25. doi:10.1080/17477160600586747

Webster, C., Russ, L., Vazou, S., Goh, T., & Erwin, H. (2015). 'Integrating movement in academic classrooms: Understanding, applying and advancing the knowledge base', *Obesity Reviews, 16*(8), 691-701. doi:10.1111/obr.12285

World Health Organization [WHO] (2010) *Global recommendations on physical activity for health,* Geneva, Switzerland: World Health Organization.

Zhu, W. (2016). '$p < 0.05, < 0.01, < 0.001, < 0.0001, < 0.00001, < 0.000001$, or < 0.0000001…', *Journal of Sport and Health Science, 5*(1), 77-79.

CHAPTER 3

PRELIMINARY FINDINGS OF ACTIVE CLASSROOMS: AN INTERVENTION TO INCREASE PHYSICAL ACTIVITY LEVELS OF PRIMARY SCHOOL CHILDREN DURING CLASS TIME

Chapter 3: Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time

Preamble

The following article outlines the design and conduct of the 'Active Classrooms' pilot study which was implemented to evaluate the effects of the intervention lessons on students' MVPA levels. This study also aimed to evaluate practical implementation issues through an evaluation of teacher acceptability of the programme. Student enjoyment of participating in the intervention lessons was also evaluated. This article has been peer-reviewed and published in *Teaching and Teacher Education*, impact factor 2015: 1.823 (Thomson Reuters, Journal Citation Reports 2016). The full citation for the article is as follows:

Martin, R. and Murtagh, E. M. (2015) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127. ISSN: 0742-051X, http://dx.doi.org/10.1016/j.tate.2015.09.007

Statement of authorship:

I hereby declare that I, Rosemarie Martin am the principal author of this article. The following statements outline my contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

(See Appendix R)

See Appendix S for ©Elsevier copyright permissions.

For changes from the published article see Appendix T.

3.1 Abstract

This study evaluates the effects of a behaviour change intervention, which encourages the integration of PA into the teaching of academic lessons, on PA levels of students. The main outcome is mean minutes of moderate-to-vigorous physical activity (MVPA) daily generated during the intervention lessons. Teacher's perceptions and students' enjoyment of the programme were also evaluated. Students accumulated a mean of 8 minutes MVPA during the intervention lessons daily. The teacher and students were very satisfied with the programme. Therefore, changing teacher behaviour towards using physically active teaching methods is a promising way of increasing children's PA levels.

Keywords: Physical activity; Classroom; Academic Content; Primary School; Accelerometer

3.2 Introduction

Less than 20% of children globally are achieving the recommended 60 minutes of moderate to vigorous PA per day for health benefits (McCoy *et al.* 2012, World Health Organization 2010). Increasing their physical activity levels has been identified as particularly important to the long- term impact on public health (Waring *et al.* 2007). Schools have been targeted as the best environments to implement PA interventions as they are a primary location to reach the majority of children (Martin and Murtagh 2015). However, ironically, schools internationally are reported to be one of the dominating locations of sedentary behaviour in children with class time representing a significant sedentary period of the day (Holt *et al.* 2013). Children are required to sit quietly to receive instruction (Gibson *et al.* 2008). Globally it is recommended that all schools develop policies to address PA as part of the school day and not just in PE or active travel (World Health Organization 2010).

School-based interventions, such as Get Moving! (Spruijt-Metz *et al.* 2008), Bizzy Breaks (Murtagh *et al.* 2013), Active and Healthy Schools (Ball *et al.* 2015) and Take 10! (Stewart *et al.* 2004) that integrate PA throughout the day have been identified as effective tools for increasing PA levels (Spruijt-Metz *et al.* 2008). They are also more sustainable and show longer term outcomes than individual level interventions since they target large populations (Barr-Anderson *et al.* 2011). The Center for Disease Control and Prevention (CDC) Comprehensive School Physical Activity Program (CSPAP) recommends the inclusion of school-based PA opportunities to increase PA levels of young people. Specifically it has been recommended that PA should be integrated into classroom learning since movement has been found to enhance learning (Centers for Disease Control and Prevention 2010). However, emphasis on Literacy and Numeracy in primary school classrooms has resulted in a lack of time for PA and a lack of emphasis on PE (Bartholomew and Jowers 2011). In order to address this problem which places emphasis on academic content to the detriment of PA, methods of integrating PA into academic lessons in the classroom are warranted. Here we distinguish between activity breaks, which involve the promotion of PA in the classroom without curriculum learning outcomes, and methods of promoting PA that allow academic content to still be taught. School-based interventions to promote PA in this manner include active lessons (Erwin *et al.* 2011a, Gibson *et al.* 2008), active homework (Lubans and Morgan 2008) and changes to the classroom environment (Cardon *et al.* 2004). The school curriculum is an ideal avenue for accessing all children and encouraging them to be physically active throughout the day. However, through a review of the literature it is evident that very few studies focus on classroom-based interventions and of those which have only four studies have integrated PA into the academic content of the primary school curriculum with PA outcomes (Bartholomew and Jowers 2011, Donnelly *et al.* 2009, Erwin *et al.* 2011a, Oliver *et al.* 2006, Riley *et al.* 2012). Results of these studies demonstrate that encouraging classroom teachers to integrate PA into the classroom can significantly improve student's PA levels during class time and over the entire school day, moving them towards achieving the recommended PA guidelines for health benefits. The researchers also found that incorporating movement in lessons can simultaneously contribute to children's academic performance (Erwin *et al.* 2011a). In these previous studies the implementation of physically active academic lessons contributed to significant improvements in time students spent engaged in academic learning and in 'on-task' behaviours (Grieco *et al.* 2009, Mahar *et al.* 2006, Riley *et al.* 2014).

Despite this evidence, few teachers use physically active teaching methods (Morgan and Hansen 2008a). Since what children do in the classroom is largely influenced by the teacher, teachers and their attitudes play a central role in determining the success or failure (Fullan 2007) of classroom based interventions therefore, it is essential that teachers are satisfied with the programme. Cothran *et al.* (2010) evaluated teachers' perceptions to PA interventions and they found that teachers' willingness to engage in PA interventions is influenced by their care for students' wellbeing and interest in their own wellbeing. Teachers' beliefs, perceptions and attitudes towards PA have been identified as the greatest barriers to PA promotion in the classroom (Morgan and Hansen 2008a) with time and assessment pressures also being identified (Cothran *et al.* 2010). More specifically, classroom management issues, maintaining teacher control, connection to the academic curriculum as well as student enjoyment of the lessons are among the factors which influence teacher decisions of including activity breaks in the classroom (McMullen *et al.* 2014). In a recent systematic review, 'lack of time' emerged as the most consistently identified barrier to implementation in school-based PA interventions (Naylor *et al.* 2015). Considering the increasing demands placed on teachers, PA integration across the curriculum is emerging as an important opportunity for PA promotion. Implementing change in the classroom is ultimately a personal, individual decision by teachers, therefore encouraging classroom teachers to assume responsibility for integrating PA into academic lessons requires behavioural change on the part of the teacher, as well as presenting them with interventions that fit with their schedules, curriculum and their beliefs and values about teaching.

Of the existing classroom based PA interventions, only Texas I-CAN! (Bartholomew and Jowers 2011) and the Physical Activity Across the Curriculum (PAAC) study (Donnelly *et al.* 2009) focus on the behaviour of the teacher. For example Texas I-CAN! (Bartholomew and Jowers 2011) emphasises the importance of teacher attitudes and perceived behaviour control for successful interventions. The authors proposed that teacher training programs might be best centred on the Theory of Planned Behaviour (Ajzen 1985) which emphasises these factors. They reported that teacher implementation was enhanced by providing the teachers with training, equipment and lesson ideas to integrate PA into academic lessons. In the PAAC intervention Gibson *et al.* (2008) emphasise that behavioural changes are mediated by self-efficacy of the teacher to perform the behaviour. Teachers' level of confidence in their ability to incorporate PA into lesson plans is achieved through teacher training sessions and goal setting in the PAAC study and these features are consistent with social cognitive theories. However, it has been argued that the Theory of Planned Behaviour does not address impulsivity, habit, self-control, associative learning and emotional processing which all have important roles in behavioural outcomes (Michie *et al.* 2011), and other behavioural change interventions including social cognition models do not analyse the target behaviour in context to develop an effective intervention. Therefore, this paper proposes an alternative to these behaviour change models by characterising the intervention and linking it to an analysis of the targeted behaviour through the use of the Behaviour Change Wheel (BCW) framework (Michie *et al.* 2011). This framework not only allows the intervention to fit with the teachers' belief systems, which is essential to encourage compliance (Cothran *et al.* 2010) but, also analyses the nature of the outcome behaviour as a starting point for identifying the type of interventions that are likely to be effective in encouraging teachers to assume responsibility for integrating PA into academic lessons. This focus on teacher behaviour and designing the intervention with the outcome behaviour as a starting point contributes to the uniqueness of the study.

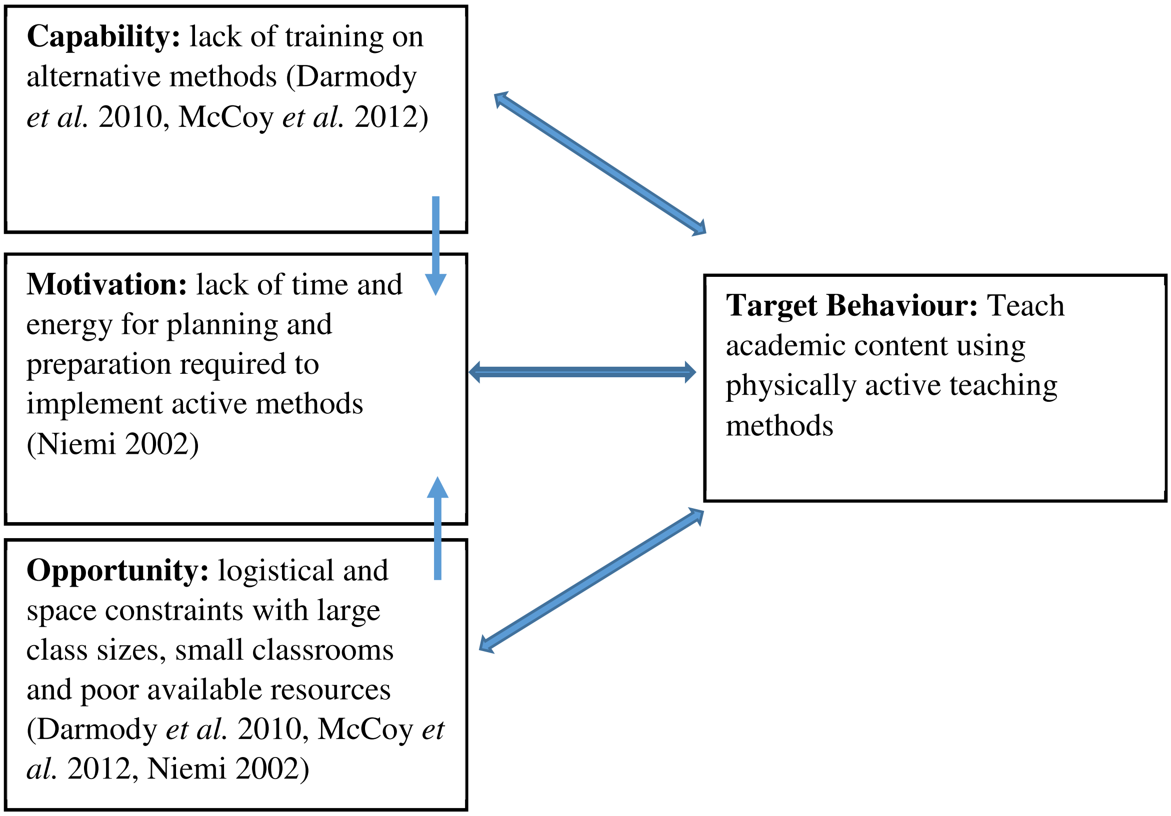
3.3 Use of Behaviour Change Theory

There is evidence that PA interventions informed by theoretically driven behaviour change models are more successful and lead to stronger more lasting changes (Michie and Abraham 2004) than those that are not. The Active Classrooms intervention design is guided by the Behaviour Change Wheel framework (Michie *et al.* 2011). This works on the principle that the target behaviour must be analysed to identify the type of interventions that are likely to be effective in bringing about the behaviour, with a target population, in a specific context. The capabilities, opportunities and motivations of the individual to perform the target behaviour are analysed and mapped onto intervention functions (COM-B). Figure 3.1 outlines the results of an analysis of the target behaviour with respect to teachers' capability, opportunity and motivation to implement physically active teaching methods. The figure design is based on a similar framework outlined in the original research (Michie *et al.* 2011) but each of the fields has been populated with barriers relevant to the target behaviour under analysis in the current study. The double headed arrows represent potential influences between components in the system and as such indicate that enacting a behavior can alter capability, opportunity and motivation.

Suggested solutions to these barriers to performing the target behaviour were then identified and linked to specific intervention functions. It emerged that teachers require further professional development to enhance their skills, education on the benefits of PA for their students, action planning, lesson plans and resources to enable them to teach using physically active teaching methods. Thus, to achieve the target behaviour Education, Training, Environmental Restructuring, and Enablement intervention functions were identified. Behaviour Change Techniques (BCTs), which are the 'active ingredients' (Michie *et al.* 2013) designed to change the behaviour were then selected from the 93 hierarchically- clustered techniques (Michie *et al.* 2013) and mapped to specific techniques to be applied in the 'Active Classrooms' intervention. These behaviour change techniques are the 'observable, replicable and irreducible components' of the intervention which specify its content and allow the intervention to be accurately replicated (Michie *et al.* 2013). The specific techniques incorporated in this pilot intervention include professional development, reorganising the classroom environment, goal setting, planning, and replacing previous teaching habits with active methods.

The incorporation of the COM-B analysis of teacher behaviour and behaviour change techniques (BCT) in the design of the ‘Active Classrooms’ intervention, endeavour to change teacher behaviour towards using physically active teaching methods therefore, enabling students to be more physically active during classroom instruction. The aim of this pilot study is to examine the effect of the ‘Active Classrooms’ intervention lessons on the MVPA levels of the children during the lessons.

Figure 3.1 Analysis of the target behaviour with respect to teachers' capability, opportunity and motivation (COM-B) (Michie et al. 2011)



3.4 Methods

3.4.1 Study Design

This paper outlines the ‘Active Classrooms’ pilot study which was conducted during school hours, over 5 consecutive school days, in the first week of October 2014. The purpose of the study is to evaluate the MVPA levels of the participants during the intervention lessons. Moderate-intensity PA requires a reasonable amount of effort and noticeably increases the heart rate (e.g. brisk walking, dancing, cycling) and vigorous-intensity PA requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate (e.g. running and chasing games, jumping rope, playing basketball/football etc.) (WHO 2010). The primary outcome is minutes and percentage time in MVPA during the intervention lessons. Comparisons will be made between the MVPA levels generated during intervention lessons and regular classroom instruction.

Design conduct and reporting of the Active Classrooms pilot intervention study adheres to the Consolidation Standards of Reporting Trials (CONSORT) (Moher *et al.* 2010, Schulz *et al.* 2010) guidelines and to the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong *et al.* 2007).

All participating students (n=28) took part in one intervention English lesson and one intervention Mathematics lesson each day. Comparative data was gathered from approximately the same duration of comparison lessons taught each day to the same students by the same teacher. Twenty participating students in the class were randomly selected to wear accelerometers. An accelerometer is a lightweight, unobtrusive device worn on an elastic belt around the participants' waist. They have been regarded as appropriate for use with primary school children because they can measure PA levels in daily life and can be used by the participant with ease (Trost 2007). They measure PA patterns and intensities in counts per minute. Student enjoyment of the programme was evaluated using a write and draw technique pre- and post-intervention. A random sample of 4 participants also engaged in a focus group discussion with the researcher, in a vacant classroom, in the school the week following the intervention. The teacher's satisfaction of the programme was evaluated through a questionnaire completed immediately post-intervention.

Table 3.1 Links between the components of the 'COM-B' model of behaviour and the intervention functions (Michie *et al.* 2008)

Model of Behaviour: Sources	Why are teachers not using physically active teaching methods?	What needs to change?	Education	Training	Environmental Restructuring	Enablement
Capability-Psychological	Teachers lacking skills to implement physically active methods (Darmody *et al.* 2010, McCoy *et al.* 2012)	Professional development/ training needs to be provided to teachers Development of action plans/goal setting	✓	✓		✓
Motivation-Reflective and Automatic	Teachers preference for direct instruction (McCoy *et al.* 2012) as active methods require much more preparatory work (Niemi 2002) Overloaded curriculum and a lack of time (Niemi 2002) Teachers' negative beliefs, perceptions and attitudes towards PA in the classroom (Morgan and Hansen 2008a)	Teachers must plan to use physically active methods and develop a habit of using them. Believe in the benefits of physically active methods by teachers (information sessions) Teachers must want to increase PA levels. Provision of integrated lesson plans and resources	✓		✓	✓
Opportunity-Physical	Space constraints within the classroom and large class sizes pose logistical constraints (McCoy *et al.* 2012) Poor teaching and learning resources (Niemi 2002)	Use of physically active methods with large groups of children even in classrooms with space constraints Provision of resources			✓	✓

Table 3.2 Examples of trial intervention features mapped onto behaviour change taxonomy and techniques (BCT)

Taxonomy	Intervention Function	BCT	Definition	Example in Active Classrooms Pilot Intervention
Shaping Knowledge	Educate Training	Instruction on how to perform a behaviour	Advise or agree on how to perform the behaviour (includes skills training)	Provide an individual information session and a sample of lesson plans to each participating teacher illustrating how to integrate physically active methods into English and Mathematics lessons
Feedback and Monitoring	Enablement	Self-monitoring of behaviour	Establish a method for the person to monitor and record their behaviour as part of a behaviour change strategy	Teachers keep a log of lessons taught using PA methods to include date, time, lesson, and duration of PA
Repetition and Substitution	Training	Behaviour Substitution	Prompt substitution of the unwanted behaviour with the wanted behaviour	Replace inactive teaching methods with physical activities in teaching English and Mathematics
Antecedents	Environment Restructuring	Restructuring the physical environment	Advise to change the physical environment in order to facilitate the performance of the wanted behaviour	Advise to arrange desks in the classroom to allow space for movement
Goals and Planning	Enablement	Goal setting (behaviour)	Set or agree a goal defined in terms of the behaviour to be achieved	Eg. Plan to teach using PA methods in at least two lessons each day (one English and one Mathematics)
	Enablement	Action planning	Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity)	Prompt to plan to teach a lesson using PA methods for at least 10 minutes twice a day during English and Mathematics lessons.

3.4.2 Recruitment and Study Participants

Prior to recruitment of the participants ethical approval for the study was granted by Mary Immaculate College Research Ethics Committee (MIREC), Limerick, Ireland (See Appendix I). One convenient primary school in Limerick, Ireland was invited to participate in the Active Classrooms pilot study. Consent was initially received from the principal allowing the school to take part. Children aged 8 - 9 years are the focus of this study therefore, the third-class teacher was invited to participate. Consent was received from the class teacher and student participants were sought from third class (students aged 8-9). All students were eligible to participate if they returned an informed consent form signed by their parents with child assent, and did not have any current injury or medical condition preventing them from participating. Twenty-eight children (100% of those invited) returned consent forms to participate (14 girls and 14 boys). Due to limited availability of devices PA measures were obtained from a random sample of 20 children (13 girls and 7 boys, aged 8-9 years) who wore accelerometers throughout the study. The teacher in this study is female aged 33 with 8 years teaching experience. The teacher indicated that she does not participate in any sports or exercises. No compensation was provided to participants in the study.

3.5 Treatments

3.5.1 Physical Activity Intervention

3.5.1.1 Active Classrooms programme

The functions of this intervention are to educate, train, and enable teachers to change their behaviour towards using physically active teaching methods in English and Mathematics lessons as indicated in Table 3.1. The details of specifically how this could be done are outlined in Table 3.2 and particulars of its implementation are outlined here. After recruitment the classroom teacher was given a one-to-one 30 minute training session which provided ideas on how to integrate PA into the academic content of English and Mathematics lessons. The teacher was educated on the use of accelerometers as well as the correct procedure for student wear. Demonstrations on how to log lessons taught and accelerometer non-wear time were also provided. Training included a description of the inactivity problem in primary school children; an explanation of the role classroom teachers can play to improve the problem, and action planning to teach using PA methods in at least two 10 minute lessons each day (one English and one Mathematics). The researcher was also available to support the teacher on a regular basis to answer any queries as they arose or offer advice and suggestions during the intervention period.

Twenty English and 20 Mathematics lesson plans which integrate PA into the curriculum content, as well as, the resources to teach them were supplied to the classroom teacher. The lesson plans were created by the research team. One member of the research team is a primary school teacher trained to teach all primary school subjects with an in-depth knowledge of the Irish Primary School Curriculum. Another member of the research team is a teacher educator with expertise in teacher education, PA and PE. Lesson plans were linked to the strands and strand units of the English and Mathematics curricula (NCCA 1999) and cover a range of topics in both subjects. English lessons outline physically active methods, such as active relays, actions corresponding to letters, exercises to illustrate answers, exercises between activity stations and running to gather scrabble letters, for the teaching of spelling, vocabulary, grammar and creative writing. English lessons are also designed to enable the children to respond to stories and oral language using PA. Mathematics lessons include ideas for teaching number, operations, spatial awareness, patterns, sequences, fractions, time, data, and problem solving using physically active methods such as hopping figures, taking pulse after rest and after exercise for 1 minute and using exercises to work out answers, illustrate or communicate answers. The lessons intend to enhance the teaching and learning of specific content areas while also increasing the MVPA levels of the students during class time. The activities were designed to last a minimum of 10 minutes but could be extended by teachers if desired, this allowed the lessons to fit within the teachers' schedules and maximise compliance. The teacher was allowed to deviate from the lesson plans supplied. The plans outlined ideas which the teacher could adapt to fit with her schedule, student needs and learning objectives being taught in the classroom at the time. The teacher was asked to indicate the code of lessons taught and the duration of each lesson taught each day on the Teacher Log provided. It was intended that these adaptable lessons provide the teacher with ways of making topics she was scheduled to teach more physically active rather than being extra lessons to be implemented in the classroom. See Appendix E and Appendix F for sample English and Mathematics lesson respectively and see Appendix G for an over view of the range of lessons provided to the teacher.

3.6 Data Collection Procedures and Measures

3.6.1 Physical Activity

PA was monitored during school hours over 5 consecutive school days using ActiGraph accelerometers (models GT3X and GT3X+, ActiGraph LLC, Pensacola, Florida) to collect the data. Accelerometers are considered to be valid and reliable objective tools for measuring children's PA levels (Dollman *et al.* 2009, McClain and Tudor-Locke 2009, Trost 2007) and the Actigraph model has good psychometric properties against other accelerometer types among children (de Vries *et al.* 2006). This study considers best practice recommendations (Ward *et al.* 2005) for accelerometer use with children such as the body location the unit is worn, epoch length, measurement period and wear time calculation. These are described in more detail below.

Accelerometers were mounted on elastic belts and worn around the waist with the accelerometer unit placed over the right hip. Each accelerometer was marked with a unique code and the teacher was provided with a list assigning each student to a particular accelerometer to ensure that each child wore the same device each day. The teacher was asked to distribute the accelerometers each morning and collect them before the children left school in the afternoon. She was also asked to record when and why any student was not wearing the device during school time (eg. absent/ swimming/ home early etc.). The teacher was asked to teach one physically active Mathematics lesson and one physically active English lesson each day and she recorded the times and duration of each active lesson taught. This allowed time filters to be applied in Actilife (ActiGraph, Pensacola, Florida) so that data could be examined for each individual physically active lesson taught. All remaining class time was considered regular teaching time. Accelerometer data was collected in 15 second epochs (time intervals). Evenson cut points were used to categorise the four intensity levels (Sedentary 0-100 counts per minute (CPM), Light 101-2295 CPM, Moderate 2296 – 4011 CPM, Vigorous > 4012 CPM) as these provide the most acceptable classification accuracy for use with children (Trost *et al.* 2011).

3.6.2 Teacher's Perceptions

The teacher's perceptions on the effectiveness and sustainability of the intervention programme were evaluated through a survey which consisted of a series of open and closed ended questions. This teacher questionnaire was adapted from that used and validated in the process evaluation of the 'Toy Box' intervention (Androutsos *et al.* 2014). The teacher was asked to indicate on a Likert-type scale the ease of implementing the programme and likelihood of continuing to use it in the future. The Likert-type scale required the teacher to specify her level of agreement or disagreement for a series of statements on symmetric agree-disagree scales. She was also requested to indicate on similar scales the effect the lessons had on the students' PA levels, and on teaching and learning in the classroom. Finally, open ended questions allowed the teacher to record any difficulties or challenges with implementing the programme and also to suggest any improvements. Table 3.3 outlines sample questions included in the teacher questionnaire which is available on request from the researchers.

Table 3.3 Sample questions from the teacher questionnaire adapted from the 'Toy Box' intervention (Androutsos *et al.* 2014)

1) Please rate the ease of implementing the active Maths/English lessons on the following scale: 1= very difficult, 2= difficult, 3= neither difficult nor easy, 4= easy, 5= very easy
2) To what extent did you enjoy teaching the active lessons?
3) To what extent do you think your students enjoyed participating in the active lessons?
4) To what extent do you feel the active Maths/ English lessons enhanced your teaching:
5) To what extent do you feel the active Maths/ English lessons enhanced your students' learning:
6) Please outline any difficulties/ challenges you found while implementing the intervention programme:
7) Please outline any strengths/weaknesses of the intervention programme:
8) Please state any changes you would make to improve the intervention to enhance teaching or learning while also encouraging physical activity in the classroom:

3.6.3 Student Enjoyment

Student enjoyment has been found to control and influence the effect of PA interventions (Howie *et al.* 2014) and teacher approval also relies on this enjoyment. Therefore, it is essential to evaluate the students' enjoyment of the programme to develop an effective intervention. The use of visual approaches such as photographs, paintings and drawings have been recommended to extend our understanding of children's perspectives (Clark and Moss 2011, Crivello *et al.* 2012, Knowles *et al.* 2013, Loveridge 2010). However, it has been acknowledged that drawings may not be useful as stand-alone images in themselves (Veale 2005) since without children's explanations they cannot be interpreted adequately. Children's comments contextualise the data for the researcher (Christensen and James 2008), their drawings provide visual data but it is the verbal material recorded as the participants give their explanations that provide the data for interpretation- words about pictures (Veale 2005). Therefore, this research has employed a write and draw technique combined with focus group discussions since this has been considered a developmentally appropriate approach to use with primary school children (Knowles *et al.* 2013, Te One 2007).

Table 3.4 Focus group discussion questions adapted from the EASY Minds study (Riley *et al.* 2014)

1	How would you describe your Mathematics classes before the Active Classrooms programme? Did you enjoy this?
2	How would you describe your English classes before the Active Classrooms programme? Did you enjoy this?
3	How would you describe the active Mathematics lessons? Did you enjoy this? Why? Can you give me an example? Did this make the Mathematics lessons more exciting/ interesting?
4	How would you describe the active English lessons? Did you enjoy this? Why? Can you give me an example? Did this make the English lessons more exciting/ interesting?
5	What kind of activities did you enjoy doing in the Active Classrooms programme?
6	Can you tell me if being active in Mathematics and English lessons helped you learn? Why/why not? Can you give me an example?
7	Is there anything else you would like to share about the Active Classrooms programme experience?

Prior to the intervention, baseline data regarding the children's experiences of English and Mathematics lessons were collected. The classroom teacher was provided with worksheets for the children and asked them to 'Draw what you think of when you think of a Mathematics lesson and what you think of when you think of an English lesson. Write a few sentences describing each picture'. These instructions were also written on the worksheet. On the final day of the intervention the teacher was asked to repeat the activity with the children using the same instructions as before. The week following the intervention a randomly selected sub-sample of 4 students (female = 3, male = 1) were invited to participate in a focus group discussion with the researcher. All students selected took part. The female researcher was known to the children as she teaches in their school. However, the researcher had never taught the participants involved in the study. The discussion took place in a classroom which was vacant at the time with only the researcher and participants present. The conversation lasted 12 minutes. The children's drawings provided a basis for the conversation. The focal questions are outlined in Table 3.4 above. These are adapted from the EASY Minds study (Riley *et al.* 2014). Additional questions specific to the children's drawings were also asked (E.g. Can you tell me what's happening in this picture?).

3.7 Data Reduction & Analysis

3.7.1 Physical Activity

For the purpose of this pilot study, the MVPA levels of the students in a random sample of 5 regular classroom lessons (mean 33 min per day) were compared to their MVPA levels during the intervention lessons (both intervention lessons per day combined = mean 36 min per day). Therefore, comparison lessons involved the same students taught by the same classroom teacher throughout the learning day at school so all children participating in the intervention also participated in the comparative lessons.

Accelerometer data was used to determine the number of minutes and percentage time in each intervention lesson the students spent in each of the PA intensity categories. The results were compared to the number of minutes and percentage time the students spent in each of the categories during regular classroom instruction. The minutes and percentage time each participant spent in each of the PA categories (sedentary, light, moderate, vigorous and in MVPA) were averaged over the entire school week, in intervention lessons, break and lunch time, during a sample of comparison lessons and during total regular instructional time (total classroom teaching time minus intervention lesson time). These averages were used in subsequent analysis. A paired samples t-test was used to compare mean minutes in MVPA between usual practice and intervention lessons. The level of significance was set at 0.05.

3.7.1.1 Wear-Time

This study examines the PA levels of the students during the school day therefore minimum wear time was set at 272 minutes (80% of the school day, 340 minutes) which follows the 70/80% rule outlined in best practice recommendations for accelerometer use (Ward *et al.* 2005). At least 70% of the children wore accelerometers on all five days of the study so all 5 days were included in the analysis. Due to the nature of this study which includes sedentary data, 10 minutes of consecutive zeros could not be classified as 'non-wear time' (Yildirim *et al.* 2011). It is possible that children may remain in sedentary behaviour for extended periods of time in the classroom. Hence, the minimum activity threshold required to start a non-wear period was set at 60 minutes. Accelerometer data from 20 randomly selected children (n=13 girls, n=7 boys) was collected in this study; data from one child was excluded from analysis on the second day as she went home early and did not meet the minimum wear time requirements. Nineteen children met the wear time requirements on the last day since one child was absent and therefore her data was excluded. All 20 children were included in the analysis on the remaining 3 days. Following recommendations for accelerometer use, 15 000 counts was set as the cut point for the upper limit count values to avoid spurious data (Esliger *et al.* 2005) and spike tolerance was set at 2 minutes.

3.7.2 Teacher Perceptions

Results of the teacher survey were coded and input into Microsoft Excel 2010 where means were calculated for analysis. The results were used to evaluate the teacher's satisfaction with the programme. Direct quotations are used to highlight themes emerging from the open ended questions.

3.7.3 Student Enjoyment: Write and Draw & Focus Groups

The focus group discussion which was audio recorded and transcribed to accurately reflect the participants' views, was framed around the children's drawings and written texts. The use of these multiple data collection sources enabled triangulation and has been recommended to strengthen the quality of the data (Crivello *et al.* 2009). The following quality measures (Knowles *et al.* 2013) were used in the analysis of the write and draw activity. The writing must be legible and the drawings must be clear representations of people, events, or places (n=27 included). The researcher analysed the data in the following phases (Ritchie and Lewis 2003): (1) familiarisation with the raw data was established through immersion in the data by listening to the recordings, writing up and reading transcripts, reading students written texts and studying notes, (2) a thematic framework was established by the researcher who identified all key issues, concepts and themes from the participants' oral and written statements. Sub themes within each theme were also identified, (3) themes and sub-themes were assigned a code and these codes were applied to the data to assist with analysis and for subsequent retrieval and exploration, (4) the data was rearranged in the form of a chart, (5) the chart was used to find associations between the themes. Quotations and pictures were subsequently used to expand and highlight emerging themes (Knowles *et al.* 2013). Feedback was obtained from the research participants by checking back (Greene and Hogan 2005) with them during the discussion to ensure that their meanings and perspectives are accurately represented. Microsoft Excel 2010 was used to assist in managing the data.

3.8 Results

Data was gathered from predominantly Irish Caucasian students in a non-socio economically disadvantaged school on the suburbs of Limerick City, Ireland. Of the 28 students invited to participate in the study all 28 returned signed informed consent and assent forms. The mean age of the 20 children randomly selected to wear accelerometers was 8.1 years.

3.8.1 Physical Activity

Two active intervention lessons (one English and one Mathematics) lasting an average of 18 minutes (5.5% of the school day) each were taught by the classroom teacher during class time each day. Students accumulated 18 minutes of light and 8 minutes of MVPA overall during the two active lessons each day. Girls (8.3 minutes) accumulated slightly more MVPA per day during the lessons than boys (7.5 minutes) however, with a p-value of 0.16 there is no significant difference between the groups. The children spent a mean of 23.6% of time in MVPA during the active lessons. The mean time (minutes) students spent in each PA category during intervention English and Mathematics lessons is outlined in Table 3.5.

A mean of 0.3 minutes was spent in MVPA during regular classroom instruction as outlined in Table 3.5. Figure 3.2 illustrates the mean percentage time spent in each PA category during comparison and intervention lessons. This figure also illustrates that the children spent over three quarters of regular classroom instruction in sedentary behaviour. This was reduced to 30% during the intervention lessons.

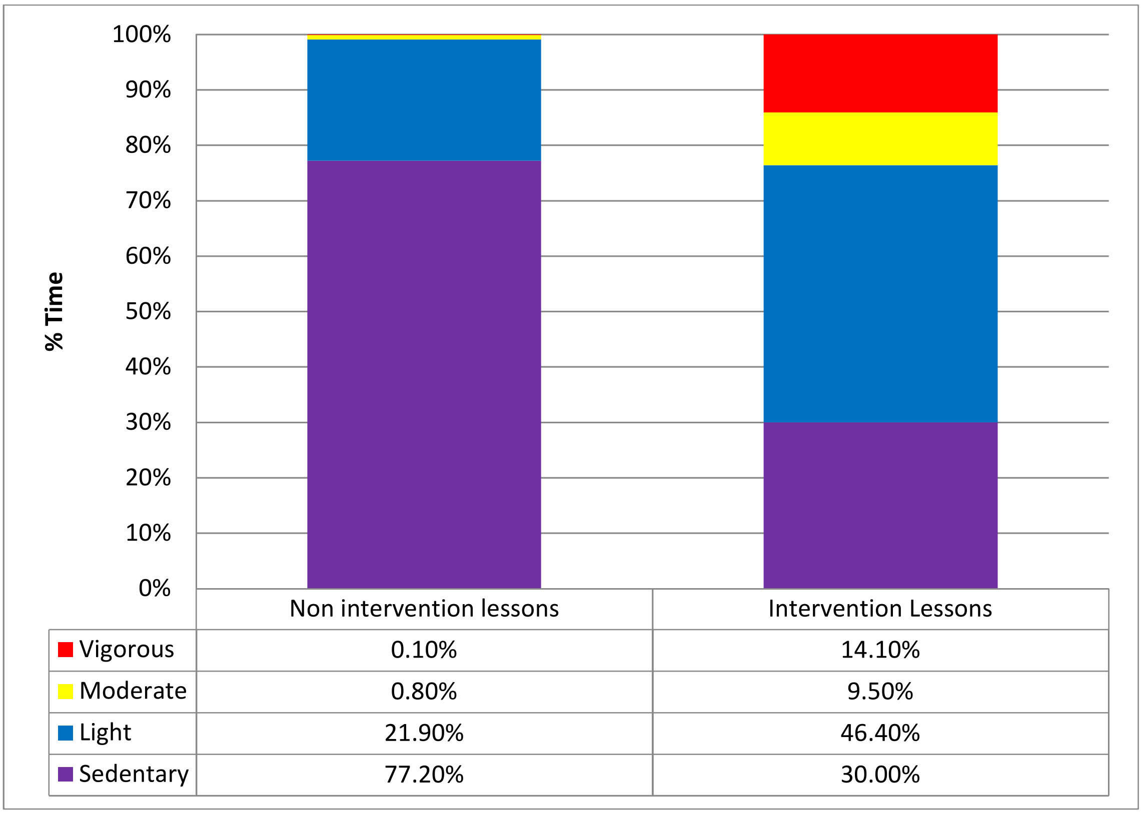


Figure 3.2 Mean % time in each PA category during comparison and intervention lessons

Table 3.5 Mean minutes in each intensity category by comparison and intervention lessons

n = 20	Comparison lessons mins per day (SD)	Intervention lessons mins per day (SD)	P Value
Sedentary	25.8 (2.7)	11.4 (2.2)	<.001
LPA	7.1 (2.1)	17.6 (1.9)	<.001
MPA	0.3 (0.2)	3.4 (0.8)	<.001
VPA	0.0 (0.1)	4.6 (1.2)	<.001
MVPA	0.3 (0.2)	8.0 (1.6)	<.001
MVPA boys (*n* = 7)	0.4 (0.3)	7.5 (1.7)	<.001
MVPA girls (*n* = 13)	0.2 (0.2)	8.3 (1.6)	<.001
Lesson duration (mins)	33.3	36.8	

Note: P values refer to differences between intervention lessons and comparison lessons

An average of 11.7% of school time during the week was spent teaching the active lessons (two lessons, five days a week). Each intervention lesson contributed 2.7% to the overall school time spent in sedentary each day. However, each lesson contributed towards 16.1% of the overall MVPA accumulated daily therefore, 33% of the students' school day MVPA throughout the week was accumulated during the intervention lessons (2 per day). This almost matches the time spent in MVPA during break and lunch times (37.8%). Regular classroom instruction contributed to 89% of the time the students spent in sedentary behaviour during the school day.

3.8.2 Teacher Satisfaction

The intervention English and Mathematics lessons were highly regarded by the teacher, receiving an average rating of 5 on a 5-point Likert-type scale. She found the lessons very easy to implement and sustainable in a classroom context. The teacher taught the English and Mathematics lessons 5 days in the week. She perceived that the children were much more active in the intervention lessons compared to previous English and Mathematics lessons and she indicated that the Active Classrooms programme greatly enhanced the teaching and learning in the classroom rating both a 5 on a 5 point Likert- type scale. She also stated that *'the children were learning without even realising it and I could see a big improvement in their work'*. The teacher identified a lack of available space for some of the activities as a limitation of the programme. She stated that '*the biggest difficulty I had was space in my classroom. I couldn't do any of the floor exercises (i.e burpees, crunches). I went to the hall on 2 occasions but the hall isn't always available'*. The teacher indicated that she is definitely likely to continue using the lessons after the study, stating that '*I will most definitely be continuing the activities and only wish I had more time to try out all the lessons'*. When asked to suggest any changes to improve the intervention to enhance teaching or learning while also encouraging PA in the classroom the teacher said '*I can't think of any changes I would make*' she added that '*the children loved it and I found that they were focused more on the rest of the days' events/ lessons'*.

3.8.3 Student Enjoyment

Twenty-seven children completed the write and draw activity and four children also participated in the focus group discussion. One blank write and draw sheet was returned because one child was absent on the day. The data collected revealed common themes relating to students' attitudes about the programme. Many students' responses identified more than one theme and so were categorised in each theme identified. The majority of responses referred to the high level of enjoyment experienced through participating in the active lessons. Most children mentioned that the lessons were 'fun' (n=26) or 'enjoyable' (n=4). Others mentioned that the lessons were great (n=3) or that they 'liked' (n=21) or 'loved' (n=21) them. Participant 10 wrote '*It is really fun. I like to do different activities and the exercises are fun too. It makes an English lesson fun'*. Participant 11 wrote '*I loved those exercises. They were really fun! Learning Mathematics and English especially Mathematics through those exercises was really, really, really, very fun!*' Health and PA (n= 26) was identified as the second theme with *participant 3* and *20* respectively stating, '*I loved the English lessons because it's …really good exercise'* and '*I am more healthy because of the lessons*'. Enhanced learning (n= 4) was another theme recognised (*participant 9*:'*being active in the lessons helps you (learn) a little bit more' and '…we were learning in a fun way'*), (participant 15: *'I like English more now with all the exercises we do. We did this thing called verb and adverb, and I am really able to understand what they are now because we had to act them out').* This theme emerged in the teacher's questionnaire also. In response to an open ended question she stated '*I loved the fun activities for Mathematics. Children were learning without even knowing. Tables can be boring for them but they loved the games so were able to learn them much better*'. Only one student expressed a negative attitude towards the lessons stating '*I don't want a Mathematics lesson, it's too hard'* (*participant 28*). It's unclear if this refers to the Mathematics content in general or the active lessons. The themes identified in the focus group discussion were consistent with those identified through the write and draw activity '*we learned sums that we didn't really do before… like multiplies. We learned a bit more, it was good fun' (student 1).* When asked if they would like to do the programme again, the children reported they '*would love it*'. The children's expressions, tone of voice and non-verbal behaviour also reinforced the enjoyment and excitement experienced through the programme. Samples of the participant's responses are displayed in Figure 3.3 and Figure 3.4 below.

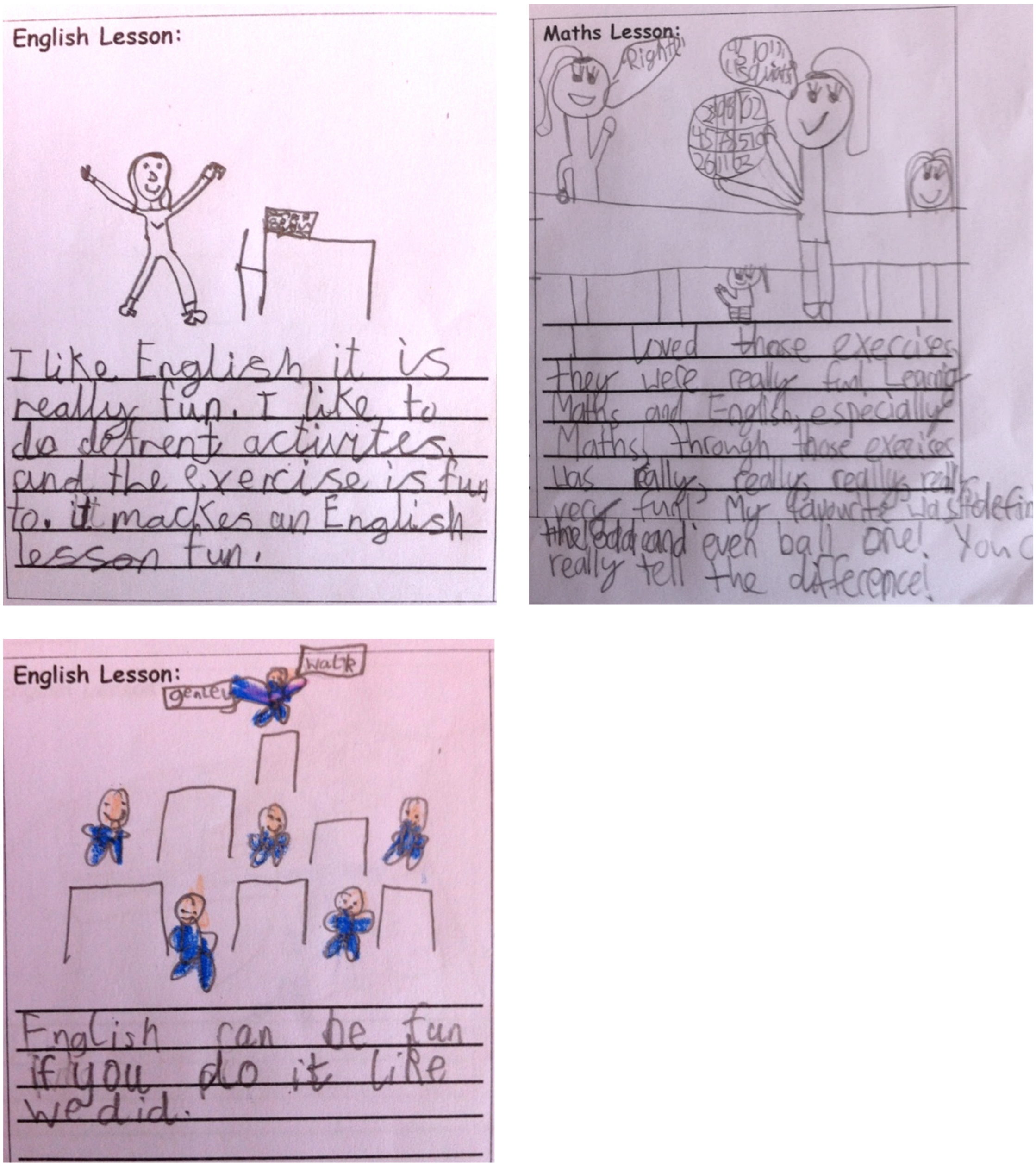


Figure 3.3 Drawings by boys and girls illustrating 'fun' English and Mathematics lessons

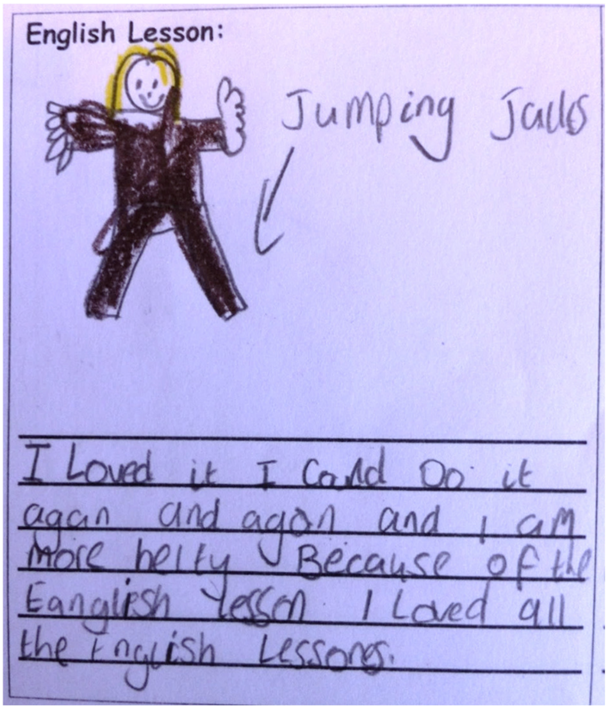


Figure 3.4 Drawing by a girl illustrating that the exercises helped her become 'more healthy'

3.9 Discussion

The purpose of this study was to evaluate the effectiveness of a curriculum integrated PA intervention on the MVPA levels of the children during the active lessons. The results of this pilot study are promising as they demonstrate that a classroom based intervention which integrates PA into the curriculum content of English and Mathematics lessons, taught by the classroom teacher, can improve the PA levels of primary school children during the intervention lessons and throughout the entire school day. These findings augment the growing body of evidence on the efficacy of teaching academic content using physically active methods (Norris *et al.* 2015). Specifically this study illustrates that changing the behaviour of the teacher enabled the students to accumulate more PA during the English and Mathematics intervention lessons than during regular lessons while also enhancing their learning and providing enjoyable experiences for them.

3.9.1 Children’s physical activity levels

The World Health Organisation recommends that children participate in at least 60 minutes of MVPA most if not every day of the week (WHO 2010) and also highly recommend that schools take an active role in implementing policies to improve PA. Conversely, out of reach targets can undermine PA participation and with time, curriculum and space limitations there are many barriers preventing schools from implementing an hour of PA each day. Therefore, accumulating at least moderate PA in short bouts throughout the day is a goal deemed easier to achieve and has many beneficial health effects, especially for those most at risk (Barr-Anderson *et al.* 2011, Janssen and LeBlanc 2010). This outlook was employed in the development of this project and proved successful in assisting the children accumulate PA in school.

In this study a mean of 23.6% of each intervention lesson was spent in MVPA. Other studies which have integrated PA and academic content have reported that children spent between ~20 and 100% of the lesson time in MVPA (Bartholomew and Jowers 2011, Donnelly *et al.* 2009, Stewart *et al.* 2004). While the duration for which children can sustain MVPA may be influenced by the length of each active lesson, for example the shortest lesson of 10 minutes enabled the children achieve moderate to vigorous intensity physical exercise and maintain these levels for 100% of the lesson (Stewart *et al.* 2004), these studies demonstrate that there may be scope to improve the proportion of time spent in MVPA during the Active Classrooms' intervention lessons. The students spent 50% (9 minutes) of each active lesson in light activity, this may suggest that the duration of the Active Classrooms' lessons implemented by the teacher (~18 minutes) was perhaps too long for the students to maintain sustained periods of moderate-to-vigorous intensity PA. Nonetheless, the intervention lessons contributed 13% of the children's recommended daily PA and any increase in children's PA levels can have significant health benefits (Janssen and LeBlanc 2010).

PA accumulated across the school day has been shown to increase whole-day PA to a degree greater than expected from the school day PA sessions alone (Groffik *et al.* 2012). However, no consensus has been drawn on discrete guidelines for school day PA accumulation. The New Zealand-based Energize Project suggests that 20 minutes of the recommended 60 minute MVPA goal should be accumulated during the school day (Rush *et al.* 2012). In contrast Nettlefold *et al.* (2011) suggest that 30 minutes (50%) of the 60 minute recommendation should be achieved during the school day. During the current study the mean MVPA accumulated across the whole school day was 24.8 minutes. This is greater than other studies which examined MVPA during school time in primary schools in Ireland. A study which evaluated Irish primary school children's PA levels during the segmented school-day found that the children accumulated a mean of 18.6 minutes of MVPA (Hegarty *et al.* 2013) during the whole school day. Hegarty *et al.* (2013) reported that children achieved the least amount of PA during class time with the accumulation of only 8 minutes of MVPA. This is much lower than the present study which accrued a mean of 15 minutes of MVPA during the same period of the day. Implementing the active lessons is largely responsible for this significant difference.

The Active Classrooms study did not find a significant difference between PA levels accumulated by males and females during the intervention lessons. This is an interesting finding since females are often shown to be less active than males, especially during school (Hegarty *et al.* 2013). It can be suggested that the PA accumulated by both males and females during the lessons are similar because all children present in the classroom were presented with the same opportunities to participate and engage in the same activities during the lessons and were requested to do so as part of their teacher's instruction of the English and Mathematics lessons. This supports assertions by Belton *et al.* (2010) who report that interventions targeted towards increasing PA during class time have a significant effect on increasing children's PA levels, particularly lesser active children and girls.

Emerging evidence demonstrates that independent of PA levels, prolonged periods of sedentary behaviours of greater than 2 hours per day are associated with an increased risk of coronary heart disease, cardiovascular disease, type II diabetes, all- cause mortality, a multitude of psychological and physiological problems as well as decreased fitness, lower self-esteem and decreased academic achievement in children and youth aged 5-17 (Katzmarzyk 2010, Owen *et al.* 2010, Tremblay *et al.* 2010, Tremblay *et al.* 2011, Treuth *et al.* 2007). Results of the Active Classrooms study illustrate that the intervention lessons not only improve the students' PA levels but also reduce time spent in sedentary behaviour when compared with regular classroom instruction. Therefore, by enabling teachers to teach traditionally sedentary academic lessons using physically active methods, this programme has the potential to break prolonged sedentary periods consequently reducing the ill effects of this behaviour.

3.9.2 Teacher Satisfaction

The high levels of teacher satisfaction with the Active Classrooms programme is encouraging for its ongoing implementation. Teacher satisfaction is essential as teachers play a central role in determining the success or failure of a change intervention (Fullan 2007) by their willingness to engage in it. Changing their methods of teaching is ultimately a personal, individual decision by the teacher and their inclination to engage is influenced by their perceptions of the programme (Cothran *et al.* 2010). Teacher satisfaction is especially imperative for the implementation of classroom-based PA interventions since what children do in the classroom is largely controlled by the teacher (Fullan 2007) and students cannot be physically active in a classroom setting without the support and guidance of the teacher. Additionally, it has been found that teacher implementation rates largely affect the benefits students receive from the intervention (Donnelly *et al.* 2009). Therefore, it is important to consider factors associated with teacher satisfaction and implementation of these lessons.

In their examination of classroom teachers' perceptions of using PA breaks in the classroom Mc Mullen *et al.* (2014) identified three main factors which contribute to teachers adopting the practice: 1) the need for classroom control, 2) a preference for breaks with connections to academic content, and 3) the importance of implementation ease and student enjoyment. These determinants of how, when and if classroom teachers will use a PA intervention in their classrooms were considered in the design of the Active Classrooms programme. In the application of the Behaviour Change Wheel Framework (Michie *et al.* 2008) the target behaviour was analysed and features included in the intervention as a result of this analysis contributed towards teacher satisfaction and compliance with the programme. Lesson plans linked to the academic content of the Irish Primary School Curriculum (NCCA 1999) with the identification of specific strands and strand units and resources required to teach them such as flashcards, a beach ball, playing cards, a PowerPoint presentation, maps etc. were provided for the teacher as well as training on how to implement the active lessons. Images on how to perform the exercises were also provided (See Appendix H). The teacher indicated that the lessons were extremely easy to implement and the provision of training and resources allowed the teacher to manage the lessons easily and maintain classroom control. This supports the recommendations for professional development and teacher preparation in relation to PA inclusion in the classroom as outlined by McMullen *et al.* (2014). Results of the Texas I-CAN study by Bartholomew *et al.* (2011) also indicate that teacher implementation rates were enhanced following training based around a theory and the provision of active lessons and equipment needed for the classroom.

Aligning with the work by McMullen *et al.* (2014) the teacher identified a lack of classroom space as an issue with implementing the lessons. She found that due to a lack of available space in the classroom the children were not able to perform some of the floor exercises however, the design of the lessons allowed the teacher to substitute these with other activities included in the programme such as jumping jacks and squat jumps which enabled her to continue with the lesson. The lesson plans were designed to last a minimum of 10 minutes each but could be extended as desired to fit into the teacher's schedule. Variations of each lesson were also included in the plans which allowed the teacher to adjust the content to suit the topics she was teaching. This finding builds on previous work by Morgan and Hansen (2008b) who found that adaptability of the programme contributes to teacher compliance and the development of positive attitudes towards PA promotion in the classroom. Adaptability gives teachers ownership allowing them to adjust the intervention to fit with their beliefs and values about teaching as well as, with their curriculum and schedule.

3.9.3 Student Enjoyment

Enjoyment is the primary element of acceptability and the dominant motivational factor for children to participate in PA (Allender *et al.* 2006). The children in this study expressed an extremely positive attitude towards the lessons claiming that they were '*fun*', '*exciting*' and '*enjoyable*'. They expressed their hope of learning actively '*doing all the exercises again'*. This finding is crucial to the potential sustainability of the 'Active Classrooms' programme as PA interventions are unlikely to be implemented widely, no matter how potentially effective and efficient they might be, if they are not shown to be acceptable to both students and teachers (Howie *et al.* 2014, McMullen *et al.* 2014, Woods *et al.* 2012). As such results of the current study build on previous studies which indicate that levels of student enjoyment have been shown to determine the beneficial effects of PA interventions with increased enjoyment resulting in increased PA (Dishman *et al.* 2005, Schneider and Cooper 2011) and where children do not experience enjoyment this may have negative effects on their future participation in PA. Physically engaging the children in lessons in ways they have not experienced before is responsible for their enjoyment of the 'Active Classrooms' lessons. Students commented on how '*you could really tell the difference*' between the active lessons and regular lessons and on how much they enjoyed throwing a ball to one another around the classroom to learn about odd and even numbers, and '*doing P.E.'* in their English and Mathematics lessons. They expressed their enjoyment of running to collect letters for a team game of scrabble and exercising while moving from station to station to write collaborative stories. This enjoyment may be attributed to their engagement in pair and small group activities which supports previous findings that children experience enjoyment during positive social interactions with their peers (Knowles *et al.* 2013).

3.9.4 Enhanced Learning

While not a planned outcome of this study, a recurrent theme identified by both students and the teacher was enhanced student learning and student focus. This finding adds to the results of previous studies which examined student time on task and academic achievement outcomes of classroom based PA interventions. Mahar *et al.* (2006) found that participation in these types of lessons resulted in a significant increase in time on task for subsequent traditional style, sedentary lessons. Bartholomew *et al.* (2011) also found that the students maintained a greater focus on academic material after a physically active lesson. Donnelly *et al.* (2009) and Erwin *et al.* (2011a) found significantly higher results in students' achievement in Mathematics and Literacy assessments. Our findings therefore lend support to the contention that, contrary to some teachers' beliefs (Morgan and Hansen 2008a), integrating PA into academic content does not detract from students' performance outcomes or behaviour. These lessons not only teach and review academic material, but they also enhance learning and student behaviour in lessons that follow. This provides strong potential to enhance teacher motivation to implement physically active academic lessons.

3.10 Limitations

Although this pilot study demonstrates the potential for encouraging classroom teachers to integrate PA into the classroom to increase children's PA levels without interrupting academic teaching time, the use of a convenience sample of only one classroom and one classroom teacher is a limitation. The inclusion of randomisation to select schools, and increasing the number of classrooms and teachers in future studies would allow generalisability of the findings while also providing a better understanding of teacher perceptions and compliance. The short time frame of this study should also be noted. While the study was not conducted using a control group, requesting the teacher to record the times and duration of the active lessons taught, allowed the researcher to filter the intervention lessons and a sample of regular lessons from the accelerometer data. Therefore, comparisons could easily be made between regular and intervention lessons to evaluate the success of the intervention on the MVPA levels of the participants. A future study is warranted using control and intervention schools to assess the effectiveness of the programme on a larger scale and over a longer time period.

3.11 Conclusion and Future Research

Our findings demonstrate that the Active Classrooms programme can improve children's PA levels when implemented each day. This initiative complements policy at a national

(Department of Health 2013) and global level (WHO 2008) by promoting PA in the school setting through changes in behaviour and education. The positive attitudes expressed towards teaching and learning using physically active methods by both the students and the teacher supports the notion that pedagogies should be adapted by teachers and teacher educators to include PA as a means to improve children's overall health. These positive attitudes were also prominent in the Wellness Weeks approach which advocated PA implemented by classroom teachers throughout the school day (Corbin *et al.* 2013). Similarly, this approach allows each teacher flexibility in implementing a programme which provides support and sound educational and PA resources.

Future recommendations include the evaluation of individual lessons to identify those which contribute most to the children's MVPA levels. Further lessons could then be designed to incorporate the most active pedagogies. Research should also be conducted to objectively assess student learning through participation in the Active Classrooms lessons. It is also acknowledged that students in this study may compensate throughout the whole day for PA accumulated during the active lessons (Metcalf *et al.* 2012). Therefore, a future larger scale controlled study should be conducted to evaluate if children are more active throughout the whole school day when intervention lessons are implemented in comparison to traditional lessons. Finally, long term follow-up to measure sustainability of the programme is warranted.

3.12 Chapter Conclusion

It is clear from the study presented above that changing teacher behaviour towards integrating movement as an instructional strategy is effective in evoking PA of moderate to vigorous intensity in the students. Both the teacher and students positively received the 'Active Classrooms' intervention. However, results of this preliminary study cannot be generalised since this study was conducted over only one school week, with one classroom teacher and a convenience sample of students. The potential influence of different lesson durations was not accounted for in the analyses of this study which must be noted as a further limitation. Additional research must therefore be carried out to determine the intervention's effectiveness when implemented by many teachers in multiple classrooms over time, in comparison to a control group while also adjusting for relevant covariates. The findings of the study described in this chapter inform the design and development of a larger randomised controlled trial of which the protocol is described in Chapter 4.

3.13 References

Ajzen, I. (1985) *From intentions to actions: A theory of planned behavior*, Springer.

Allender, S., Cowburn, G., & Foster, C. (2006). 'Understanding participation in sport and physical activity among children and adults: A review of qualitative studies', *Health Education Research, 21*(6), 826-835. doi:10.1093/her/cyl063

Androutsos, O., Apostolidou, E., Iotova, V., Socha, P., Birnbaum, J., Moreno, L., De Bourdeaudhuij, I., Koletzko, B., & Manios, Y. (2014). 'Process evaluation design and tools used in a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study', *Obesity Reviews,* 15 Suppl 3*,* 74-80.

Ball, S., Kovarik, J., and Leidy, H. (2015). 'Active and Healthy Schools', *Physical Educator,* 72(2).

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A. and Yancey, A. K. (2011) 'Integration of short bouts of physical activity into organizational routine: A systematic review of the literature', *American Journal of Preventive Medicine*, 40(1), 76-93.

Bartholomew, J. B. and Jowers, E. M. (2011) 'Physically active academic lessons in elementary children', *Preventive Medicine*, 52 Suppl 1, S51-4.

Cardon, G., De Clercq, D., De Bourdeaudhuij, I. and Breithecker, D. (2004) 'Sitting habits in elementary schoolchildren: a traditional versus a "Moving school"', *Patient Education and Counseling*, 54(2), 133-142.

Centers for Disease Control and Prevention [CDC]. (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Christensen, P. and James, A. (2008) *Research with children: Perspectives and practices*, Routledge.

Clark, A. and Moss, P. (2011) *Listening to young children: The mosaic approach*, NCB.

Corbin, C. B., Kulinna, P. H., Dean, M., and Reeves, J. (2013). 'Wellness Weeks: A Total School Approach for Promoting Physical Activity and Nutrition', *Journal of Physical Education, Recreation & Dance,* 84(6), 35-41.

Cothran, D. J., Kulinna, P. H. and Garn, A. C. (2010) 'Classroom teachers and physical activity integration', *Teaching and Teacher Education*, 26(7), 1381-1388.

Crivello, G., Camfield, L. and Woodhead, M. (2009) 'How can children tell us about their wellbeing? Exploring the potential of participatory research approaches within young lives', *Social Indicators Research*, 90(1), 51-72.

Dalli, C. and Te One, S. (2012) 'Involving children in educational research: researcher reflections on challenges', *International Journal of Early Years Education*, 20(3), 224-233.

Darmody, M., Smyth, E. and Doherty, C. (2010) 'Designing primary schools for the future', *Economic and Social Research Institute (ESRI) Research Series.*

Department of Health (2013). 'Healthy Ireland: A framework for improved health and wellbeing 2013 – 2025', *Dublin.*

de Vries, S. I., Bakker, I., Hopman-Rock, M., Hirasing, R. A. and van Mechelen, W. (2006) 'Clinimetric review of motion sensors in children and adolescents', *Journal of Clinical Epidemiology*, 59(7), 670-680.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). 'Enjoyment mediates effects of a school-based physical-activity intervention', *Medicine and Science in Sports and Exercise, 37*(3), 478-487.

Dollman, J., Okely, A. D., Hardy, L., Timperio, A., Salmon, J. and Hills, A. P. (2009) 'A hitchhiker's guide to assessing young people's physical activity: Deciding what method to use', *Journal of Science and Medicine in Sport*, 12(5), 518-25.

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., Dubose, K., Mayo, M., Schmelzle, K., Ryan, J., Jacobsen, D. and Williams, S. (2009) 'Physical activity across the curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine*, 49, 336 - 341.

Erwin, H., Abel, M., Beighle, A., & Beets, M. (2011a). 'Promoting children's health through physically active math classes: A pilot study', *Health Promotion Practice, 12*(2), 244-251.

Erwin, H., Beighle, A., Morgan, C., & Noland, M. (2011b). 'Effect of a low-cost, teacher-directed classroom intervention on elementary students' physical activity', *Journal of School Health, 81*(8), 455-461.

Esliger, D. W., Copeland, J. L., Barnes, J. D. and Tremblay, M. S. (2005) 'Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring', *Journal of Physical Activity & Health*, 2(3).

Fullan, M. (2007) *The new meaning of educational change*, Routledge.

Gibson, C., Smith, B., DuBose, K., Greene, J. L., Bailey, B., Williams, S., Ryan, J., Schmelzle, K., Washburn, R., Sullivan, D., Mayo, M. and Donnelly, J. (2008) 'Physical activity across the curriculum: year one process evaluation results', *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 36.

Greene, S. and Hogan, D. eds. (2005) *Researching children's experience: Approaches and methods*, London: Sage.

Grieco, L. A., Jowers, E. M., and Bartholomew, J. B. (2009). 'Physically active academic lessons and time on task: The moderating effect of body mass index', *Medicine and Science in Sports and Exercise,* 41(10), 1921-1926.

Groffik, D., Sigmund, E., Frömel, K., Chmelík, F. and Lokvencová, P. N. (2012) 'The contribution of school breaks to the all-day physical activity of 9-and 10-year-old overweight and non-overweight children', *International Journal of Public Health*, 57(4), 711-718.

Hegarty, D., Murtagh, E. M., and Ní Chróinín, D. (2013). 'An evaluation of Irish primary school children's physical activity during the segmented school-day', *Proceedings of the seventh physical education, physical activity and youth sport forum: Youth Sport: understanding, intervening and prolonging engagement in youth sport, physical education and physical activity, DCU*, 115-121.

Holt, E., Bartee, T. and Heelan, K. (2013) 'Evaluation of a Policy to Integrate Physical Activity Into the School Day', *Journal of Physical Activity & Health*, 10(4), 480-487.

Howie, E. K., Newman-Norlund, R. D. and Pate, R. R. (2014) 'Smiles Count but Minutes Matter: Responses to Classroom Exercise Breaks', *American Journal of Health Behavior*, 38(5), 681-689.

Janssen, I. and LeBlanc, A. (2010) 'Systematic review of the health benefits of physical activity and fitness in school-aged children and youth', *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 40.

Katzmarzyk, P. T. (2010) 'Physical Activity, Sedentary Behavior, and Health: Paradigm Paralysis or Paradigm Shift?', *Diabetes*, 59(11), 2717-2725.

Knowles, Z. R., Parnell, D., Ridgers, N. and Stratton, G. (2013) 'Learning from the experts: exploring playground experience and activities using a write and draw technique', *Journal of Physical Activity and Health*, 10(3), 406.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W. and Chen, C. (2008) 'Evaluation of a classroom-based physical activity promoting programme', *Obesity Reviews*, 9, 130-134.

Loveridge, J. (2010) *Involving children and young people in research in educational settings, Report to the Ministry of Education*, Victoria, New Zealand: Ministry of Education. *Available from:* www.educationcounts.govt.nz/publications, [Accessed: 23rd June 2012].

Lubans, D. and Morgan, P. (2008) 'Evaluation of an extra-curricular school sport programme promoting lifestyle and lifetime activity for adolescents', *Journal of Sports Sciences*, 26(5), 519-529.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). 'Effects of a classroom-based program on physical activity and on-task behavior', *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Martin, R. and Murtagh, E. M. (2015) 'An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191.

McClain, J. J. and Tudor-Locke, C. (2009) 'Objective monitoring of physical activity in children: considerations for instrument selection', *Journal of Science and Medicine in Sport*, 12(5), 526-533.

McCoy, S., Smyth, E. and Banks, J. (2012) 'The primary classroom: Insights from the growing up in Ireland study', *Dublin: ESRI and NCCA*.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). 'Physical activity opportunities during the school day: Classroom teachers' perceptions of using activity breaks in the classroom', *Journal of Teaching in Physical Education, 33*(4), 511-527.

Metcalf, B., Henley, W. and Wilkin, T. (2012) 'Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54)', *BMJ: British Medical Journal*, 345.

Michie, S. and Abraham, C. (2004) 'Interventions to change health behaviours: evidence-based or evidence-inspired?', *Psychology & Health*, 19(1), 29-49.

Michie, S., Johnston, M., Francis, J., Hardeman, W. and Eccles, M. (2008) 'From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques', *Applied Psychology*, 57(4), 660-680.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J. and Wood, C. E. (2013) 'The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions', *Annals of Behavioral Medicine*, 46(1), 81-95.

Michie, S., van Stralen, M. M. and West, R. (2011) 'The behaviour change wheel: a new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), 42-52.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M. and Altman, D. G. (2010) 'CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials', *Journal of Clinical Epidemiology*, 63(8), e1-e37.

Morgan, P. J. and Hansen, V. (2008a) 'Classroom teachers' perceptions of the impact of barriers to teaching physical education on the quality of physical education programs', *Research Quarterly for Exercise and Sport*, 79, 506 - 516.

Morgan, P. J. and Hansen, V. (2008b) 'The relationship between PE biographies and PE teaching practices of classroom teachers', *Sport, Education and Society*, 13(4), 373-391.

Murtagh, E., Mulvihill, M. and Markey, O. (2013) 'Bizzy Break! The Effect of a Classroom- Based Activity Break on In-School Physical Activity Levels of Primary School Children', *Pediatric Exercise Science*, 25(2), 300-307.

NCCA (1999) *Primary School Curriculum*, Department of Education and Science, Dublin, Ireland: Stationery Office.

Nettlefold, L., McKay, H., Warburton, D., McGuire, K., Bredin, S. and Naylor, P. (2011) 'The challenge of low physical activity during the school day: at recess, lunch and in physical education', *British Journal of Sports Medicine*, 45(10), 813-819.

Niemi, H. (2002) 'Active learning—a cultural change needed in teacher education and schools', *Teaching and Teacher Education*, 18(7), 763-780.

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O. and Stamatakis, E. (2015) 'Physically active lessons as physical activity and educational interventions: A systematic review of methods and results', *Preventive Medicine,* 72, 116-125.

Oliver, M., Schofield, G. and McEvoy, E. (2006) 'An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study', *The Journal of School Health*, 76(2), 74-79.

Owen, N., Healy, G. N., Matthews, C. E. and Dunstan, D. W. (2010) 'Too Much Sitting: The Population-Health Science of Sedentary Behavior', *Exercise and Sport Sciences Reviews*, 38(3), 105-113.

Riley, N., Lubans, D. R., Holmes, K. and Morgan, P. J. (2014) 'Rationale and study protocol of the EASY Minds (Encouraging Activity to Stimulate Young Minds) program: cluster randomized controlled trial of a primary school-based physical activity integration program for mathematics', *BMC Public Health*, 14(1), 816-825.

Riley, N., Morgan, P. and Lubans, D. (2012) 'Preliminary findings of the E.A.S.Y. (Encouraging Activity to Stimulate Young) Minds feasibility study: A curriculum-based physical activity integration program in the primary school', *Journal of Science and Medicine in Sport*, 15, Supplement 1(0), S90.

Ritchie, J. and Lewis, J. (2003) *Qualitative research practice: a guide for social science students and researchers*, London: Sage.

Rush, E., Coppinger, T., Obolonkin, V., Hinckson, E., McGrath, L., McLennan, S. and Graham, D. (2012) 'Use of pedometers to identify less active children and time spent in moderate to vigorous physical activity in the school setting', *Journal of Science and Medicine in Sport*, 15(3), 226-230.

Schneider, M., & Cooper, D. M. (2011). 'Enjoyment of exercise moderates the impact of a school-based physical activity intervention', *International Journal of Behavioral Nutrition & Physical Activity, 8*(1), 64-64.

Schulz, K. F., Altman, D. G. and Moher, D. (2010) 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials*, 11, 32.

Spruijt-Metz, D., Nguyen-Michel, S. T., Goran, M. I., Chou, C. P. and Huang, T. T. (2008) 'Reducing sedentary behavior in minority girls via a theory-based, tailored classroom media intervention', *International Journal of Pediatric Obesity*, 3(4), 240-8.

Stewart, J. A., Dennison, D. A., Kohl, H. W. and Doyle, J. A. (2004) 'Exercise Level and Energy Expenditure in the TAKE 10!® In-Class Physical Activity Program', *Journal of School Health*, 74(10), 397-400.

Te One, S. (2007) 'Participatory-research methods with young children: Experiences from the field', *Early Childhood Folio*,11, 21-26.

Tong, A., Sainsbury, P. and Craig, J. (2007) 'Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups', *International Journal for Quality in Health Care*, 19(6), 349-357.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N. and Owen, N. (2010) 'Physiological and health implications of a sedentary lifestyle', *Applied Physiology, Nutrition, and Metabolism*, 35(6), 725-40.

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G. and Gorber, S. C. (2011) 'Systematic review of sedentary behaviour and health indicators in school-aged children and youth', *International Journal of Behavioral Nutrition & Physical Activity*, 8(1), 98.

Treuth, M. S., Catellier, D. J., Schmitz, K. H., Pate, R. R., Elder, J. P., McMurray, R. G., Blew, R. M., Yang, S. and Webber, L. (2007) 'Weekend and weekday patterns of physical activity in overweight and normal-weight adolescent girls', *Obesity (Silver Spring)*, 15(7), 1782-8.

Trost, S. G. (2007) 'State of the Art Reviews: Measurement of Physical Activity in Children and Adolescents', *American Journal of Lifestyle Medicine*, 1(4), 299-314.

Trost, S. G., Loprinzi, P. D., Moore, R. and Pfeiffer, K. A. (2011) 'Comparison of accelerometer cut points for predicting activity intensity in youth', *Medicine & Science in Sports & Exercise*, 43(7), 1360-1368.

U.S. Dept. of Health and Human Services (1996). *Physical activity and health: a report of the Surgeon General*: DIANE Publishing.

Veale, A. (2005) 'Creative methodologies in participatory research with children' in *Researching children's experience: Approaches and methods*, 253-272, London: Sage.

Ward, D. S., Evenson, K. R., Vaughn, A., Rodgers, A. B. and Troiano, R. P. (2005) 'Accelerometer Use in Physical Activity: Best Practices and Research Recommendations', *Medicine & Science in Sports & Exercise*, 37 Supplement 11, S582-S588.

Waring, M., Warburton, P. and Coy, M. (2007) 'Observation of children's physical activity levels in primary school: Is the school an ideal setting for meeting government activity targets?', *European Physical Education Review*, 13(1), 25.

Woods, C. B., Tannehill, D. and Walsh, J. (2012) 'An examination of the relationship between enjoyment, physical education, physical activity and health in Irish adolescents', *Irish Educational Studies*, 31(3), 263-280.

World Health Organisation [WHO] (2010) *Global recommendations on physical activity for health*, Geneva, Switzerland: World Health Organisation.

World Health Organisation [WHO] (2008) *School policy framework: Implementation of the WHO global strategy on diet, physical activity and health*, Geneva, Switzerland: World Health Organisation.

Yildirim, M., te Velde, S. J., Brug, J., Chinapaw, M. J. M., Verloigne, M., de Bourdeaudhuij, I., Androutsos, O., Manios, Y., Felso, R., Kovács, É., Doessegger, A. and Bringolf-Isler, B. (2011) 'Study protocol of physical activity and sedentary behaviour measurement among schoolchildren by accelerometry--cross-sectional survey as part of the ENERGY-project', *BMC Public Health*, 11(1), 182-182.

CHAPTER 4

AN INTERVENTION TO IMPROVE THE PHYSICAL ACTIVITY LEVELS OF CHILDREN: DESIGN AND RATIONALE OF THE 'ACTIVE CLASSROOMS' CLUSTER RANDOMISED CONTROLLED TRIAL

Chapter 4: An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial

Preamble

The following article outlines the design of a behaviour change intervention guided by the BCW framework (Michie *et al.* 2011). The study design and rationale follow the CONSORT guidelines (Moher *et al.* 2010, Schultz *et al*. 2010) in order to ensure robustness in designing, evaluating and reporting the effectiveness of the 'Active Classrooms' programme. The intervention and study design have been informed by a review of the literature (Chapter 2) and the implementation of a pilot study (Chapter 3). The following article has been peer-reviewed and published in *Contemporary Clinical Trials*, impact factor 2015: 2.052 (Thomson Reuters Journal Citation Reports 2016). The full citation for the article is as follows:

Martin, R. and Murtagh, E. M. (2015) 'An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191. ISSN: 1551-7144, http://dx.doi.org/10.1016/j.cct.2015.01.019

Statement of authorship:

I hereby declare that I, Rosemarie Martin am the principal author of this article. The following statements outline my contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).
  (See Appendix R)

See Appendix S for ©Elsevier copyright permissions.

For changes from the published article see Appendix T.

4.1 Abstract

Background: Recent evidence demonstrates that children are not engaging in the recommended 60mins of moderate to vigorous PA per day. PA interventions have been acknowledged by the WHO (2010) as a key strategy to increase the PA levels of children. School has been recognised as a primary location for reaching the majority of children and providing PA opportunities for them. However, the sedentary nature of lessons carried out in the classroom has been identified as a contributing factor to physical inactivity among this age group.

Purpose: To develop and evaluate a classroom-based intervention which integrates PA and academic content, and evaluate its effects on the PA levels of children aged 8-11 in Ireland.

Methods: Active Classrooms is an 8-week classroom based intervention guided by the behaviour change wheel (BCW) framework (Michie et al. 2011) that will be evaluated using a cluster randomised controlled trial (RCT). Study measures will be taken at baseline, during the final week of the intervention and at follow-up after 4 months. The primary outcome is minutes of MVPA during school time objectively assessed using accelerometers (Actigraph). Teachers' perceptions on the effectiveness and use of the intervention and students' enjoyment of the programme will be evaluated post intervention.

Conclusions: Changing teacher behaviour towards using physically active teaching methods may increase the moderate to vigorous PA levels of their students. Therefore, the results of this study may have important implications for the health of children both now and into the future.

Trial Registration: ISRCTN14265493

Keywords: Physical activity; Classroom; Academic Content; Cluster Randomized Controlled Trial; Primary School; Accelerometer

Abbreviations: PA, physical activity; MVPA, moderate to vigorous physical activity; BCW, behaviour change wheel; BCT, behaviour change techniques; RCT randomised controlled trial; WHO, World Health Organisation; NCDs, non-communicable diseases; AC, Active Classrooms

4.2 Introduction

Recent evidence has shown that children who engage in high levels of physical activity (PA) are at a reduced risk of cardiovascular disease, obesity, Type II Diabetes, cancer and other chronic illness (Physical Activity Guidelines Advisory Committee 2008). It has been suggested that for health improvements to occur reducing the risks of premature death and the burden of non-communicable diseases (NCDs), PA should be made a public health priority throughout the world (Hallal *et al.* 2012). It is estimated that less than 20% of children globally (WHO 2010, Griffiths *et al.* 2013) and less than 50% of children in Ireland (Williams 2009) meet public health guidelines which recommend that children aged 5-17 years should accumulate at least 60 minutes of moderate- to-vigorous physical activity (MVPA) every day (WHO 2010). Increasing the PA levels of children has been identified as particularly important given the long-term impact on public health (Waring *et al.* 2007). PA plays an important role in the prevention of overweight and obesity in childhood and adolescence, and reducing the risk of obesity in adulthood (Hills *et al.* 2011). Many studies have shown that interventions (Livingstone 2001) can increase PA levels and childhood is a critical time to intervene.

Schools have been targeted as one of the best environments to implement PA interventions as they are a primary location to reach the majority of children. However, ironically, schools internationally are reported to be one of the dominating environments of sedentary behaviour in children with class time representing a significant sedentary period of the day (Holt *et al.* 2013). The school curriculum is an ideal avenue for accessing all children and encouraging them to be physically active throughout the day. However, emphasis on literacy and numeracy in primary school classrooms has resulted in a lack of time for activity breaks and a lack of emphasis on PE. In order to address this problem which places emphasis on academic content to the detriment of PA, methods of integrating PA into academic lessons in the classroom are warranted.

In reviews of the literature (Dobbins *et al.* 2009, Erwin *et al.* 2012) it has been found that very few studies focus on classroom-based interventions (Cardon *et al.* 2004, Mahar *et al.* 2006, Oliver *et al.* 2006, Gibson *et al.* 2008, Donnelly *et al.* 2009, Erwin *et al.* 2011a, Erwin *et al.* 2011b) and of those which have only three studies have integrated PA into academic content (Donnelly *et al.* 2009, Bartholomew and Jowers 2011, Erwin *et al.* 2011a). These interventions demonstrate that integrating PA into academic content improves students' PA levels during school time without affecting academic teaching time. However, only one of these studies used accelerometer measures and a randomised control trial (Donnelly *et al.* 2009). The other studies (Bartholomew and Jowers 2011, Erwin *et al.* 2011a) use predominantly pedometer measures and have no control group for comparison measures or do not include randomisation. The Theory of Planned Behaviour (Ajzen 1985) and the Ecological Model (Sallis *et al.* 2008) were used to guide these interventions. The Physical Activity Across the Curriculum (PAAC) study (Donnelly *et al.* 2009) refers to Bandura's Social Cognitive Theory and the importance of self-efficacy and goal setting to successfully perform a desired behaviour (Gibson *et al.* 2008). The literature suggests that when designing interventions for children the application of a behavioural theory is essential (Eather *et al.* 2013) since it allows the researcher to determine how the intervention worked and how future interventions can be improved (Michie and Abraham 2004). Therefore, the proposed study aims to build on the strengths and recommendations of previous research through the use of accelerometers, an RCT, behaviour change theory, as well as teacher and student evaluations of the programmes which will enable a robust design.

This study aims to develop an innovative and engaging, 8-week, classroom-based intervention which integrates PA and academic content of the English and Maths curricula, and evaluate its effects on the PA levels of Irish primary school boys and girls. The primary outcome is change in minutes of MVPA measured using accelerometers. Secondary outcomes are teacher satisfaction with the programme and its implementation, and student enjoyment of the programme. The proposed study builds on a successful pilot of the 'Active Classrooms' programme where significant intervention effects were found for MVPA levels of the participants during active lessons. Furthermore, the children and teacher reported on the enhanced learning experienced through participating in the programme. However, the pilot study was carried out in a single classroom and there was no control group.

This paper describes the methodological procedures used to implement and evaluate the effectiveness of the Active Classrooms intervention.

4.3 Methods

4.3.1 Study Design

Active Classrooms is an 8-week classroom-based PA intervention guided by the Behaviour Change Wheel (BCW) and will be evaluated using a Cluster RCT with follow-up after 4 months. Figure 4.1 illustrates the flow of participants through the study. Ethical approval for the study has been granted by Mary Immaculate College Research Ethics

Committee (MIREC), Limerick, Ireland (See Appendix I and Appendix J for ethical approval form, participant information sheets and consent forms).

Design, conduct and reporting of the Active Classrooms intervention will adhere to the Consolidation Standards of Reporting Trials (CONSORT) guidelines (Moher *et al.* 2010, Schulz *et al.* 2010).

A randomly selected sample of primary schools in the study region will be invited to participate. Following the initial recruitment process, school principals, teachers, parents and study participants will provide written informed consent and/or assent. The schools will be randomly allocated to receive an intervention to be implemented over 8- weeks and to commence after baseline data collection, or to a delayed-treatment control group. All eligible participants will complete baseline assessments and follow-up evaluations which will be conducted during week 8 and week 16.

The primary outcome will be change in class time minutes of moderate- to vigorous-intensity physical activity (MVPA) measured using accelerometers at baseline, post intervention and four months follow-up.

4.3.1.1 Use of Behaviour Change Theory

Previous PA interventions have been grounded in Bandura's Social Cognitive Theory (1977), Skinner's PRECEDE model (1953), the Theory of Planned Behaviour (Ajzen 1985), the Ecological Model (Sallis *et al.* 2008) and Rosenstock's Health Belief Model (1966) to initiate short and long term behaviour change (Dobbins *et al.* 2009). The applications of behavioural theories are deemed essential when designing interventions for children (Eather *et al.* 2013). Theoretical frameworks can help researchers determine how the intervention worked and how future interventions can be improved. Indeed, there is evidence that PA interventions informed by theoretically-driven behaviour change models are more successful and lead to stronger and more lasting changes (Michie and Abraham 2004). However, many of these theoretical models have been criticised as they do not address impulsivity, habit, self-control, associative learning and emotional processing which all have important roles in behavioural outcomes, and they do not analyse the target behaviour to develop effective interventions (Michie *et al.* 2011). The Active Classrooms intervention design is therefore, guided by the Behaviour Change Wheel (BCW) framework (Michie *et al.* 2011). This framework is based on the theory that outcome behaviours must be understood in their context with consideration given to the individuals' existing capability, opportunity and motivation to achieve these target behaviours (COM-B) i.e. the capability of the individual, the opportunity provided to the individual and the individual's motivation in a particular context, result in particular behaviour. Table 4.1 summarises how these factors have been considered and how they relate to the target behaviours, in order to decide what support/tools teachers would need to engage the children in physically active behaviour in the classroom. It has been identified that children engage in very little physically active behaviour during regular classroom instruction. This occurs because more 'traditional' whole-class teaching still dominates in primary classrooms (Darmody *et al.* 2010, McCoy *et al.* 2012), therefore teachers are not providing opportunities for the children to be physically active. Although teachers are aware of the benefits of active learning (Niemi 2002) they may not be aware of the effects of sedentary classroom behaviour. Evidence has shown that 'traditional' inactive teaching methods are used due to a lack of training on alternative methods (lack of capability) (Darmody *et al.* 2010, McCoy *et al.* 2012), logistical and space constraints with large class sizes, small classrooms and poor available resources (lack of physical opportunity) (Niemi 2002, Darmody *et al.* 2010, McCoy *et al.* 2012). Active learning methods also initially require much more planning and preparation than traditional methods causing teachers to worry about whether they have time and energy to implement them (Niemi 2002) (a lack of automatic and/or reflective motivation). An intervention providing a sample of integrated teaching resources which can be used with large groups of students in all classrooms and training for teachers on the benefits and use of these resources would help overcome these physical and motivational barriers to increase PA levels during the school day. In line with the BCW framework the intervention functions to be addressed are Education, Persuasion, Training, Environment Restructuring, Modelling and Enablement (See Table 4.1) which are outlined in more detail below. This will be achieved through the development of resources, action plans, setting of achievable goals, professional development training, reorganisation of the classroom environment, use of appropriate classroom management techniques, and replacement of old teaching habits with active methods. The active, 'observable, replicable, and irreducible components' (Michie *et al.* 2011) of the BCW framework which identify content and implementation options for the intervention are called behaviour change techniques (BCTs). The behaviour change techniques (BCT) are the 'active ingredients' (Michie *et al.* 2013) designed to change the behaviour and those which will be incorporated in this intervention are outlined in Table 4.2.

Table 4.1 Links between the components of the 'COM-B' model of behaviour and the intervention functions (Michie *et al.* 2008)

Model of Behaviour: Sources	Why are teachers not using physically active teaching methods?	What needs to change?	Education	Persuasion	Training	Environmental Restructuring	Modelling	Enablement
Capability-Psychological	• Teachers lacking skills to implement physically active methods (Darmody *et al.* 2010, McCoy *et al.* 2012)	• Professional development/ training needs to be provided to teachers • Development of action plans/goal setting	✓		✓			✓
Motivation-Reflective and Automatic	• Teachers preference for direct instruction (McCoy *et al.* 2012) as active methods require much more preparatory work (Niemi 2002) • Overloaded curriculum and a lack of time (Niemi 2002) • Teachers' negative beliefs, perceptions and attitudes towards PA in the classroom (Morgan and Hansen 2008)	• Teachers must plan to use physically active methods and develop a habit of using them. • Believe in the benefits of physically active methods by teachers (information sessions) • Teachers must want to increase PA levels. • Provision of integrated lesson plans and resources	✓	✓		✓	✓	✓
Opportunity-Physical	• Space constraints within the classroom and large class sizes pose logistical constraints (McCoy *et al.* 2012) • Poor teaching and learning resources (Niemi 2002)	• Use of physically active methods with large groups of children even in classrooms with space constraints • Provision of resources				✓		✓

Table 4.2 Examples of trial intervention features mapped onto behaviour change taxonomy and techniques (BCT)

Taxonomy	Intervention Function	BCT	Definition	Example in Active Classrooms Intervention
Shaping Knowledge	Training	Instruction on how to perform a behaviour	Advise or agree on how to perform the behaviour (includes skills training)	Provide an individual information session and a sample of lesson plans to each participating teacher illustrating how to integrate physically active methods into English and Maths lessons
Associations	Education, Environment Restructuring	Prompts/ cues	Introduce social stimulus with the purpose of prompting the behaviour	Text message at the beginning of each week prompting the use of active methods. Poster to display in the classroom requiring daily ticks when active lessons have been taught.
Comparison of outcomes	Persuasion	Persuasive source	Present verbal or visual communication from a credible source in favour of the behaviour	Present results of PAAC programme (Donnelly *et al.* 2009) to show increase in PA levels of children in the classroom
Feedback and Monitoring	Enablement	Self- monitoring of behaviour	Establish a method for the person to monitor and record their behaviour as part of a behaviour change strategy	Teachers keep a log of lessons taught using PA methods to include date, time, lesson, and duration of PA
Repetition and Substitution	Training	Behaviour Substitution	Prompt substitution of the unwanted behaviour with the wanted behaviour	Replace inactive teaching methods with physical activities in teaching English and Maths
	Training	Habit reversal	Prompt repetition of the wanted behaviour to replace the unwanted habitual behaviour	Use active methodologies as often as possible to replace habitual inactive methods
	Training	Generalisation of a target behaviour	Advise to perform the wanted behaviour already performed in a particular situation, in another situation	Advise to use active methods across other topics in English and Maths and in other subject areas
Antecedents	Environment Restructuring	Restructuring the physical environment	Advise to change the physical environment in order to facilitate the performance of the wanted behaviour	Advise to arrange desks in the classroom to allow space for movement

Table 4.2 Examples of trial intervention features mapped onto behaviour change taxonomy and techniques (BCT) (cont'd)

Taxonomy	Intervention Function	BCT	Definition	Example in Active Classrooms Intervention
Comparison of behaviour	Education	Information about others' approval	Provide information about what other people think of the behaviour. The information clarifies whether others will like, approve or disapprove of what they are doing.	Share anonymous feedback from the teachers who implemented the pilot on what they thought of the programme
Goals and Planning	Enablement	Problem solving	Analyse factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators	Teachers complete a reflective exercise to analyse factors influencing the behaviour and engage in discussion with the researcher to generate strategies that include overcoming barriers and/or increasing facilitators
	Enablement	Goal setting (behaviour)	Set or agree a goal defined in terms of the behaviour to be achieved	Eg. Plan to teach using PA methods in at least two lessons each day (one English and one Maths)
	Enablement	Action planning	Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity)	Prompt to plan to teach a lesson using PA methods for at least 10 minutes twice a day during English and Maths lessons.

4.4 Sample/ Participants and Setting

Primary Schools: Randomly selected primary schools located around Munster, Ireland will be invited to participate in the Active Classrooms program in 2014/15. Of the primary schools within the study region, those that meet the following criteria will be eligible to participate in the study: co-educational schools with a minimum of 20 students in each class (to meet sample size requirements). Thirty-one schools, identified using the Department of Education and Skills database, are eligible to participate. Ten schools will be recruited.

Students: All students in third/fifth class of participating schools are eligible to participate in the programme if they return a signed informed consent letter from their parent(s) with child assent, and do not currently have a medical condition or physical injury preventing testing or participation. **Teachers:** All teachers teaching third/fifth class of participating schools are eligible to participate in the program if they return a signed informed consent letter. Figure 4.**Error! Reference source not found.**1 depicts the flow of participants through the trial.

4.5 Recruitment Procedures

Prior to recruitment, a random number function in Microsoft Excel will be used to determine the order in which the eligible primary schools are approached to participate. Invitations to participate will be sent to the principals of the first 10 randomly selected schools who will be given 2 weeks to respond. After this time, follow up phone calls will be made to the principals of invited schools who have not yet replied. If a selected school declines, an additional letter will be sent to the next eligible school on the list until 10 schools accept the invitation to participate.

The letter sent to the principals of selected schools will outline the study in detail and invite an expression of interest to participate. Upon receipt of their expression of interest to participate, the researcher will contact the Principal by phone. A face-to-face meeting will be requested with both the Principal and the classroom teachers to outline the requirements of the study. Written consent will be sought from both the Principal and the classroom teachers in each school before participants from relevant classes are recruited. Should a school decide to withdraw during the study the principal can do so by informing the researcher and the next school on the list will be invited to participate.

Students: In an effort to maximise parent and student consent a number of strategies that have been used successfully in similar research as below (Lubans *et al.* 2010, Okely *et al.* 2011, Wolfenden *et al.* 2011) will be adopted. All students in participating classes will be provided with an information package that will contain a child friendly brochure and a parent/guardian brochure outlining the study, an assent form, and a consent form for parents/guardians asking for consent for their child to participate in the study data collection. Parents will be asked to return the consent form to the school if they wish their child to participate in the study. Assent must also be obtained from each child and should a child withdraw assent this decision will override parental consent. The researcher's contact details will be provided to the parents should they have any questions regarding the research. Classroom teachers will be asked to remind parents to return the forms if they wish their child to participate. A replacement consent form will be sent to parents providing verbal consent or if they have lost their forms. A minimum of 20 consenting students will allow the class to participate. Should a student decide to withdraw during the study they can do so by informing their teacher.

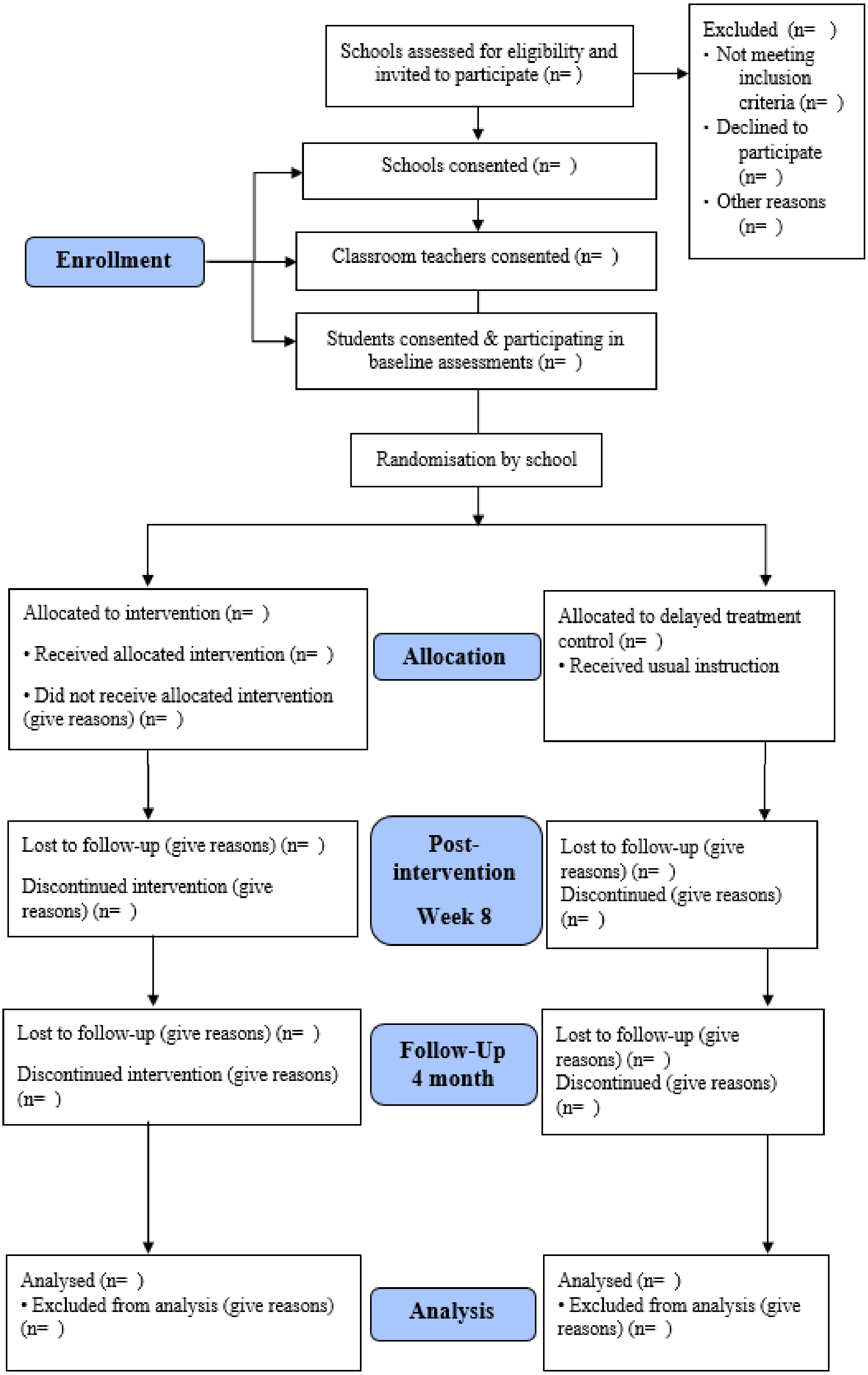


Figure 4.1 Flow of participants through Active Classrooms

4.6 Sample Size Calculation

The primary outcome variable in this study is minutes in MVPA measured by accelerometers. Power calculations to determine the sample size necessary to detect changes in MVPA are based on previous studies (Donnelly *et al.* 2009, Fairclough *et al.* 2012, Jago *et al.* 2013). Sample sizes are calculated to detect a mean difference of 10 minutes per day (Donnelly *et al.* 2009, Jago *et al.* 2013) of school day MVPA between intervention and control groups at the end of the intervention period. A standard deviation of 12 minutes (Basterfield *et al.* 2008, Fairclough *et al.* 2012) is used as this value has been reported in the literature when describing the PA patterns in primary school children. Using Minitab17 software a 2 sample t-test with an alpha of 0.05 and power of 73%, a sample size of 180 participants (18 per class) will be required for analysis. Applying an intra-cluster correlation of 0.05 to the formula outlined by Hemming et al (2011) (Hemming *et al.* 2011), 9 clusters are sufficient for the trial. Ten classes and a minimum of 20 students within each class will be recruited to account for possible dropouts.

4.7 Blinding and Randomisation

Randomisation by school will be performed after the schools have been recruited. Randomisation will be undertaken by an independent third party who will blindly allocate the ten schools into one of the two treatment conditions, the Active Classroom intervention or a delayed-treatment control group, at a ratio of 1:1. Participating schools and the researcher will be blinded to treatment conditions during baseline assessments to reduce participation bias (Jadad 1998). After baseline data collection the researcher will be informed to which group each school has been allocated and will then inform the school principals and classroom teachers.

4.8 Physical Activity Intervention

4.8.1 Treatments

The explicit incorporation of strategies such as teacher professional learning, on-going teacher support, availability of credible leadership, provision of resources and prompts, and monitoring and feedback of intervention adoption have been suggested to be important to ensure sustainability of intervention programs (Wilson and Kurz 2008, Damschroder *et al.* 2009, Forman *et al.* 2009) and will be adopted in this study. These features are important to support intervention adoption and behavioural changes within classrooms and combined with the objective evaluation measures, contribute to the uniqueness of the study and will provide evidence to support the effectiveness of the Active Classrooms intervention for improving the PA levels of children without interrupting academic teaching time.

4.8.1.1 Intervention

An 8 week programme has been designed which integrates PA into the Irish Primary English and Maths Curricula. Intervention lessons will be delivered by classroom teachers during normal English and Maths instructional time each day during weeks 1 to 8. The programme is designed for teachers to teach English and Maths lessons using physically active teaching methods, to improve the PA levels of their students during the school day, without interrupting academic teaching time.

Intervention Functions:

The functions of this intervention are to educate, train, persuade, restructure the environment, and enable the teachers to change their behaviour towards using physically active teaching methods in English and Maths lessons (See Table 4.1). These functions occur in an integrated way and are outlined as such below.

Teacher Training: Training has been shown to be an effective implementation support strategy (Moulding *et al.* 1999, de Meester *et al.* 2009). A once off, 40 minute, individual information & training session will provide teachers in the intervention group with *training* on their role in implementing the physically active lessons. All teachers will undergo an identical training session to ensure understanding and consistency between teachers and to maximise compliance. Reflexive exercises on the methods teachers currently use, levels of MVPA the children currently engage in in classroom lessons, and changing teaching practices and the *environmental structure* to enhance levels of activity will be incorporated. Knowledge (*education*) will be shared with the teachers on the benefits of teaching using active methods and the effects of physical inactivity. The training session intends to foster skill development and enhance teaching styles to engage children in active lessons and effectively increase their MVPA levels in the classroom (See Table 4.3 detailing the content of the teacher information and training session).

Table 4.3 Teacher training workshop agenda

Agenda Item	Description
Introduction to Active Classrooms	• Brief description of inactivity problem in primary school children • Role classroom teachers can play • Active Classrooms integrates PA into academic content with a focus on English and Maths • Physically active teaching methods • Does not reduce academic teaching time
Physically Active Methods	• Explanation of PA as any type of movement • Explanation of moderate and vigorous PA • Examples of physically active teaching methods for English and Maths • Preparation of the classroom environment
Reflective Exercise	• Teacher analyses his/her current teaching style, asks him/herself if they could implement this intervention? Why/why not? • Teacher engages in discussion with the researcher exploring ideas to overcome barriers
Lesson Planning	• Researcher shares sample lesson plans for physically active Maths and English lessons
Conclusion	• Intervention Timeline • Researcher contact details • Support available

Resources: Teachers will receive resource material containing sample intervention lessons linked to the English and Maths Irish Primary School Curriculum. This will *enable* them to enhance the PA levels of the students during the lessons (See Appendix E, Appendix F, Appendix G and Appendix H). They will also be encouraged to generate strategies to use physically active methods, develop plans to use the lessons daily, create prompts for themselves to use the lessons at specific times each day, and track their progress by recording lessons implemented.

Prompts: The researcher will provide prompts such as text messages and interactive posters to teaching staff to remind and *persuade* them to carry out the intervention with their classes on the appropriate weeks.

Intervention adoption performance feedback: Principals and intervention teachers at each school will be given feedback on teacher and pupil satisfaction, and the effectiveness of the intervention programme on the PA levels of the students after the study has been completed. This feedback as well as an explanation of how a similar intervention worked in the Physical Activity Across the Curriculum (PAAC) study (Donnelly and Lambourne 2011) also intends to *persuade* the teachers to change their behaviour.

4.8.1.2 Delayed-Treatment Control Group

The control group will participate in English and Maths lessons with their classroom teacher as normal during the 8-week period. Control schools will participate in the measurement components of the study only. The lesson content will be decided as usual by the classroom teacher. Teachers in control schools will receive a text prompt at the beginning of data collection weeks reminding them to distribute the accelerometers each day and to record pupil non- wear time. They will also be offered all developed intervention materials and the results of the study after follow-up data at 4 months have been collected.

Support and leadership will be available from the researcher to the teachers throughout the study in the form of making decisions related to timing, arranging delivery and collection of accelerometers and resources, providing materials, sample lessons and advice to enhance teaching and learning of the teachers' current topics, being available to speak to the teachers at their request, should they have any issues, and offering encouragement.

4.9 Data collection procedures and measures

Data collection will commence in January 2015. Schools will be placed in pairs on a rolling weekly schedule with each pair allocated 3 data collection weeks. All data will be collected by the researcher at baseline, on the 8th intervention week and at 4-months follow-up. All participants will complete a questionnaire to collect demographic information and will wear an accelerometer each school day during data collection weeks. The researcher will distribute the accelerometers to the schools on Mondays before school and collect them on Fridays after school. All teachers in both intervention and control groups will be trained on how the children should wear the accelerometers and how to log non-wear time. The accelerometers and instructions for use will be given to the classroom teacher who will distribute the devices to the students at the beginning of each school day and collect them at the end of each school day. Adherence will be monitored by having classroom teachers keep a record log in which they will indicate when and what intervention lessons they carried out with the class each day. Teachers will also record student's accelerometer non-wear time and the reasons why eg. due to water activities, absence etc. To improve compliance, teachers will be sent a text message each data collection week reminding them to distribute the accelerometers and complete the log (Lubans *et al.* 2010, Okely *et al.* 2011).

4.10 Outcome Measures

Daily PA levels of all participating students within each class will be collected using accelerometer measures detailed below. Participants will be asked to wear the accelerometers during normal school day activities (Bartholomew and Jowers 2011, Murtagh *et al.* 2013) except while swimming, for five consecutive school days of baseline and intervention measurement. The age and sex of the children in each class will be recorded and an identifying code paired with an accelerometer will be assigned to each student.

Objectively measured PA data will be collected via accelerometers (Actigraph) Accelerometry provides an objective, valid and reliable way of measuring PA in young people (Trost 2007, Dollman *et al.* 2009, McClain and Tudor-Locke 2009). The Actigraph model has been selected due to their common use and good psychometric properties against other accelerometer types among children (de Vries *et al.* 2006). Although there is best practice for accelerometer use there is no consensus on several issues eg: no. of days measurement for school children to reflect their habitual activity therefore this study will consider best practice recommendations (Yildirim *et al.* 2011).

The primary outcome will be student PA defined as mean minutes of MVPA. Percentage of time spent in MVPA will also be calculated to adjust for individual accelerometer wear time. The accelerometers will be attached to an elastic belt and worn over the right hip. Raw data will be collected and stored in 15 second epochs as this allows for pattern recognition techniques to be applied to the data later, if desired. Fifteen second epochs are highly recommended and have been shown to have the best sensitivity and specificity for use with children when compared to others (Evenson *et al.* 2008, Trost *et al.* 2011). The Actilife software classifies the intensity for each 15 second period according to the selected cut points. The Evenson cut-points (Evenson *et al.* 2008) will be used to categorize different intensities of PA as these provide the most acceptable classification accuracy for all four levels of PA intensity and they performed best among children of all ages (Trost *et al.* 2011). Guided by the 70/80% rule a day is defined as a period that 70% of the students record accelerometer data and 80% of that observed period constitutes a minimal day for data collection (Ward *et al.* 2005). A regular school day is 340 minutes therefore, it is expected that the monitors are worn for 272 minutes (4hrs 32 minutes) on school days.

Based on recommendations (Esliger *et al.* 2005) a cut point for the upper limit count values will be set to avoid spurious data. Esliger *et al.* (2005) found that count values of >15,000/min are very unusual and implausible therefore, count values above 15,000 will be considered as missing data. For outcome measures of minutes of MVPA the expectation maximisation (EM) algorithm was found to have greater precision in predicting missing values than multiple imputation (Catellier *et al.* 2005) therefore this procedure of imputation will be used for missing data in this study.

4.11 Data Management

Microsoft Excel will be used to prepare and clean accelerometer data files according to non-wear time (described below), invalid data (eg days that do not have enough wearing time and implausibly high count values), and specific bout definitions such as bouts of sedentary time.

This study is only taking the students' PA levels while 'in-school' into consideration. Therefore, students are expected to wear the accelerometers throughout the school day (Cardon *et al.* 2004) except during water activities. Exact school-times will be collected in forms filled out by the principal of each school allowing filters for school times to be applied during data cleaning. Similar data processing criterion from a study by Sluijs *et al.* (2011) and Yildirim *et al.* (2011) will be used. In brief, the total valid hours per school day and the total time spent in sedentary behaviour, light, moderate and vigorous activity will be obtained. The mean percentages of time spent in sedentary, moderate and vigorous activity categories per school day will be calculated.

Wear time calculation is not solely excluding all zero count values from data, as sedentary behaviour is part of data (Yildirim *et al.* 2011). Unlike previous studies (Sluijs *et al.* 2011, Yildirim *et al.* 2011) 10 minutes of continuous zero counts cannot be classified as 'non-wear time' since students may engage in sustained periods of sedentary behaviour in the classroom. For this reason teachers will be asked to record non-wear time such as if students are absent from school or if they need to remove the accelerometers to engage in water activities.

4.12 Assessment on Effectiveness, Teacher and Student Attitudes

Immediately post-intervention, questionnaires will be administered to assess teachers' attitudes toward the effectiveness and sustainability of the intervention project. The questionnaire has been designed to determine teachers' perceptions on the various aspects of the programme and to elicit their ideas on how to improve the intervention project. The questionnaire should take no more than 15 minutes to complete. The questionnaire design is described below.

- Demographic Information: 5 structured quick response questions will be used to determine the personal characteristics of the teachers (name, age bracket, sex, class level, and school).
- Implementation experience: information relating to the participants experience in implementing the intervention lessons is sought through the use of 5 structured closed and open ended questions. Teachers are asked to rate the ease with which they found the implementation of the intervention lessons on a scale of 1-5 with 1 being most difficult and 5 being the easiest to implement. On 5- point Likert format scales they are asked to indicate how often they used the intervention lessons and how likely they are to continue using them in the future. The participants are also asked for reasons for their answers so that factors supporting and inhibiting implementation of the intervention can be identified.
- PA Levels: Teachers are asked to indicate, on a Likert format scale, the effect they believe the lessons had on their students' PA levels.
- Teaching and Learning: Teachers are asked to indicate on Likert format scales the degree to which they believe the intervention lessons enhanced their teaching and their students' learning.
- Evaluation: Finally the teachers are asked to identify any difficulties or challenges they found while implementing the intervention and to make suggestions to improve the program. A sample of teachers will be interviewed to further explore their experiences of the programme.

4.12.1 Student Voice

Student enjoyment has been found to moderate and mediate the effect of PA interventions (Howie *et al.* 2014) and teacher acceptance also relies on this enjoyment. Therefore, to develop an effective intervention it is essential to evaluate the students' enjoyment of the programme. The use of approaches that incorporate the visual have been recommended to extend our understanding of children's perspectives (Crivello *et al.* 2009, Loveridge 2010, Clark and Moss 2011, Dalli and Te One 2012, Knowles *et al.* 2013). However, it has been identified that drawings may not be useful as visual images in themselves (Veale 2005) since they cannot be interpreted adequately without children's explanations. Therefore, the write and draw technique combined with focus group discussions has been regarded as a developmentally appropriate methodology to use with primary school children (Te One 2007, Knowles *et al.* 2013). This methodology enables children to express their opinions and views as well as providing an insight into their belief system. Focus group discussions framed around the children's drawings and written texts strengthen the quality of the data (Crivello *et al.* 2009) and the use of these multiple data collection sources enable triangulation. As a result of this evidence, the students' enjoyment of the Active Classrooms programme will be evaluated through the use of the write and draw technique combined with focus group discussions (Knowles *et al.* 2013).

At baseline the students will be asked to draw pictures of themselves in English and Maths lessons and write about each one. Post-intervention they will be asked to repeat this task. A randomly selected sub group of four participating students from each class will engage in focus group discussions with the researcher. The children's drawings and written texts will form the basis of the discussion. Through engagement in conversation with the children, the researcher will translate the images and text into spoken words. Clarification will be sought to ensure the researcher has an accurate perception of the children's views, knowledge and experiences. Focus group interviews will be audio taped to ease the analysis process. The non-verbal behaviours of the individuals and their reactions to the issues discussed and questions asked will also be recorded (Crivello *et al.* 2009) to assist with interpretation. To promote complete and transparent reporting among researchers and indirectly improve the rigor, comprehensiveness and credibility of interview and focus group studies, a 32 item Consolidating Criteria for Reporting Qualitative Research (COREQ) checklist was developed (Tong *et al.* 2007). This checklist will be followed in reporting the qualitative sections of the study.

4.13 Statistical Methods

The effectiveness of the intervention will be assessed using a mixed design ANOVA to compare the change in the primary outcome (within subjects and between treatments) when measured as the mean and total weekly MVPA levels while adjusting for the following covariates as appropriate: baseline MVPA level, age, gender and class. All data will be inputted to Microsoft Excel and subsequently SPSS where statistical comparisons will be made between control and intervention groups to evaluate the effectiveness of the intervention on MVPA levels. Analyses using cluster-level summaries are reported to be stronger than analyses based on individual-level data when there are less than 15 clusters per treatment arm (Hayes and Bennett 1999). Therefore the primary outcome for this study will be analysed by calculating the change in the mean number of minutes of MVPA within each classroom and then comparing the classroom-level means of the intervention group with the classroom-level means of the control group.

Both fixed (intervention effects) and random (classrooms in schools) effects will be used in this study therefore, mixed design ANOVA is appropriate for analysing the data. The data in this study are a three- level clustered repeated- measure data set (the individual students are nested within classrooms which are in turn nested within schools and measures will be taken at baseline, after the intervention and at follow-up). Mixed design ANOVA allows researchers to determine if each of the within and between subject effects have an influence on the dependent variable when controlling for variance due to other factors, such as gender, class and age, as well as determining if the combined effect of the factors has an influence on the dependent variable (O'Donoghue 2012). Differences in PA levels between participants in the intervention and control groups will be measured using t-tests at baseline and follow-up (Eather *et al.* 2011) and they will be represented using suitable numerical summaries and graphical techniques. Normality testing will be performed and non-parametric tests (O'Donoghue 2012) will be applied to compare data if necessary. Differences between those who complete and those who drop out of the study will be examined using independent samples t-tests. Multiple imputation will be considered if the dropout rate is substantial.

Analysis of questionnaires and focus groups: Focus group discussions will be recorded and transcribed. Closed and Likert Format questionnaire responses will be coded and data will be inserted into an Excel spreadsheet for analysis. Open-ended questions and focus group discussions will be analysed using a recursive approach (Cohen *et al.* 2007). Quotes with similar meanings will be grouped together and labelled with a theme. All statistical analyses will be performed using SPSS version 21 software package.

4.14 Discussion

The purpose of this study is to evaluate the effectiveness of a classroom-based, teacher-led initiative on the PA levels of Irish primary school boys and girls. Physically active teaching methods will be integrated into English and Maths lessons with the intention of increasing MVPA levels in the classroom setting. The intervention is guided by the behaviour change wheel (BCW) framework which relies on specific behaviour change techniques to modify the behaviour of the teachers, encouraging them to use these physically active teaching methods in their English and Maths lessons. The goal is to increase the daily MVPA levels of the students.

The lack of classroom-based PA interventions which integrate academic content in a meaningful way highlights the need for this intervention. What children do in the classroom is largely influenced by the teacher, therefore teachers and their attitudes play a central role in determining the success or failure (Fullan 2007) of classroom based interventions. Consequently, implementing change in the classroom is ultimately a personal, individual decision by teachers. Encouraging classroom teachers to assume responsibility for integrating PA into academic lessons requires behavioural change on the part of the teacher, as well as, presenting them with interventions that fit with their schedules, curriculum and their beliefs and values about teaching (Cothran *et al.* 2010). The Behaviour Change Wheel (Michie *et al.* 2011) framework requires an analysis of this target behaviour to develop an effective intervention based on the teachers' specific needs. The lessons, resources and materials are designed to fit into the curriculum currently being taught by the teacher. They outline and enable physically active teaching methods, and intend to enhance both the teaching and learning of the content while also facilitating the students to be more physically active. This contributes to the uniqueness of the study.

Student enjoyment has a large effect on the success of PA interventions (Howie *et al.* 2014) and teacher acceptance also relies on this enjoyment. Therefore, to develop an effective intervention it is essential to evaluate the students' enjoyment of the programme. The teacher and student evaluations will allow us to explore the impact of specific elements of the intervention. This evaluation will provide valuable information for other researchers looking to improve PA levels of primary school children through classroom-based interventions which integrate academic content.

The study described in this paper is innovative, as it proposes an intervention which provides teachers with lesson ideas and resources enabling them to teach academic content using physically active teaching methods in their classrooms. The use of accelerometers is also noteworthy since accelerometry quantifies the intensity of the PA accumulated. It is envisaged that a sustainable and transparent intervention has been developed to change teacher behaviour towards the use of active teaching methods, which will contribute towards increasing MVPA levels of children in classrooms. If successful, the Active Classrooms intervention could be widely disseminated to provide an effective means of improving the PA levels of a large population of children, therefore contributing to overall public health.

4.15 Chapter Conclusion

The article articulated within Chapter 4 presents the considerations given to the development of the intervention and methods to be employed in recruiting the participants, conducting the investigation, gathering and analysing data and reporting the results. Elements contributing to the uniqueness of the study are also highlighted. The following two chapters outline a report of the cluster randomised controlled trial. The effects of the intervention on the MVPA levels of participating students and teacher ratings of their satisfaction with the programme are presented in Chapter 5. Chapter 6 delves deeper into the teachers' perceptions of the programme and also presents students' experiences of participating in the programme.

4.16 References

Ajzen, I. (1985) *From intentions to actions: A theory of planned behavior*, Springer.

Bartholomew, J. B. and Jowers, E. M. (2011) 'Physically active academic lessons in elementary children', *Preventive Medicine*, 52 Suppl 1, S51-4.

Basterfield, L., Adamson, A. J., Parkinson, K. N., Maute, U., Li, P. X., Reilly, J. J. and Gateshead Millennium Study Core, T. (2008) 'Surveillance of physical activity in the UK is flawed: validation of the Health Survey for England Physical Activity Questionnaire', *Archives of Disease in Childhood*, 93(12), 1054-1058.

Cardon, G., De Clercq, D., De Bourdeaudhuij, I. and Breithecker, D. (2004) 'Sitting habits in elementary schoolchildren: a traditional versus a "Moving school"', *Patient Education and Counseling*, 54(2), 133-142.

Catellier, D. J., Hannan, P. J., Murray, D. M., Addy, C. L., Conway, T. L., Yang, S. and Rice, J. C. (2005) 'Imputation of missing data when measuring physical activity by accelerometry', *Medicine & Science in Sports & Exercise*, 37 Suppl 11, S555.

Clark, A. and Moss, P. (2011) *Listening to young children: The mosaic approach*, London: Jessica Kingsley Publishers.

Cohen, L., Manion, L. and Morrison, K. (2007) *Research methods in education Ed 6*, London: Taylor & Francis Ltd.

Cothran, D. J., Kulinna, P. H. and Garn, A. C. (2010) 'Classroom teachers and physical activity integration', *Teaching and Teacher Education*, 26(7), 1381-1388.

Crivello, G., Camfield, L. and Woodhead, M. (2009) 'How can children tell us about their wellbeing? Exploring the potential of participatory research approaches within young lives', *Social Indicators Research*, 90(1), 51-72.

Dalli, C. and Te One, S. (2012) 'Involving children in educational research: researcher reflections on challenges', *International Journal of Early Years Education*, 20(3), 224-233.

Damschroder, L. J., Aron, D. C., Keith, R. E., Kirsh, S. R., Alexander, J. A. and Lowery, J. C. (2009) 'Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science', *Implementation Science*, 4(1), 50.

Darmody, M., Smyth, E. and Doherty, C. (2010) 'Designing primary schools for the future', *Economic and Social Research Institute (ESRI) Research Series*.

de Meester, F., van Lenthe, F., Spittaels, H., Lien, N. and De Bourdeaudhuij, I. (2009) 'Interventions for promoting physical activity among European teenagers: a systematic review', *International Journal of Behavioral Nutrition and Physical Activity*, 6(1), 82.

de Vries, S. I., Bakker, I., Hopman-Rock, M., Hirasing, R. A. and van Mechelen, W. (2006) 'Clinimetric review of motion sensors in children and adolescents', *Journal of Clinical Epidemiology*, 59(7), 670-680.

Dobbins, M., De Corby, K., Robeson, P., Husson, H. and Tirilis, D. (2009) 'School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18', *Cochrane Database of Systematic Reviews*, 2009/01/23(1), CD007651.

Dollman, J., Okely, A. D., Hardy, L., Timperio, A., Salmon, J. and Hills, A. P. (2009) 'A hitchhiker's guide to assessing young people's physical activity: Deciding what method to use', *Journal of Science and Medicine in Sport*, 12(5), 518-25.

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., Dubose, K., Mayo, M., Schmelzle, K., Ryan, J., Jacobsen, D. and Williams, S. (2009) 'Physical activity across the curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine*, 49, 336 - 341.

Donnelly, J. E. and Lambourne, K. (2011) 'Classroom-based physical activity, cognition, and academic achievement', *Preventive Medicine*, 52 Suppl 1, S36-42.

Eather, N., Morgan, P. J. and Lubans, D. R. (2011) 'Improving health-related fitness in children: the Fit-4-Fun randomized controlled trial study protocol', *BMC Public Health*, 11, 902.

Eather, N., Morgan, P. J. and Lubans, D. R. (2013) 'Social support from teachers mediates physical activity behavior change in children participating in the Fit-4-Fun intervention', *International Journal of Behaviour, Nutrition and Physical Activity*, 10, 68.

Erwin, H., Abel, M., Beighle, A. and Beets, M. (2011a) 'Promoting children's health through physically active math classes: a pilot study', *Health Promotion Practice*, 12(2), 244-51.

Erwin, H., Beighle, A., Morgan and Noland (2011b) 'Effect of a Low-Cost, Teacher-Directed Classroom Intervention on Elementary Students' Physical Activity', *Journal of School Health*, 81(8), 455-461.

Erwin, H., Fedewa, A., Beighle, A. and Ahn, S. (2012) 'A Quantitative Review of Physical Activity, Health, and Learning Outcomes Associated With Classroom-Based Physical Activity Interventions', *Journal of Applied School Psychology*, 28(1), 14-36.

Esliger, D. W., Copeland, J. L., Barnes, J. D. and Tremblay, M. S. (2005) 'Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring', *Journal of Physical Activity & Health*, 2(3).

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S. and McMurray, R. G. (2008) 'Calibration of two objective measures of physical activity for children', *Journal of Sports Sciences*, 26(14), 1557-1565.

Fairclough, S. J., Beighle, A., Erwin, H. and Ridgers, N. D. (2012) 'School day segmented physical activity patterns of high and low active children', *BMC Public Health*, 12(1), 406.

Forman, S. G., Olin, S. S., Hoagwood, K. E., Crowe, M. and Saka, N. (2009) 'Evidence-based interventions in schools: Developers’ views of implementation barriers and facilitators', *School Mental Health*, 1(1), 26-36.

Fullan, M. (2007) *The new meaning of educational change*, London: Routledge.

Gibson, C., Smith, B., DuBose, K., Greene, J. L., Bailey, B., Williams, S., Ryan, J., Schmelzle, K., Washburn, R., Sullivan, D., Mayo, M. and Donnelly, J. (2008) 'Physical activity across the curriculum: year one process evaluation results', *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 36.

Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., Cole, T. J., Law, C., Joshi, H. and Ness, A. R. (2013) 'How active are our children? Findings from the Millennium Cohort Study', *The BMJ Open*, 3(8), e002893.

Hallal, P. C., Bauman, A. E., Heath, G. W., Kohl, H. W., Lee, I. M. and Pratt, M. (2012) 'Physical activity: more of the same is not enough', *The Lancet*, 380(9838), 190-191.

Hayes, R. and Bennett, S. (1999) 'Simple sample size calculation for cluster-randomized trials', *International Journal of Epidemiology*, 28(2), 319-326.

Hemming, K., Girling, A. J., Sitch, A. J., Marsh, J. and Lilford, R. J. (2011) 'Sample size calculations for cluster randomised controlled trials with a fixed number of clusters', *BMC Medical Research Methodology*, 11(1), 102.

Hills, A. P., Andersen, L. B. and Byrne, N. M. (2011) 'Physical activity and obesity in children', *British Journal of Sports Medicine*, 45(11), 866-870.

Holt, E., Bartee, T. and Heelan, K. (2013) 'Evaluation of a Policy to Integrate Physical Activity Into the School Day', *Journal of Physical Activity & Health*, 10(4), 480-487.

Howie, E. K., Newman-Norlund, R. D. and Pate, R. R. (2014) 'Smiles Count but Minutes Matter: Responses to Classroom Exercise Breaks', *American Journal of Health Behavior*, 38(5), 681-689.

Jadad, A. R. (1998) *Randomised controlled trials: a user's guide*, London: BMJ Books.

Jago, R., Sebire, S., Turner, K., Bentley, G., Goodred, J., Fox, K., Stewart-Brown, S. and Lucas, P. (2013) 'Feasibility trial evaluation of a physical activity and screen-viewing course for parents of 6 to 8year-old children: Teamplay', *International Journal of Behavioral Nutrition and Physical Activity*, 10(1), 31.

Knowles, Z. R., Parnell, D., Ridgers, N. and Stratton, G. (2013) 'Learning from the experts: exploring playground experience and activities using a write and draw technique', *Journal of Physical Activity and Health*, 10(3), 406.

Livingstone, M. (2001) 'Childhood obesity in Europe: a growing concern', *Public Health and Nutrition*, 4(1a), 109-116.

Loveridge, J. (2010) *Involving children and young people in research in educational settings, Report to the Ministry of Education*, Victoria, New Zealand: Ministry of Education. *Available from:* www.educationcounts.govt.nz/publications, [Accessed: 23rd June 2012].

Lubans, D. R., Morgan, P. J., Dewar, D., Collins, C. E., Plotnikoff, R. C., Okely, A. D., Batterham, M. J., Finn, T. and Callister, R. (2010) 'The Nutrition and Enjoyable Activity for Teen Girls (NEAT girls) randomized controlled trial for adolescent girls from disadvantaged secondary schools: rationale, study protocol, and baseline results', *BMC Public Health*, 10(1), 652.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). 'Effects of a classroom-based program on physical activity and on-task behavior', *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

McClain, J. J. and Tudor-Locke, C. (2009) 'Objective monitoring of physical activity in children: considerations for instrument selection', *Journal of Science and Medicine in Sport*, 12(5), 526-533.

McCoy, S., Smyth, E. and Banks, J. (2012) *The primary classroom: Insights from the growing up in Ireland study*, Dublin: ESRI and NCCA.

Michie, S. and Abraham, C. (2004) 'Interventions to change health behaviours: evidence-based or evidence-inspired?', *Psychology & Health*, 19(1), 29-49.

Michie, S., Johnston, M., Francis, J., Hardeman, W. and Eccles, M. (2008) 'From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques', *Applied Psychology*, 57(4), 660-680.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J. and Wood, C. E. (2013) 'The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions', *Annals of Behavioral Medicine*, 46(1), 81-95.

Michie, S., van Stralen, M. M. and West, R. (2011) 'The behaviour change wheel: a new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), 42-52.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M. and Altman, D. G. (2010) 'CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials', *Journal of Clinical Epidemiology*, 63(8), e1-e37.

Morgan, P. J. and Hansen, V. (2008) 'The relationship between PE biographies and PE teaching practices of classroom teachers', *Sport, Education and Society*, 13(4), 373-391.

Moulding, N. T., Silagy, C. and Weller, D. (1999) 'A framework for effective management of change in clinical practice: dissemination and implementation of clinical practice guidelines', *Quality in Health Care*, 8(3), 177-183.

Murtagh, E., Mulvihill, M. and Markey, O. (2013) 'Bizzy Break! The Effect of a Classroom- Based Activity Break on In-School Physical Activity Levels of Primary School Children', *Pediatric Exercise Science*, 25(2), 300-307.

Niemi, H. (2002) 'Active learning—a cultural change needed in teacher education and schools', *Teaching and Teacher Education*, 18(7), 763-780.

O'Donoghue, P. (2012) *Statistics for sport and exercise studies: an introduction*, London: Routledge.

Okely, A. D., Cotton, W. G., Lubans, D. R., Morgan, P. J., Puglisi, L., Miller, J., Wright, J., Batterham, M. J., Peralta, L. R. and Perry, J. (2011) 'A school-based intervention to promote physical activity among adolescent girls: Rationale, design, and baseline data from the Girls in Sport group randomised controlled trial', *BMC Public Health*, 11(1), 658.

Oliver, M., Schofield, G. and McEvoy, E. (2006) 'An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study', *The Journal of School Health*, 76(2), 74-79.

Physical Activity Guidelines Advisory Committee (2008) *Physical activity guidelines advisory committee report, 2008*, Washington, DC: US Department of Health and Human Services, 2008, A1-H14.

Sallis, J. F., Owen, N. and Fisher, E. B. (2008) 'Ecological models of health behavior', *Health Behavior and Health Education: Theory, Research, and Practice*, 4, 465-486.

Schulz, K. F., Altman, D. G. and Moher, D. (2010) 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials*, 11, 32.

Sluijs, E. M., Jones, N. R., Jones, A. P., Sharp, S. J., Harrison, F. and Griffin, S. J. (2011) 'School□level correlates of physical activity intensity in 10-year-old children', *International Journal of Pediatric Obesity*, 6(2Part2), e574-e581.

Te One, S. (2007) 'Participatory-research methods with young children: Experiences from the field', *Early Childhood Folio*, 2007, 11, 21-26.

Tong, A., Sainsbury, P. and Craig, J. (2007) 'Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups', *International Journal for Quality in Health Care*, 19(6), 349-357.

Trost, S. G. (2007) 'State of the Art Reviews: Measurement of Physical Activity in Children and Adolescents', *American Journal of Lifestyle Medicine*, 1(4), 299-314.

Trost, S. G., Loprinzi, P. D., Moore, R. and Pfeiffer, K. A. (2011) 'Comparison of accelerometer cut points for predicting activity intensity in youth', *Medicine & Science in Sports & Exercise*, 43(7), 1360-8.

Veale, A. (2005) 'Creative methodologies in participatory research with children', *Researching Children's Experience: Approaches and Methods*, 253-272.

Ward, D. S., Evenson, K. R., Vaughn, A., Rodgers, A. B. and Troiano, R. P. (2005) 'Accelerometer Use in Physical Activity: Best Practices and Research Recommendations', *Medicine & Science in Sports & Exercise*, 37 Suppl 11, S582-S588.

Waring, M., Warburton, P. and Coy, M. (2007) 'Observation of children's physical activity levels in primary school: Is the school an ideal setting for meeting government activity targets?', *European Physical Education Review*, 13(1), 25.

World Health Organization [WHO] (2010) *Global recommendations on physical activity for health,* Geneva, Switzerland: World Health Organization.

Williams, J., Greene, S., Doyle, E., Harris, E., Layte, R., McCoy, S., McCrory, C., Murray, A., Nixon, E., O'Dowd, T., O'Moore, M., Quail, A., Smyth, E., Swords, L., Thornton, M. (2009) *Growing Up in Ireland, National Longitudinal Study of Children, Report 1: The Lives of 9- Year - Olds*, Dublin: Stationery Office.

Wilson, K. D. and Kurz, R. S. (2008) 'Bridging implementation and institutionalization within organizations: proposed employment of continuous quality improvement to further dissemination', *Journal of Public Health Management and Practice*, 14(2), 109-116.

Wolfenden, L., Neve, M., Farrell, L., Lecathelinais, C., Bell, C., Milat, A., Wiggers, J. and Sutherland, R. (2011) 'Physical activity policies and practices of childcare centers in Australia', *Journal of Paediatrics and Child Health*, 47(3), 73-76.

Yildirim, M., te Velde, S. J., Brug, J., Chinapaw, M. J. M., Verloigne, M., de Bourdeaudhuij, I., Androutsos, O., Manios, Y., Felso, R., Kovács, É., Doessegger, A. and Bringolf-Isler, B. (2011) 'Study protocol of physical activity and sedentary behaviour measurement among schoolchildren by accelerometry--cross-sectional survey as part of the ENERGY-project', *BMC Public Health*, 11(1), 182-182.

CHAPTER 5

ACTIVE CLASSROOMS: A CLUSTER RANDOMISED CONTROLLED TRIAL EVALUATING THE EFFECTS OF A MOVEMENT INTEGRATION INTERVENTION ON THE PHYSICAL ACTIVITY LEVELS OF PRIMARY SCHOOL CHILDREN

Chapter 5: Active Classrooms: A cluster randomised controlled trial evaluating the effects of a movement integration intervention on the physical activity levels of primary school children

Preamble

The following article describes an 8-week cluster randomised controlled trial designed to evaluate the effects of the 'Active Classrooms' intervention on the MVPA levels of primary school children during class time and throughout the school day. Teacher perceptions of implementing the programme and their ratings of students' engagement are also evaluated. This article has been peer-reviewed and accepted for publication in *Journal of Physical Activity and Health*, ©Human Kinetics impact factor 1.884. The full citation for the article is as follows:

Martin, R. and Murtagh, E. M. (2015) 'Active Classrooms: A cluster randomised controlled trial evaluating the effects of a movement integration intervention on the physical activity levels of primary school children', *Journal of Physical Activity and Health*, (accepted for publication 22.11.2016, See Appendix Q), http://dx.doi.org/10.1123/jpah.2016-0358

Statement of authorship:

I hereby declare that I, Rosemarie Martin am the principal author of this article. The following statements outline my contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

(See Appendix R)

See Appendix S for ©Human Kinetics copyright permissions.

5.1 Abstract

Design: A cluster randomized controlled trial was conducted to assess the effectiveness of the 'Active Classrooms' intervention, which integrates movement into academic lessons, on the MVPA levels of primary school children during class-time and throughout the school day. **Methods**: Ten classroom teachers and their students aged 8-12 years were recruited and randomized into the 'Active Classrooms' intervention group (n=131students, n=5teachers) or a delayed-treatment controlled group (n=117students, n=5teachers). The intervention group participated in active academic lessons taught by the classroom teacher over an 8-week period. Accelerometers were used to gather PA data at baseline, post-intervention and at 4 months follow-up. Teachers completed a questionnaire to evaluate the programme. **Results:** A significant difference for change in daily class time MVPA levels was identified between the treatment (n=95) and control (n=91) groups from pre- to post-intervention (p<.001) and this difference was maintained at follow-up (p<.001). No significant difference emerged between the treatment and control groups for change in school day MVPA levels from pre- to post-intervention (p=.52) or follow-up (p=.09). Teachers reported that they were highly satisfied with the programme. **Conclusions**: Movement integration has the potential to improve PA levels of primary school children in the classroom.

Keywords: public health, teaching, exercise, intervention study, motion sensors, youth

Trial Registration Number: ISRCTN14265493

5.2 Introduction

Declining PA levels of primary school children have become major health issues in recent years. Internationally only one in five children achieve the recommended 60 minutes of MVPA daily (World Health Organization 2010). These high levels of physical inactivity track across phases of life into adulthood (Hill *et al.* 2011), are linked to obesity, cardiovascular disease, coronary heart disease, hypertension, type 2 diabetes, and cancer and have resulted in higher rates of morbidity and mortality (Naylor and McKay 2009, World Health Organization 2010). This is also particularly true to Ireland with 70% of boys and 84% of girls aged 9-18 years not achieving 60 mins of PA daily (Inchley *et al.* 2016). The World Health Organization (WHO) (2008) and the Global Advocacy for Physical Activity (GAPA) specifically identified schools as a target setting for the promotion of PA among children and youth (World Health Organisation 2008, GAPA 2010). However, school environments may also contribute to the promotion of poor exercise habits with children spending the majority of their time in school engaged in sedentary classroom behavior (Fairclough *et al.* 2012). It has been argued that PE alone cannot provide sufficient activity to help students meet recommended levels of PA to achieve health benefits since it is a subject which occurs too infrequently (50-80 hours per year, ~10% of total teaching time) (European Commission 2013) and provides limited amounts of moderate-to-vigorous activity due to lack of space and equipment, large class sizes, and in some cases inadequate teacher training (Morgan and Hansen 2008b). It has consequently been recommended that schools internationally develop policies to increase students' PA levels across the school day, in addition to PE classes (Ward 2011). In Ireland the Department of Education and Skills (Curriculum and Assessment Policy Unit 2016) released a circular (0013/2016) recommending that all primary schools develop a formal plan to promote PA outside of the PE curriculum. However, with emphasis on assessment subjects such as literacy and numeracy, time for activity breaks within the classroom is limited. In order to address this problem which places emphasis on academic material to the detriment of PA, methods of embedding PA into academic lessons in the classroom are warranted (Martin and Murtagh 2015a).

The Centers for Disease Control and Prevention (2010) devised the Comprehensive School Physical Activity Program (CSPAP) to encourage schools to provide students with multiple opportunities to accumulate PA during the school day. One component of the program includes the integration of PA into classroom lessons. Two systematic reviews of the literature identified 16 published interventions which integrate PA into academic lessons (Norris *et al.* 2015, Webster *et al.* 2015). These existing interventions have illustrated that contrary to teachers' beliefs that these lessons reduce traditional teaching time and interrupt learning (Morgan and Hansen 2008a), physically active academic lessons have been proven to not only positively influence students' PA levels but also improve their academic attainment, health, classroom behavior, time-on-task and concentration (Norris *et al.* 2015, de Greeff *et al.* 2016). Therefore, there is strong evidence supporting the recommendations by the Comprehensive School Physical Activity Program (CSPAP) (Centers for Disease Control and Prevention 2010) to integrate PA into academic lessons.

Factors influencing the success of PA interventions in the classroom have been examined previously. Cothran *et al.* (2010) and McMullen *et al.* (2014) concluded that teacher attitudes towards and satisfaction with PA programmes are keys to their success. Teacher decisions to integrate PA are influenced by student engagement in the lessons, classroom management issues, maintaining teacher control and connection to the academic curriculum (McMullen *et al.* 2014). Student enjoyment has been shown to influence teacher satisfaction and approval of classroom based programmes (McMullen *et al.* 2014, Martin and Murtagh 2015b). However, few previous interventions which integrate PA into academic content in the classroom evaluated these factors (Finn and McInnis 2014, Riley *et al.* 2015). In the Active Science Curriculum study (Finn and McInnis 2014) PA data were gathered and used as a resource to teach science lessons. Teacher interviews reported positive attitudes towards the programme and student questionnaires and focus groups revealed that students enjoyed the lessons while learning the science content and skills. PA levels were not evaluated in this study. Riley *et al.* (2015) evaluated teacher and student satisfaction of the EASY Minds pilot study which integrated PA into the mathematics curriculum. They reported that both teachers and students were highly satisfied with the programme. They also reported significant improvements in MVPA levels and time-on-task during the lessons. TAKE 10! (Peregrin 2001) is a US based programme which engages students in PA while reinforcing academic learning objectives from literacy, numeracy, science, health and social studies curricula. This programme was developed and revised using teacher input and feedback. It has since been adapted and successfully implemented across the globe in interventions such as Physical Activity Across the Curriculum (PAAC) (Donnelly *et al.* 2009), Happy 10! (Liu *et al.* 2008, Li *et al.* 2010) and F&V (Mullender-Wijnsma *et al.* 2015). TAKE 10! has been well received by teachers (Mahar *et al.* 2006, Cheryl Gibson *et al.* 2008) and students (Barry *et al.* 2003) and it has therefore, been shown to be effective in improving students' PA levels (Liu *et al.* 2008, Donnelly *et al.* 2009). Hence, to illustrate the effectiveness of such PA interventions it is vitally important that PA levels of the students are evaluated, as well as teacher acceptability of the programme. Since there is a paucity of studies focusing on these outcomes they will be evaluated in the 'Active Classrooms' study.

The 'Active Classrooms' intervention was designed based on the Behavior Change Wheel framework (Michie *et al.* 2008), which emphasizes that for behavior change to occur it is essential to evaluate the capabilities, opportunities and motivations (COM-B) of classroom teachers to use PA as an instructional strategy and then facilitate them with solutions to the barriers which prevent the desired behavior from being carried out (Michie *et al.* 2011b). Details are outlined in Appendix K and Appendix L and discussed in detail in the published protocol for this study (Martin and Murtagh 2015a). The current study was informed by the results of a pilot study which indicated that the intervention lessons had a positive effect on the MVPA levels of the students, contributing a mean of 8 minutes to their school day PA accumulation (Martin and Murtagh 2015b). Comparisons were made between MVPA levels of the students during the intervention lessons and during regular classroom instruction. The teacher was very satisfied with the programme and acknowledged that the lessons were easy to implement. Participating students revealed that they really enjoyed the activities. Although not an explicit outcome of the study it also emerged that the teacher and students perceived that the active lessons enhanced teaching and student learning in the classroom. Further evaluation of the programme is required to assess its effectiveness on a larger scale, with control and intervention classes and over a longer period of time.

The primary aim of the 'Active Classrooms' programme was to improve the PA levels of Irish primary school children by integrating PA into the teaching of English and Mathematics academic content of the Irish Primary School Curriculum. Accelerometry was used to obtain objective PA data. Secondary objectives included an evaluation of teacher acceptability of the programme and teacher ratings of their students' engagement in the programme.

5.3 Methods

5.3.1 Study Design

This paper outlines the 'Active Classrooms' cluster randomised controlled trial which was designed to evaluate the effect of active academic lessons on the MVPA levels of primary school children, during class time and throughout the entire school day. The primary outcomes are change in minutes per day and percentage time in MVPA during class time and throughout the school day. Comparisons will be made between the MVPA levels generated between control and intervention schools.

Design conduct and reporting of the 'Active Classrooms' randomised controlled trial adheres to the Consolidation standards of Reporting Trials (CONSORT) (Moher *et al.* 2010, Schulz *et al.* 2010) guidelines. Further methodological details are outlined in the study's protocol paper (Martin and Murtagh 2015a). The 'Active Classrooms' trial is registered with an International Standard Randomised Controlled Trial Number (ISRCTN14265493).

5.3.2 Recruitment and Study Participants

Prior to recruitment ethical approval was granted by Mary Immaculate College Research Ethics Committee, Limerick, Ireland. Thirty-one primary schools, identified using the Department of Education and Skills database, met eligibility criteria to participate in the study. These criteria included proximity to the university (within a 20km radius), co-educational schools, and to meet sample size requirements having a minimum of 20 students in each class. Schools which had already received incentives such as the 'Active School Flag' for improving PA during school time were not deemed eligible to participate. A 2-sample t-test with an alpha of 0.05 and power of 73%, in Minitab17 calculated a sample size of 180 participants (18 per class) to detect a mean difference of 10 min ± 12 mins MVPA between the control and intervention groups. An intra-cluster correlation of 0.05 was applied to the formula outlined by Hemming *et al.* (2011) which deemed 9 clusters sufficient for the trial. Ten clusters with a minimum of 20 participants within each were recruited to account for possible dropouts. A random number function in Microsoft Excel determined the order in which schools were invited to participate. To recruit the target number of ten schools, twenty-one schools were approached by the researchers. Of these, 4 schools failed to respond to the invitation despite follow-up contact being made, 7 schools declined to participate due to time or space restraints or because they were already participating in other projects at the time and 10 schools in Limerick, Ireland volunteered to participate. Face to face meetings were arranged with the principal and participating classroom teacher in each participating school to outline the requirements of the study. Schools were matched on participating grade level. After baseline measures were collected each school was assigned a number, which an independent third party drew out of a hat to blindly and randomly allocate each school into the delayed treatment control or the ‘Active Classrooms’ intervention group at a ratio of 1:1.

5.3.2.1 Participants

The target age for students to be included in this study was 8-12 years therefore, one teacher of 3rd - 5th class in each school was invited to participate. The principal and teacher who agreed to participate in each school completed and returned consent forms. Ten primary schools and 10 classroom teachers (1 per school) were recruited to participate in the study. Each class was randomly assigned to the intervention (n = 5, 3 male and 2 female teachers) or control (n = 5, 2 male and 3 female teachers) group after baseline data collection. Equal grade levels were represented in each group. All ten schools completed the study. Written parental consent and child assent were obtained from each student in the participating class prior to commencement of the study. All students in classes randomized to the intervention group participated in the physically active lessons since they were incorporated into the teachers’ instructional time however, measurement data were not obtained unless consent and assent were granted. All students in control classrooms received regular instruction without any additional PA incorporated. A sub-sample of 20 students in each participating class were randomly selected to wear accelerometers during school hours for each of the PA data collection weeks. Two hundred and forty-eight students (n = 131 intervention (69 boys, 62 girls) and n = 117 control (58 boys, 59 girls)) with a mean age of 8.9 years (± .95) returned signed consent and assent forms to participate. Of these, baseline BMI measures were gathered from 244 students and a sub sample of 200 (20 per class) provided PA data. All 5 teachers in the intervention group returned completed questionnaires. Table 5.1 outlines baseline characteristics of students randomized to the ‘Active Classrooms’ intervention and control groups. Flow of participants through the ‘Active Classrooms’ study are illustrated in Figure 5.1.

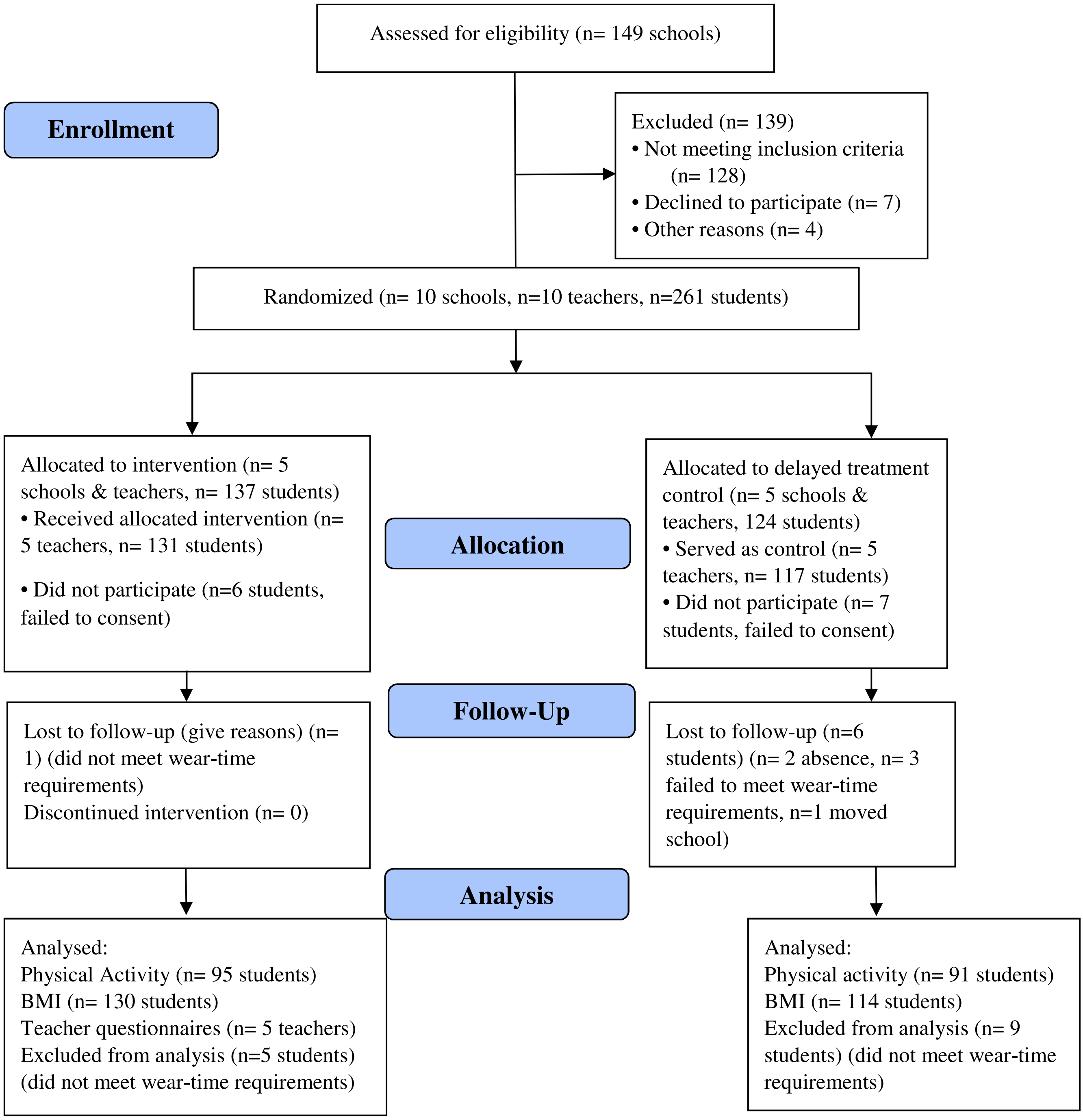


Figure 5.1 Flow of participants through the Active Classrooms study

Table 5.1 Baseline characteristics of students randomized to the Active Classrooms intervention and delayed treatment control group

Characteristics	Control (n=99)		Intervention (n=98)		All children (n=197)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Age (years)	9.1	0.9	8.8	1.0	8.9	1.0
Weight (kg)	34.0	7.8	35.2	8.0	34.6	7.9
Height (m)	137.2	7.4	138.6	7.3	137.9	7.4
BMI (kg/m^2)	17.9	2.6	18.2	2.9	18.0	2.8

Abbreviations: MVPA, moderate-to-vigorous physical activity; Sed, sedentary; n, number; SD, standard deviation

5.3.3 Treatments

5.3.3.1 Physical activity intervention

The 'Active Classrooms' programme was developed by a university-based teacher educator and a doctoral student who is also a primary school teacher. It is an 8-week behavior change intervention designed to educate, train and enable primary teachers to change their teaching methods towards engaging children in physical activity while learning the academic content of English and Mathematics lessons. The intervention is novel in that it was designed using the Behavior Change Wheel framework (Michie *et al.* 2011b). Details on the use of this behavior change theory and its application in the design of this intervention programme have been published previously and are summarized in Appendix K and Appendix L (Martin and Murtagh 2015a). Teachers in the intervention group attended a 1-hour workshop, were provided with lesson ideas, resources and reminders, encouraged to plan, set targets and engage in self-reflection to enable them to teach using physically active methods. Lesson ideas provided were linked to specific strands and strand units of the Mathematics and English Primary School Curriculum in Ireland (NCCA 1999) and aimed to compliment the teaching of specific content within those strand units by engaging the students in physical activities during their learning. The researchers requested that teachers incorporate at least one active English lesson idea and one active Mathematics lesson idea into their teaching each day. Lesson ideas provided to the teachers were designed to last a minimum of 10 minutes each but could be extended and adapted by the teachers as desired to fit with their schedules and planning. Adherence was monitored by having classroom teachers keep a record log in which they indicated when and what intervention lessons they carried out with their class each day. This also served as a self-monitoring tool for the teachers to perform the behavior. The programme sought to improve the PA levels of the students during the school day without interrupting academic teaching time.

Teacher training. Once off individual training was provided to all participating teachers in the intervention group. Each training session lasted a minimum of 1 hour which included questions from the teachers. Content details of the training sessions are outlined in Martin and Murtagh (2015b) and can also be viewed in Appendix M below.

Delayed- treatment control group. Teachers in the delayed- treatment control group continued teaching English and Mathematics lessons as normal throughout the 8-week period. They did not receive any training, information or resources regarding the active lessons.

5.3.4 Data Collection Procedures and Measures

5.3.4.1 Physical activity

Data collection commenced in October 2014. Schools were randomly placed in pairs on a rolling weekly schedule with each pair allocated 3 data collection weeks. All data was collected during school hours for 5 consecutive days at baseline (week 0), post-intervention (week 8) and at 4 months follow-up (week 16). All participants completed a questionnaire to collect demographic information and 20 randomly selected students in each class wore an accelerometer each school day during data collection weeks. ActiGraph accelerometers (models GT3X and GT3X+, ActiGraph LLC, Pensacola, Florida) were used. Data collection and accelerometer wear procedures identical to those detailed in the protocol paper were carried out during PA measurement (Martin and Murtagh 2015a). That is, accelerometers were mounted on elastic belts and worn around the participants' waist with the accelerometer unit placed over the right hip. PA data was collected in 15 second epochs to account for children's natural activity levels which occur in short bouts (Evenson *et al.* 2008). Since they have been shown to have the most acceptable classification accuracy for accelerometer use with children (Trost *et al.* 2011), Evenson cut points were applied to intensity levels.

Wear-time. This study follows best practice recommendations for accelerometer use with children (Ward *et al.* 2005, Trost *et al.* 2011). The 70/80% rule for determining wear time, outlined by Ward *et al.* (2005) is adopted in this study. A rationale for its use and details of its implementation have been reported previously (Martin and Murtagh 2015a). As PA levels of the students were examined only during the school day 272 minutes (80% of the school day, 340 minutes) was set as the minimum accelerometer wear time. Since over 70% (>140) of the students met wear time requirements on all 5 days of each measurement week, all 5 days were included in the analysis. The minimum activity threshold required to start a non-wear period was set at 60 minutes to allow for accurate collection of sedentary data (Martin and Murtagh 2015a), 15,000 counts was set as the cut point for the upper limit count values to avoid spurious data (Esliger *et al.* 2005) and spike tolerance was set at 2 minutes.

5.3.4.2 BMI calculations

Weight and height measures were collected from all participating children at baseline. Children were measured in their socks, uniform t-shirts and trousers using a stadiometer (Seca Corp, Model #214 Road Rod, Hanover, MD) and digital scale (Seca Corp, Model #899, Germany). See Appendix N for standard operating procedures used. Measurements were taken and recorded privately by the researchers and results were not disclosed to participants. BMI was calculated as kg/m^2 following recommendations by Cole *et al.* (2000).

5.3.4.3 Teacher's perceptions

Questionnaires modelled on that used and validated in the process evaluation of the 'Toy Box' intervention (Androutsos *et al.* 2014) were administered to all teachers in the intervention group at post-intervention. Demographic information was collected through 5 structured quick response questions (name, age, sex, class level, school). Likert format questions were used to assess teachers' opinions on the ease of implementing the programme, its effect on students' PA and enjoyment levels, the effect of the physically active lessons on teaching and learning in the classroom, and the sustainability of the programme. Details regarding the structure of the teacher questionnaire and a sample of specific questions asked have been outlined previously (Martin and Murtagh 2015b).

5.3.5 Data Reduction & Analysis

5.3.5.1 Physical activity

All accelerometer, BMI and participant demographic data was imported into Microsoft Excel where it was cleaned and subsequently imported into SPSS version 21 for analysis. A Shapiro-Wilk's test ($p > 0.05$) (Shapiro and Wilk 1965, Razali and Wah 2011, O'Donoghue 2012) indicated that MVPA was approximately normally distributed. A repeated measures ANCOVA adjusting for the cluster randomised design by weighting class estimates according to their size was conducted to assess the change in mean MVPA levels over the 3 time points between groups. Adjustments were made for sex, age and BMI category. Further analyses were carried out using ANOVAs and t-tests were used to evaluate the effect of the intervention on sex of participants. An α level of 0.05 was used for all statistical tests. Since p-values could be impacted by the sample size employed (Zhu 2016), Effect Sizes (ES) using Cohen's d index (Cohen 1988) were also calculated and reported. Minutes in class time MVPA were calculated by subtracting break and lunch time MVPA from time spent in MVPA throughout the school day. Results are presented in mean minutes and percentage time spent in MVPA daily during class time and during the entire school day.

5.3.5.2 Teacher perceptions

Teacher satisfaction and sustainability of the programme were evaluated using Likert format questions. Teachers were asked to indicate their responses on a 5 point rating scale ranging from 1 meaning least likely/disagree to 5 meaning most likely/agree. Questions included an evaluation of teacher and student enjoyment levels as well as, the degree to which teachers felt the programme improved their teaching and their students' learning. Results were coded and input into Microsoft Excel 2010 where means were calculated based on each item number for analysis.

5.4 Results

5.4.1 Physical Activity

5.4.1.1 School day MVPA levels

Twenty randomly selected students in each participating class (5 intervention (I) and 5 control (C) classes) wore accelerometers in order to measure PA. PA data was therefore collected from 100 students in the intervention group (52 boys, 48 girls) and 100 children in the control group (49 boys, 51 girls). A total of 186 students (91 control, 95 intervention) met accelerometer wear time requirements for whole school day across the three time periods and were included in the PA data analysis. Results of the weighted analysis found no significant interaction between treatment and time for change in school day MVPA levels from baseline to post-intervention ($p = .062$) and no statistically significant difference between the groups ($p = .52$). Effect size (ES) calculations using Cohen's d (Cohen 1988) index indicate a medium ES for change between the groups from baseline to post-intervention ($d = .77$). Baseline to follow-up results found a statistically significant interaction between treatment and time indicating that the control and intervention groups were having a significantly different effect over time ($p = .006$) for change in school day MVPA levels. Differences between the treatments were not found to be statistically significant ($p = .09$), however a large ES emerged for change between the groups from baseline to follow-up ($d = .92$). MVPA levels of the intervention group increased by 2.4 ± 7.1 mins while the control group decreased by -3.9 ± 7.4 mins indicating a mean difference of 6.3 ± 1.05 mins. A significant interaction was identified between treatment and BMI category ($p = .023$) as well as gender and BMI category ($p = .007$). MVPA levels of children in the obese category at baseline increased over time while all other categories remained the same or decreased. Significant differences were also identified for change in MVPA accumulated by boys and girls over time depending on their treatment (baseline to week 8: Boys: I = 1.5 ± 6.0, C = -1.8 ± 6.7; Girls: I = 1.5 ± 4.5; C = -4.6 ± 5.9; week 8 to 4 months: Boys: I = .4 ± 3.6, C = -.21 ± 6.9, Girls: I = 1.4 ± 3.6; C = -1.2 ± 6.2, $p < .05$). A large ES was found between girls in the intervention and control groups from baseline to week 8 ($d = 1.2$) and baseline to follow-up ($d = 1.51$). Table 5.2 outlines mean time in minutes and percentage time daily each treatment group spent in sedentary, light and moderate-to-vigorous PA during the school day over the three measurement periods.

5.4.1.2 Class time MVPA levels

Results illustrate a significant difference for change in daily class time MVPA levels accumulated over the 3 time points ($p = 0.029$) and also significant differences between treatment groups ($p < 0.001$). The average measure for the intervention group was significantly higher than the control group (see Table 5.3). Results show changes of 1.6 ± 3.8 mins for the intervention group and -1.9 ± 4.2 mins for the control group from baseline to week 8 (mean difference: -3.5 ± .57 mins, $p < .001$) and these results were maintained at 4 months follow-up (I: 1.6 ± 4.2 mins, C: -2.7 ± 4.8 mins, mean difference: 4.3 ± .66 mins, $p < .001$). Large effect sizes were found between the groups from baseline to week 8 and baseline to follow-up ($d = 1.03$; $d = .96$). A significant interaction was found between BMI categories and treatment ($p = 0.024$) with MVPA levels of children in obese & underweight categories increasing over time. A significant difference also emerged for effects on gender, over time, dependent on the treatment group ($p < .05$). Boys and girls in the intervention group experienced greater increases in MVPA levels during the intervention than their counterparts in the control group (baseline to week 8: Boys: I = 1.4 ± 4.5, C = -1.4 ± 4.6; Girls: I = 1.7 ± 2.7; C = -2.5 ± 3.7; week 8 to 4 months:

Boys: I = -.6 ± 4.7, C = -.5 ± 4.8, Girls: I = .7 ± 3.7; C = -1.0 ± 4.9). However, girls in the intervention group experienced greater effects of the intervention than boys in comparison to their counter parts in the control group at week 8 (boys: d = 0.85, girls: d = 1.38) and at 4 months follow-up (boys: d = 0.63, girls: d = 1.42). Table 5.3 outlines mean time in minutes and percentage time daily each group spent in sedentary, light, and moderate-to-vigorous PA during class time over the three measurement periods.

Table 5.2 Intervention effects of the Active Classrooms programme on school time daily physical activity. Mean (SD)

	Baseline		Week 8		Group x Time p value[a]	Effect size	4 month follow-up		Group* Time p value[a]	Effect size
	Control group (n=91)	Intervention group (n=95)	Control group (n=91)	Intervention group (n=95)			Control group (n=91)	Intervention group (n=95)		
Sedentary minutes	214.7 (24.8)	222.7 (22.5)	218 (26.9)	214.9 (22.3)	.78	-.46	213.5 (32.0)	216.1 (23.7)	.26	-.25
LPA minutes	96.3(20.6)	92.1 (19.6)	95.7 (19.9)	94.1 (21.3)	.31	.13	94.3 (23.6)	94 (20.7)	.43	.06
MVPA minutes	21.5 (6.2)	19.2 (6.7)	18.2 (5.9)	20.7 (6.1)	.52	.77	17.4 (6.9)	21.5 (7.6)	.09	.92
Sedentary %	64.6 (7.5)	66.7 (6.7)	65.7 (8.1)	65.2 (6.8)	.78	-.36	65.7 (9.8)	65.2 (7.1)	.26	-.36
LPA %	29.0 (6.2)	27.6 (5.9)	28.8 (6.0)	28.5 (6.5)	.31	.18	29.0 (7.3)	28.3 (6.2)	.43	.11
MVPA %	6.5 (1.9)	5.7 (2.0)	5.5 (1.8)	6.3 (1.9)	.52	.84	5.4 (2.1)	6.5 (2.3)	.09	.90

[a]based on weighted means with adjustments for age, sex and BMI category

Abbreviations: MVPA moderate-to-vigorous physical activity; LPA light physical activity; SD standard deviation

Table 5.3 Intervention effects of the Active Classrooms programme on class time[a] daily physical activity. Mean (SD)

	Baseline		Week 8		Group x Time p value[b]	Effect size	4 month follow-up		Group* Time p value[b]	Effect size
	Control group (n=91)	Intervention group (n=95)	Control group (n=91)	Intervention group (n=95)			Control group (n=91)	Intervention group (n=95)		
Sedentary minutes	203.6 (22.2)	209.6 (22.3)	205.5 (24.0)	202.2 (20.6)	.543	-.42	201.4 (30.7)	203.3 (20.7)	.175	-.20
LPA minutes	75.7 (19.0)	71.7 (19.4)	75.1 (18.5)	73.4 (20.2)	.279	.12	73.7 (22.4)	74.2 (18.9)	.486	.23
MVPA minutes	10.3 (3.1)	10.5 (4.3)	8.3 (3.3)	12.0 (3.5)	< .001*	1.03	7.6 (4.0)	12.1 (4.8)	< .001*	0.96
Sedentary %	70.3 (7.7)	71.8 (7.6)	71.1 (8.3)	70.3 (7.2)	.543	-.30	71.2 (10.9)	70.2 (7.1)	.175	-.32
LPA %	26.1 (6.6)	24.6 (6.6)	26.0 (6.4)	25.5 (7.0)	.279	.15	26.1 (7.9)	25.7 (6.5)	.486	.16
MVPA %	3.6 (1.1)	3.6 (1.5)	2.9 (1.1)	4.2 (1.2)	< .001*	1.13	2.7 (1.4)	4.2 (1.7)	< .001*	0.96

[a]class time is defined as whole school day minus break and lunch time, [b]based on weighted means with adjustments for age, sex and BMI category, *P < .001

Abbreviations: MVPA moderate-to-vigorous physical activity; LPA light physical activity; SD standard deviation

5.4.2 Teacher Perceptions

Three male and 2 female teachers aged 25-35 years completed the questionnaire. Teachers rated the programme an overall mean of 4.3 ± 0.36 on a 5-point scale for ease of implementation and sustainability. They indicated that the programme improved their teaching of literacy and numeracy by rating the programme an average of 4.2 ± 0.83 for its contribution towards enhancing their teaching of literacy and 4 ± 1.0 for improvements in their teaching of numeracy lessons in the classroom. The teachers also rated the programme highly with regard to student learning (mean = 4.2 ± 0.84 for student learning in both literacy and numeracy). Teachers were highly satisfied with the programme with both their own and their students' enjoyment receiving an average rating of 4.6 ± 0.55 each. Teachers rated numeracy lessons (mean = 4 ± 0.7) as slightly easier to implement than literacy lessons (mean = 3.8 ± 0.84) however, they indicated that they are equally as likely to continue teaching both in the future (literacy mean = 4.2 ± 0.44, numeracy mean = 4.2 ± 0.44). The teachers also indicated that their students were highly active during the lessons (literacy mean = 4.8 ± 0.44, numeracy mean = 5 ± 0).

5.5 Discussion

The 'Active Classrooms' study sought to change teacher behavior towards teaching English and Mathematics lessons using physically active teaching methods in order to improve PA levels of primary school children without interrupting academic teaching time. The intervention produced positive results for improvements in MVPA. Results were sustained at four months post-intervention.

The 'Active Classrooms' programme was designed based on the Behavior Change Wheel (BCW) framework (Michie *et al.* 2011) which emphasizes that for behavior change to occur it is essential to evaluate the capabilities, opportunities and motivations (COM-B) of classroom teachers to use PA as an instructional strategy and then facilitate them with solutions to the barriers which prevent the desired behavior from being carried out (Michie *et al.* 2011). This framework has been successfully applied to a range of health-related behaviors such as hearing aid use (Barker *et al.* 2016), medication adherence (Jackson *et al.* 2014) and attentive eating (Robinson *et al.* 2013). Giving such adequate consideration to the development, piloting and practical implementation issues in advance of the main evaluation of an intervention has been highly recommended by the Medical Research Council (Craig *et al.* 2008). Understanding and applying these factors through the BCW framework (Michie *et al.* 2011) in the current study resulted in the development of a meaningful and effective intervention which improved students' PA levels.

The BCW identified specific intervention functions that would address the areas of need which were identified in the existing literature. For example, in order to overcome the shortcomings we identified in psychological capability (Martin and Murtagh 2015a) the BCW recommends the use of education and training. Incorporation of a workshop for teachers gave them the skills, knowledge and autonomy required to implement active lessons in the classroom. As noted in many previous studies (DuBose *et al.* 2008, McMullen *et al.* 2014, Riley *et al.* 2015, Benes *et al.* 2016) the importance of teacher training on the implementation of such programmes cannot be overlooked. Emphasis was placed on the potential to integrate movement into their existing academic lessons by substituting inactive teaching methods for active ones. This is an important element contributing to the successful implementation of the 'Active Classrooms' programme since teachers' perceptions of active lessons as additional or stand-alone lessons have previously been acknowledged as impediments to their compliance with such programmes (Cothran *et al.* 2010, McMullen *et al.* 2014).

While differences between the groups were not statistically significant, results indicate a large intervention effect size (Cohen 1988) on students' whole school day MVPA levels. The large effect size in absence of a statistically significant result is a relatively common occurrence (Alhija and Levy 2009) and may be due to small sample size (Simard and Nielsen 2005) or large variability (Nickerson 2000). Nonetheless, the effect size noted in the present study gives an indication of the magnitude and practical significance of the treatment effect (Cohen 1988, Kirk 1996). Our findings lend support to previous studies which integrate movement into academic lessons in the primary school classroom (Donnelly *et al.* 2009, Riley *et al.* 2015, Norris *et al.* 2015). Donnelly *et al.* (2009) reported that children in PAAC schools accumulated 12% greater school day MVPA than children in control schools. Similarly, children participating in the EASY Minds pilot study accumulated 8.7% more MVPA during the school day than the control group (Riley *et al.* 2015). In the present 'Active Classrooms' study children in the intervention group accumulated >22% greater school day MVPA than the control group. The magnitude of improvement in school day MVPA may be influenced by whether teachers are educated about PA intensity. Riley *et al.* (2016) previously commented that the lack of changes in MVPA during their 6-week movement integration programme may have been influenced by the fact that PA intensity was not discussed in the professional learning workshops. The authors concluded that integrating movement without consideration for its intensity may have been the teachers' focus. This may also have been the case in a similar study in which Erwin *et al.* (2011b) do not refer to PA intensity during in-service training provided to teachers. On the contrary, DuBose *et al.* (2008) included intensity training for teachers in the PAAC study and similar to the 'Active Classrooms' study, their findings demonstrated positive results for improvements in MVPA.

Results of the current study indicate that MVPA levels of the control group significantly decreased from baseline to post-intervention ($p < .001$, $t = 4.792$, $df = 95$). This decrease may be due to weather and seasonal change since PA data were collected during different seasons (autumn/winter/spring). A review evaluating the effects of seasons and weather on PA, reports that adverse weather conditions associated with winter are significant barriers to engaging in PA particularly among children (Tucker and Gilliland 2007). Post-intervention and follow-up data for the current study were gathered during the country's coldest and wettest months of the year (MET Eireann 2016). The increase in MVPA levels identified in the intervention group, despite being exposed to similar seasonal and weather conditions as the control group, highlights the benefit of integrating movement into the classroom. Movement integration interventions provide children with opportunities to be physically active indoors regardless of weather conditions.

A unique design component of the Active Classrooms study was that alongside school day MVPA we also reported MVPA accumulated in class-time periods only (i.e. minutes in MVPA throughout the school day minus break and lunch time MVPA). Our findings that the intervention group accumulated >55% (12 minutes) of the school day's MVPA during class time is an important consideration. While teachers were asked to integrate movement into daily Mathematics and English lesson, it is possible that they may have adapted the lessons and used movement as an instructional strategy in other subjects (Riley *et al.* 2016). Students in the intervention group achieved 39% more MVPA during class time than the control group. This is contrary to other research which suggests that students exposed to additional PA opportunities may restrict PA in other parts of the school day (Fremeaux *et al.* 2011). However, it must be noted that although the intervention improved MVPA accumulation, results indicate that movement integration cannot stand alone in achieving the Institute of Medicine (IOM) recommendation of 30 minutes MVPA during school hours (Kohl and Cook 2013). Therefore, this study substantiates the CDC (2010) recommendation that school-based interventions must provide multiple opportunities for PA accumulation throughout the school day. This study demonstrates that movement integration could serve as an effective classroom-based component.

As a result of the 'Active Classrooms' study, boys and girls accumulated similar amounts of MVPA during class time. However, the intervention had a greater effect on the MVPA levels of girls. This may be due to girls having lower usual levels of MVPA than boys especially during school time and therefore more scope for improvement (Fairclough *et al.* 2012, Hegarty *et al.* 2013). Both boys and girls accumulated similar amounts of MVPA during class time since all children present in the classroom were exposed to the same opportunities to engage in the physical activities as they were directed to do so as part of the teachers' instruction of the English and Mathematics lessons. This is supported by the results of the pilot study (Martin and Murtagh 2015b) in which both boys and girls accumulated similar amounts of MVPA during the active lessons. It is possible however, that as a result of participating in the programme girls increased their MVPA in other segments of the school day illustrating that the active lessons may have served as a catalyst for more movement (Ridgers *et al.* 2014). The intervention demonstrated large effects on girls for both school day (week 8: d = 1.2, follow-up: d= 1.51) and class time (week 8: d = 1.38, follow-up: d= 1.42) MVPA levels in comparison to girls in the control group. Despite considering school time only, these findings may have noteworthy implications since a widening inequality between boys' and girls' PA levels has been identified globally with girls achieving much less time in MVPA than boys (World Health Organization 2016). Girls have been identified as difficult to reach with biological, psychological, social and environmental factors influencing their participation in PA (Sallis *et al.* 2000). Same sex peer participation has been identified as a key factor in engaging girls (Bailey *et al.* 2005), however this might not always be possible within mixed-sex school settings. Providing girls with access to PA and opportunities to be physically active in school with their peers have been found to be successful in improving girls' PA levels (Oliver *et al.* 2006, Webber *et al.* 2008). Results from the current study demonstrate this and also support assertions that the more opportunities available to girls to be physically active, the more active they are (Bailey *et al.* 2005). Therefore, this study contributes to the literature supporting classroom-based PA interventions as structured opportunities to improve children's PA levels and especially benefit less active children and girls, with the hope of improving PA for all and closing the gap between the genders (Oliver *et al.* 2006, Liu *et al.* 2007, Belton *et al.* 2010, Fairclough *et al.* 2012, Norris *et al.* 2015).

Few previous studies have evaluated the sustainability of classroom- based PA interventions through inclusion of follow-up measures (Norris *et al.* 2015). An evaluation of the effect and sustainability of classroom PA breaks reported that increases in PA were maintained after a 3- month period ($p < .001$) (Erwin *et al.* 2011b). Intervention effects of the 'Active Classrooms' study were sustained at 4 months and this is supported by the process evaluation reports by the teachers, in which they indicate that they would be 'very likely' to continue integrating movement into academic lessons. These results are promising in that they illustrate that teachers can and want to maintain this instructional method therefore contributing to the long-term sustainability of the project and consequently improvements in students' PA levels. Many previous studies have concluded that classroom teacher acceptability of and satisfaction with classroom-based PA programmes are central to their success (McMullen *et al.* 2014, Cohen *et al.* 2015). The high satisfaction expressed by teachers with the 'Active Classrooms' programme may be attributed to the analysis of the desired behavior and development of the intervention through the BCW framework (Michie *et al.* 2011) which ensured that teachers were provided with a programme incorporating elements they prioritize. Such elements include connection of the lessons to the school curriculum and enjoyable activities for students (Cothran *et al.* 2010, McMullen *et al.* 2014). To the best of our knowledge this is the first study of its kind which integrates the academic content of the Irish Primary School Curriculum (NCCA 1999). Teachers reported great student enjoyment and enhanced teaching and learning as a result of participating in the Active Classrooms programme. Therefore, it could be suggested that the use of formative research as a first step resulted in the development of an intervention which is effective in improving PA levels, acceptable to teachers and sustainable.

5.6 Strengths and Limitations

A strength of this study is the use of a behavior change theory which analyzed the target behavior and resulted in the development of an intervention which enabled teachers to overcome the barriers, allowing them to effectively change their behavior towards integrating movement in the classroom. Implementation of the lessons in the classroom by classroom teachers, as opposed to trained specialists or researchers, is also an advantage since they are the target population for such a resource and it is their beliefs, attitudes and perceptions that influence the effectiveness and sustainability of such interventions in primary schools (Cothran *et al.* 2010). The cluster RCT design, evaluation of teacher perspectives and use of accelerometer data are also strengths of the study.

Despite these strengths, the generalizability of results is subject to certain limitations. For instance, the sample population was limited to a group of schools located in Munster, Ireland and the intervention material was focused on the Irish Primary Curriculum. A generally small group of teachers participated in the study and observations were not carried out to evaluate consistency between them or compliance. Compliance was self-regulated by the teachers. A further limitation of the study is that PA measures were gathered only during school hours therefore, the data does not provide information regarding the students' PA patterns outside of school. Finally, although a 4-month follow-up was included to evaluate the sustainability of the intervention, a longer intervention and follow-up period would more precisely indicate long term effects.

5.7 Conclusion and Future Research

This study illustrates the effectiveness of the 'Active Classrooms' programme in improving the MVPA levels of primary school children during class time. It highlights the role classroom teachers' play in making a significant difference to their students' MVPA levels. Teacher acceptability of classroom-based interventions is of paramount importance if they are to be effective. By enabling the teachers to use physically active teaching methods for academic instruction, this intervention significantly improved MVPA levels while also ensuring teacher satisfaction. Future research could objectively assess learning and retention of academic material as a direct outcome of engaging in the active lessons, in comparison to traditional methods. It must also be emphasized that physically active academic lessons are not intended to replace PE but to serve as additional avenues for the integration of PA throughout the school day. Findings of the current study have important implications for future policy and practice in designing and implementing classroom-based PA interventions. Improvements in PA levels and teacher satisfaction towards using physically active teaching methods support the concept that pedagogies can be adapted by teachers and teacher educators to integrate short bouts of PA as a means to improve students' overall health. Development of future interventions must be centered around teachers and the school curriculum; aiming to improve students' PA levels whilst preserving educational value. Education and training should be provided to teachers with emphasis on PA intensity and integration of movement through substituting inactive teaching methods for active ones. Movement integration interventions have potential to serve as one facet of wider school-based interventions to move children towards achieving IOM (Kohl and Cook 2013) recommendations of 30-minutes in MVPA during school hours.

5.8 Acknowledgments
We sincerely thank the schools, teachers, children and their parents for their participation and for making the Active Classrooms study possible. We would like to thank Séamus Martin and Marie Giltenane for their assistance with resources. We thank Irene Hogan and Dr. Tara Coppinger of Cork Institute of Technology and Dr. Sarahjane Belton of Dublin City University for the use of accelerometers. Finally, we thank Dr. Jean Saunders of the Statistical Consulting Unit, University of Limerick for her advice on the statistical analysis.

5.9 Funding
This trial did not receive any specific grant from funding agencies.

5.10 Chapter Conclusion
The article presented in the current chapter describes the effects of a teacher behavior change intervention on the MVPA levels of their students. The design, implementation and analysis of this study follows the trial protocol outlined in Chapter 4. It must be noted however, that differences in PA levels between participants at baseline (as described in section 4.13) were not evaluated due to recent evidence describing this analysis as superfluous (de Boer *et al.* 2015). De Boer *et al.* (2015) argue that including prognostic variables from baseline analysis may lead to the omission of important covariates which could affect outcome results. Results of this cluster randomised controlled trial indicate that the 'Active Classrooms' intervention was effective in improving students' MVPA levels during class time thus demonstrating that integrating movement during the school day is an effective means of contributing to children's health. Teachers also reported that they were highly satisfied with the programme. However, results of the teacher questionnaire outlined in the current study are objective ratings without verbal descriptions or explanations of what barriers were faced or what contributed to the success of the programme. These descriptions could provide information which would be valuable to informing future policy and practice. Additionally, since student enjoyment has also been highlighted in the literature as an essential element contributing to positive outcomes, successful implementation and sustainability of classroom-based PA programmes, student opinions should not be overlooked. These measures were included in the design of the 'Active Classrooms' study (see Chapter 4) to identify, in depth, teacher and student insights of participating in the programme and are reported in the chapter which follows.

5.11 References

Alhija, F. N.-A. and Levy, A. (2009) 'Effect size reporting practices in published articles', *Educational and Psychological Measurement*, 69(2), 245-265.

Androutsos, O., Apostolidou, E., Iotova, V., Socha, P., Birnbaum, J., Moreno, L., De Bourdeaudhuij, I., Koletzko, B. and Manios, Y. (2014) 'Process evaluation design and tools used in a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study', *Obesity Reviews*, 15(S3), 74-80.

Bailey, R., Wellard, I. and Dismore, H. (2005) 'Girls' participation in physical activities and sports: Benefits, patterns, influences and ways forward', *World Health Organization technical paper commissioned from ICSSPE in Physical Activty and Health Alliance*.

Barker, F., Atkins, L. and de Lusignan, S. (2016) 'Applying the COM-B behaviour model and behaviour change wheel to develop an intervention to improve hearing-aid use in adult auditory rehabilitation', *International Journal of Audiology*, 1-9.

Barry, M., Mosca, C., Dennison, D., Kohl, H. and Hill, J. (2003) 'Take 10! program and attraction to physical activity and classroom environment in elementary school students', *Medicine & Science in Sports & Exercise*, 35(5), S134.

Belton, S., Brady, P., Meegan, S. and Woods, C. (2010) 'Pedometer step count and BMI of Irish primary school children aged 6-9 years', *Preventive Medicine*, 50(4), 189-92.

Benes, S., Finn, K. E., Sullivan, E. C. and Yan, Z. (2016) 'Teachers' Perceptions of Using Movement in the Classroom', *Physical Educator*, 73(1), 110-135.

Centers for Disease Control and Prevention [CDC]. (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*, 2nd ed., New York, NY: Psychology Press.

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Callister, R. and Lubans, D. R. (2015) 'Physical Activity and Skills Intervention: SCORES Cluster Randomized Controlled Trial', *Medicine & Science in Sports & Exercise*, 47(4), 765-774.

Cole, T. J., Bellizzi, M. C., Flegal, K. M. and Dietz, W. H. (2000) 'Establishing a standard definition for child overweight and obesity worldwide: international survey', *The BMJ*, 320(7244), 1240.

Cothran, D. J., Kulinna, P. H. and Garn, A. C. (2010) 'Classroom teachers and physical activity integration', *Teaching and Teacher Education*, 26(7), 1381-1388.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I. and Petticrew, M. (2008) 'Developing and evaluating complex interventions: the new Medical Research Council guidance', *The BMJ*, 337, a1655.

Curriculum and Assessment Policy Unit (2016) *Circular 0013/2016: Promotion of healthy lifestyles in primary schools*, Dublin, Ireland: Department of Education and Skills.

de Boer, M. R., Waterlander, W. E., Kuijper, L. D., Steenhuis, I. H. and Twisk, J. W. (2015) 'Testing for baseline differences in randomized controlled trials: an unhealthy research behavior that is hard to eradicate', *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 4.

de Greeff, J. W., Hartman, E., Mullender-Wijnsma, M. J., Bosker, R. J., Doolaard, S. and Visscher, C. (2016) 'Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children', *Health Education Research*, 31(2), 185-194.

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., Dubose, K., Mayo, M., Schmelzle, K., Ryan, J., Jacobsen, D. and Williams, S. (2009) 'Physical activity across the curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine*, 49, 336 - 341.

DuBose, K. D., Mayo, M. S., Gibson, C. A., Green, J. L., Hill, J. O., Jacobsen, D. J., Smith, B. K., Sullivan, D. K., Washburn, R. A. and Donnelly, J. E. (2008) 'Physical activity across the curriculum (PAAC): Rationale and design', *Contemporary Clinical Trials*, 29(1), 83-93.

Erwin, H., Abel, M., Beighle, A. and Beets, M. (2011a) 'Promoting children's health through physically active math classes: a pilot study', *Health Promotion Practice*, 12(2), 244-51.

Erwin, H., Beighle, A., Morgan, C. and Noland, M. (2011b) 'Effect of a low-cost, teacher-directed classroom intervention on elementary students' physical activity', *Journal of School Health*, 81(8), 455-461.

Esliger, D. W., Copeland, J. L., Barnes, J. D. and Tremblay, M. S. (2005) 'Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring', *Journal of Physical Activity & Health*, 2(3).

European Commission/EACEA/Eurydice. (2013) *Physical Education and Sport at School in Europe Eurydice Report*, Luxembourg, European Commission.

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S. and McMurray, R. G. (2008) 'Calibration of two objective measures of physical activity for children', *Journal of Sports Sciences*, 26(14), 1557-1565.

Fairclough, S. J., Beighle, A., Erwin, H. and Ridgers, N. D. (2012) 'School day segmented physical activity patterns of high and low active children', *BMC Public Health*, 12(1), 406.

Finn, K. E. and McInnis, K. J. (2014) 'Teachers' and Students' Perceptions of the Active Science Curriculum: Incorporating Physical Activity Into Middle School Science Classrooms', *Physical Educator*, 71(2), 234-253.

Fremeaux, A., Mallam, K., Metcalf, B., Hosking, J., Voss, L. and Wilkin, T. (2011) 'The impact of school-time activity on total physical activity: the activitystat hypothesis (EarlyBird 46)', *International Journal of Obesity*, 35(10), 1277-1283.

GAPA (2010) 'NCD Prevention: Investments that Work for Physical Activity', *Health Promotion*, 17(2), 5-15.

Gibson, C., Smith, B., DuBose, K., Greene, J. L., Bailey, B., Williams, S., Ryan, J., Schmelzle, K., Washburn, R., Sullivan, D., Mayo, M. and Donnelly, J. (2008) 'Physical activity across the curriculum: year one process evaluation results', *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 36.

Hegarty, D., Murtagh, E. M. and Ní Chróinín, D. (2013) 'An evaluation of Irish primary school children's physical activity during the segmented school-day', *Proceedings of the seventh physical education, physical activity and youth sport forum: Youth Sport: understanding, intervening and prolonging engagement in youth sport, physical education and physical activity*, DCU(June 2013), 115-121.

Hemming, K., Girling, A. J., Sitch, A. J., Marsh, J. and Lilford, R. J. (2011) 'Sample size calculations for cluster randomised controlled trials with a fixed number of clusters', *BMC Medical Research Methodology*, 11(1), 102.

Hill, L. J., Williams, J. H., Aucott, L., Thomson, J. and Mon-Williams, M. (2011) 'How does exercise benefit performance on cognitive tests in primary-school pupils?', *Developmental Medicine and Child Neurology*, 53(7), 630-5.

Inchley, J., Currie, D., Young, T., Samdal, O., Torsheim, T., Augustson, L., Mathison, F., Aleman-Diaz, A., Molcho, M., Weber, M. and Barnekow, V. (2016) *Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-aged Children (HBSC) study: International report from the 2013/2014 survey,* Copenhagen: WHO Regional Office for Europe.

Jackson, C., Eliasson, L., Barber, N. and Weinman, J. (2014) 'Applying COM-B to medication adherence', *The European Health Psychologist*, 16(1), 7-17.

Kirk, R. E. (1996) 'Practical significance: A concept whose time has come', *Educational and Psychological Measurement*, 56(5), 746-759.

Kohl, H. W. and Cook, H. D., Eds.; Committee on Physical Activity and Physical Education in the School Environment; Food and Nutrition Board; Institute of Medicine. (2013) *Educating the student body: Taking physical activity and physical education to school*, Washington D.C., National Academies Press.

Li, Y. P., Hu, X. Q., Schouten, E. G., Liu, A. L., Du, S. M., Li, L. Z., Cui, Z. H., Wang, D., Kok, F. J., Hu, F. B. and Ma, G. S. (2010) 'Report on childhood obesity in China (8): effects and sustainability of physical activity intervention on body composition of Chinese youth', *Biomedical and Environmental Sciences*, 23(3), 180-7.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W. and Chen, C. (2007) 'Report on childhood obesity in China (6) evaluation of a classroom-based physical activity promotion program', *Biomedical and Environmental Sciences*, 20(1), 19.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W. and Chen, C. (2008) 'Evaluation of a classroom-based physical activity promoting programme', *Obesity Reviews*, 9, 130-134.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). ‘Effects of a classroom-based program on physical activity and on-task behavior’, *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Martin, R. and Murtagh, E. M. (2015a) 'An intervention to improve the physical activity levels of children: Design and rationale of the ‘Active Classrooms’ cluster randomised controlled trial', *Contemporary Clinical Trials*, 41, 180-191.

Martin, R. and Murtagh, E. M. (2015b) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). ‘Physical activity opportunities during the school day: Classroom teachers’ perceptions of using activity breaks in the classroom’, *Journal of Teaching in Physical Education, 33*(4), 511-527.

MET Eireann (2016) 'The Irish Meteorological Service Online'. *Available from*: www.met.ie, [Accessed: 8th August 2016].

Michie, S., Johnston, M., Francis, J., Hardeman, W. and Eccles, M. (2008) 'From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques', *Applied Psychology*, 57(4), 660-680.

Michie, S., van Stralen, M. M. and West, R. (2011) 'The behaviour change wheel: a new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), 42-52.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M. and Altman, D. G. (2010) 'CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials', *Journal of Clinical Epidemiology*, 63(8), e1-e37.

Morgan, P. J. and Hansen, V. (2008a) 'Classroom teachers' perceptions of the impact of barriers to teaching physical education on the quality of physical education programs', *Research Quarterly for Exercise and Sport*, 79, 506 - 516.

Morgan, P. J. and Hansen, V. (2008b) 'Physical education in primary schools: Classroom teachers' perceptions of benefits and outcomes', *Health Education Journal*, 67(3), 196-207.

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S. and Visscher, C. (2015) 'Improving academic performance of school‐age children by physical activity in the classroom: 1‐year program evaluation', *Journal of School Health*, 85(6), 365-371.

Naylor, P. J. and McKay, H. A. (2009) 'Prevention in the first place: schools a setting for action on physical inactivity', *British Journal of Sports Medicine*, 43(1), 10-13.

NCCA (1999) *Primary School Curriculum*, Department of Education and Science, Dublin, Ireland: Stationery Office.

Nickerson, R. S. (2000) 'Null hypothesis significance testing: a review of an old and continuing controversy', *Psychological Methods*, 5(2), 241.

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O. and Stamatakis, E. (2015) 'Physically active lessons as physical activity and educational interventions: A systematic review of methods and results', *Preventive Medicine,* 72, 116-125.

O'Donoghue, P. (2012) *Statistics for sport and exercise studies: an introduction*, London: Routledge.

Oliver, M., Schofield, G. and McEvoy, E. (2006) 'An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study', *The Journal of School Health*, 76(2), 74-79.

Peregrin, T. (2001) 'Take 10!: Classroom-based program fights obesity by getting kids out of their seats', *Journal of the Academy of Nutrition and Dietetics*, 101(12), 1409.

Razali, N. M. and Wah, Y. B. (2011) 'Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests', *Journal of Statistical Modeling and Analytics*, 2(1), 21-33.

Ridgers, N. D., Timperio, A., Cerin, E. and Salmon, J. (2014) 'Compensation of physical activity and sedentary time in primary school children', *Medicine & Science in Sports & Exercise*, 46(8), 1564-9.

Riley, N., Lubans, D., Holmes, K. and Morgan, P. (2016) 'Findings From the EASY Minds Cluster Randomized Controlled Trial: Evaluation of a Physical Activity Integration Program for Mathematics in Primary Schools', *Journal of Physical Activity & Health,* 13(2), 198-206.

Riley, N., Lubans, D. R., Morgan, P. J. and Young, M. (2015) 'Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial', *Journal of Science and Medicine in Sport*, 18(6), 656-661.

Robinson, E., Higgs, S., Daley, A. J., Jolly, K., Lycett, D., Lewis, A. and Aveyard, P. (2013) 'Development and feasibility testing of a smart phone based attentive eating intervention', *BMC Public Health*, 13(1), 639.

Sallis, J., Prochaska, J. and Taylor, W. (2000) 'A review of correlates of physical activity of children and adolescents', *Medicine & Science in Sports & Exercise*, 32, 963 - 975.

Schulz, K. F., Altman, D. G. and Moher, D. (2010) 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials*, 11, 32.

Shapiro, S. S. and Wilk, M. B. (1965) 'An analysis of variance test for normality (complete samples)', *Biometrika*, 52(3/4), 591-611.

Simard, V. and Nielsen, T. A. (2005) 'Sleep paralysis-associated sensed presence as a possible manifestation of social anxiety', *Dreaming*, 15(4), 245.

Trost, S. G., Loprinzi, P. D., Moore, R. and Pfeiffer, K. A. (2011) 'Comparison of accelerometer cut points for predicting activity intensity in youth', *Medicine & Science in Sports & Exercise*, 43(7), 1360-8.

Tucker, P. and Gilliland, J. (2007) 'The effect of season and weather on physical activity: a systematic review', *Public Health*, 121(12), 909-922.

Ward, D. (2011) 'School policies on physical education and physical activity', *Research Synthesis. Active Living Research*.

Ward, D. S., Evenson, K. R., Vaughn, A., Rodgers, A. B. and Troiano, R. P. (2005) 'Accelerometer Use in Physical Activity: Best Practices and Research Recommendations', *Medicine & Science in Sports & Exercise*, 37 Suppl 11, S582-S588.

Webber, L. S., Catellier, D. J., Lytle, L. A., Murray, D. M., Pratt, C. A., Young, D. R., Elder, J. P., Lohman, T. G., Stevens, J. and Jobe, J. B. (2008) 'Promoting physical activity in middle school girls: Trial of Activity for Adolescent Girls', *American Journal of Preventive Medicine*, 34(3), 173-184.

Webster, C., Russ, L., Vazou, S., Goh, T. and Erwin, H. (2015) 'Integrating movement in academic classrooms: understanding, applying and advancing the knowledge base', *Obesity Reviews*, 16(8), 691-701.

World Health Organisation [WHO] (2008) *School policy framework: Implementation of the WHO global strategy on diet, physical activity and health,* Geneva, Switzerland: World Health Organisation.

World Health Organisation [WHO] (2010) *Global recommendations on physical activity for health,* Geneva, Switzerland: World Health Organisation.

World Health Organization (2016) *EUR/RC65/9 Physical activity strategy for the WHO European Region 2016–2025*, *Available from:* http://www.thehealthwell.info/node/927643, [Accessed: 9th July 2016].

Zhu, W. (2016) 'p< 0.05,< 0.01,< 0.001,< 0.0001,< 0.00001,< 0.000001, or< 0.0000001…', *Journal of Sport and Health Science*, 5(1), 77-79.

CHAPTER 6

TEACHERS' AND STUDENTS' PERSPECTIVES OF PARTICIPATING IN THE 'ACTIVE CLASSROOMS' MOVEMENT INTEGRATION PROGRAMME

Chapter 6: Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme

Preamble

The following article gives a voice to the teachers and students who participated in the 'Active Classrooms' randomised controlled trial, reported in Chapter 5, by describing their perceptions of participating in the programme. This article highlights the students' enjoyment of the intervention lessons. Findings are supported by presenting raw data in the form of quotations, illustrations and written text from the students. Teachers identified elements which they believed contributed to the success of the intervention and links are made between these and the intervention design outlined in Chapter 4. This article has been peer reviewed and published in *Teaching and Teacher Education*, impact factor 2015: 1.823 (Thomson Reuters, Journal Citation Reports 2016). The full citation for the article is as follows:

Martin, R. and Murtagh, E. M. (2017) 'Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme', *Teaching and Teacher Education*, 63, 218-230 http://dx.doi.org/10.1016/j.tate.2017.01.002

Statement of authorship:

I hereby declare that I, Rosemarie Martin am the principal author of this article. The following statements outline my contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

(See Appendix R)

See Appendix S for ©Elsevier copyright permissions.

For changes from the published article see Appendix T.

6.1 Abstract

This paper evaluates perceptions of 5 teachers and 129 students of participating in an 8-week primary school movement integration intervention. Following training and provision of resources, teachers were asked to teach 2 active lessons each day. Teachers completed questionnaires at post-intervention. Students participated in 'draw and write' activities and focus group interviews. Teachers reported great satisfaction, noting student enjoyment, enhanced teaching and learning, and provision of resources as contributing to the success of the programme. Students expressed high levels of enjoyment, with emphasis on peer-engagement, perceived health benefits and improved academic motivation.

Keywords: draw and write, primary school, movement integration, classroom, physical activity, behaviour change

6.2 Introduction

To meet the needs and challenges of our ever-changing society, educational systems must constantly evolve and develop. Movement integration - teaching curriculum content using physically active methods - has become increasingly popular to serve as an intervention for combatting poor PA levels among school-aged children (Norris *et al*. 2015, Webster *et al*. 2015). PA has been linked to many health benefits for children including reduced risk of premature morbidity from cardiovascular disease, cancer, diabetes, respiratory disease, and obesity, as well as, contributing to higher self-esteem, positive mental health, improved cognition and academic performance (Have *et al.* 2016, Hill *et al*. 2011, WHO 2010). However, only a minority of children and young people globally are meeting the recommendation of 60 minutes of MVPA daily (WHO 2010). This is particularly true to Ireland with findings that only 19% of primary children (Woods *et al*. 2010) meet this public health recommendation with significant decreases observed with age (Inchley *et al.* 2016). This has resulted in a growing concern around children's inactivity levels. The World Health Organisation (2016) devised a European PA strategy which identified schools as key locations to implement PA interventions. However, with an already overcrowded curriculum, core academic subjects such as literacy and numeracy are being prioritised over PE and PA breaks (Mahar *et al.* 2006). In fact, schools have been acknowledged as one of the main environments of inactive behaviour, with the sedentary nature of lessons carried out in the classroom identified as a contributory factor to physical inactivity among this age group (Martin and Murtagh 2015b; Holt *et al*. 2013). In order to address this problem a multi-component Comprehensive School Physical Activity Program (CSPAP) is supported by the Centers for Disease Control and Prevention (2013) encouraging schools to provide students with multiple opportunities for accumulating PA during the school day. One component of the programme suggests the integration of PA into academic lessons in the classroom. This suggestion has been supported by evidence which illustrates that integrating movement into academic lessons has the potential to not only improve students' MVPA levels during the school day (Dunn, *et al*. 2011, Goh *et al.* 2014, Liu *et al.* 2007, Riley *et al*. 2015), but also to enhance facilitators of learning such as concentration, cognition, time-on-task (de Greeff *et al.* 2016, Mullender-Wijnsma *et al.* 2015), executive functions such as organisation (Have *et al.* 2016) and academic achievement (Donnelly *et al.* 2009, Donnelly and Lambourne 2011, Norris *et al.* 2015, Reed *et al.* 2010). However, research studies have reported that such interventions cannot be successfully implemented or sustained without teacher and student approval (Martin and Murtagh 2015b, Cothran *et al*. 2010, Dishman *et al.* 2005, Hodges *et al*. 2015, Howie *et al*. 2014, McMullen *et al*. 2014).

Teachers influence the amount and intensity of PA their students are exposed to during class time, therefore teachers and their attitudes play a central role in determining the success or failure of classroom–based interventions (Martin and Murtagh 2015b, Fullan 2007). Student enjoyment has also been found to moderate and mediate the effects of PA interventions, as well as teacher approval of such programmes (Martin and Murtagh 2015b, Howie *et al.* 2014, McMullen *et al.* 2014). Increased enjoyment of active lessons has led to increased engagement in the lessons and increased PA levels (Dishman *et al.* 2005). In evaluations of teacher perceptions of classroom-based PA programmes teachers have emphasised the importance of student 'buy-in' if such programmes are to be successfully implemented (Benes *et al.* 2016, Hodges *et al.* 2015). In addition, students' PA self-efficacy has been identified as a factor which determines their participation in PA (Trost *et al.* 2001). Enjoyment has been acknowledged as the primary mediator of this self-efficacy (Lubans *et al.* 2008, van Stralen *et al.* 2011). Therefore, teacher attitudes and student enjoyment should be key components in the evaluation of classroom based programmes. While few previous studies which integrate movement into academic content have considered teacher and student perceptions, existing findings are promising. Teacher interviews, student questionnaires and focus groups revealed that both teachers and students reported positive attitudes towards the Active Science Curriculum in which PA data were gathered and used in science lessons (Finn and McInnis 2014). PA was integrated into mathematics in the EASY Minds study (Riley *et al.* 2015) and results indicated high satisfaction and enjoyment of the programme. Such positive teacher and student attitudes towards classroom based programmes contribute towards their success in improving student PA levels.

The 'Active Classrooms' programme was developed to improve the MVPA levels of primary school students during class time and throughout the entire school day. This programme sought to change the behaviour of teachers towards teaching academic content of English and Mathematics lessons using physically active pedagogies. The Behaviour Change Wheel (BCW) framework (Michie *et al.* 2011) was used in the development of the programme. This involved the identification and evaluation of potential barriers, and outlining of intervention content and implementation options in order to assist teachers in overcoming these barriers to change their behaviour towards teaching using physically active methods (Martin and Murtagh 2015a). Preliminary findings of the 'Active Classrooms' study reveal that students accumulated eight minutes of MVPA daily during the intervention lessons (Martin and Murtagh 2015b). Given the aforementioned need to evaluate teacher and students' experiences of any classroom-based programme, this paper intends to give students a voice by evaluating their enjoyment and exploring teacher insights of their experiences of the programme.

6.3 Methods

6.3.1 Study Design

The 'Active Classrooms' cluster randomised controlled trial is an 8- week intervention programme which was designed to evaluate the effects of movement integration lessons on the MVPA levels of primary school children, during class time and throughout the entire school day. The effects of the intervention on students' MVPA levels are reported in Martin and Murtagh (2017). The current paper reports teacher and student perceptions of participating in the programme. Design conduct and reporting of these qualitative aspects of the study adheres to the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong *et al.* 2007). Further details of the study design are outlined in the study's protocol paper (Martin and Murtagh 2015a) and findings of the pilot study have been previously reported (Martin and Murtagh 2015b). The 'Active Classrooms' trial is registered with an International Standard Randomized Controlled Trial Number (ISRCTN14265493).

6.3.2 Recruitment and Study Participants

Ethical approval was granted by the Mary Immaculate College Research Ethics Committee, Limerick, Ireland. Using the Department of Education and Skills database, 31 primary schools were identified as meeting the study's eligibility criteria which include situation within a 20-km radius of the university, co-educational and having a minimum of 20 students per class to meet sample size requirements (180 students) (Martin and Murtagh 2015a). The order in which schools were invited to participate was determined by a random number generation function in Microsoft Excel. To recruit the target number of 10 schools, invitations were sent to 21 schools. Time and space restraints, and/or participation in other programmes prevented 7 schools from participating and despite follow-up contact being made, 4 schools failed to respond to the invitation. Ten schools agreed to participate. One classroom teacher in 3rd- 5th class from each participating school and his/her students (aged 8-12 years) were invited to participate in the study. The researcher met with the principal and participating teacher to outline the requirements of the study. After baseline data collection at Week 0, schools were randomly allocated into a delayed treatment control or 'Active Classrooms' intervention group at a ratio of 1:1. All participating students and teachers in the intervention group were eligible to participate in the programme evaluation elements.

6.3.3 Participants

Teachers of 3rd- 5th class (children aged 8 – 12 years) in each school were invited to participate. Consent forms were completed by all participating principals and classroom teachers prior to obtaining parental consent and assent from students in each participating class. All students in classes randomised to the intervention group took part in movement integration lessons each day over the 8-week period since they were part of the teacher's instruction; however, feedback on their perceptions of the programme was only obtained from those who granted consent and assent (n = 129). All students in control classes received regular instruction and did not complete evaluations post-intervention. All teachers (n = 5) in the intervention group who returned signed consent forms, taught English and Maths lessons using physically active methods and completed open ended evaluation questionnaires.

6.3.4 Intervention

'Active Classrooms' is an 8-week PA intervention programme designed based on the Behaviour Change Wheel framework (Michie *et al.* 2011). Details on the use of this behaviour change theory and its application in the design of the 'Active Classrooms' study have been published previously (Martin and Murtagh 2015a). Through inclusion of a 1-hour workshop the programme intended to educate and train teachers to assist them in changing their behaviour towards integrating physically active teaching methods into academic subjects in the classroom. Details on the training content have been published previously (Martin and Murtagh 2015a). This workshop included self-reflection by the teachers to identify barriers to performing the behaviour (time, space, resources etc.). To help overcome these barriers teachers in the intervention group then received 40 lesson ideas, teaching resources and reminders to implement the lessons. They were encouraged to set targets and had assistance with planning to teach using movement integration (Martin and Murtagh 2015a). The lesson ideas that were provided to teachers (20 English and 20 Mathematics) were linked to specific strands and strand units of the English and Mathematics Primary School Curriculum in Ireland (NCCA 1999) and intended to complement the teaching of specific content within these subjects by engaging students in physical activities during the lessons. They were designed to last a minimum of 10 minutes but could be extended and adapted to fit with the teachers' schedules and curricular planning. Teachers were asked to integrate at least one active English lesson and one active Mathematics lesson daily. They were also requested to maintain a daily record log indicating when and what intervention lessons they taught. This log served as a self-monitoring tool for teachers to perform the behaviour and an evaluation of their fidelity to the programme. Teachers in the delayed-treatment control group did not receive any training, resources or information regarding the active lessons during the study and were requested to continue teaching English and Mathematics lessons as normal throughout the 8-week period.

6.4 Data Collection Procedures and Measures

6.4.1 Student Enjoyment

Deemed essential for the effectiveness of PA interventions with children (Howie *et al.* 2014, McMullen *et al.* 2014), student enjoyment of the Active Classrooms programme was evaluated. Drawing provides an alternative means of meaningful expression for young people (Thomson 2009) and it provides researchers with insights into their experiences, opinions, opportunities and barriers to PA (Azzarito 2016). The draw and write technique combined with focus group discussions have been regarded as developmentally appropriate strategies to use with primary school aged children (Knowles *et al.* 2013, Te One 2007) and were adopted in this study to evaluate their experiences of the programme. Children's explanations of their drawings through verbal and written text allow their images to be adequately contextualised and interpreted by the researcher (Christensen *et al.* 2008, Veale 2005). Although the 'draw and write technique' has been used previously in health and education based research to evaluate children's perceptions of PE (Koekoek *et al.* 2009), sport education (MacPhail *et al.* 2003), recess interventions (Knowles *et al.* 2013), and exercise and sport in general (Burrows *et al.* 1999), it is a technique which has not been frequently used to evaluate the attitudes of students towards classroom-based PA interventions. The 'draw and write technique' allows students to convey elements of the programme which are prominent and important in their minds, and illustrate experiences which they may not otherwise be able to verbalise effectively (Pridmore *et al.* 1995). The students' pictures and words are presented verbatim eliminating researcher interpretation therefore, contributing to the uniqueness of this study.

All children completed the draw and write task at baseline prior to allocation into intervention and control groups. To standardise the task teachers were provided with worksheets and a script of instructions. Teachers were asked to instruct the children in English to 'draw a picture of themselves in an English lesson and in a Maths lesson and to write a description of each one.' These instructions were also printed on the children's worksheets (See Appendix O). Upon completion of the 8–week Active Classrooms programme students in the intervention group were asked to repeat this task. The week following the intervention a randomly selected subsample of 4 students from each class in the intervention group were invited to participate in focus group discussions with the researcher. The female researcher was familiar to the children as she had previously visited the classroom. Focus groups were held with each sub-group of children in vacant classrooms, in their own schools, with only the researcher and participants present. Classroom doors were left ajar allowing the focus groups to be visible to the classroom teacher/ principal or other staff members throughout. Discussion questions were framed around the children's experiences, drawings and written texts. The focal questions were adapted from the EASY Minds study (Riley *et al.* 2014) and have been outlined previously in the Active Classrooms pilot study (Martin and Murtagh 2015b). The main questions focused on eliciting descriptions of the children's experiences of their previous English and Maths lessons and the active lessons. They were asked if they enjoyed their previous lessons and the active lessons and if so to explain specifically what they enjoyed about them. They were asked if the active lessons helped them learn and if being active made the lessons more interesting/exciting. The children were also asked additional questions specific to their drawings such as, 'can you explain what is happening in this picture?' and 'can you tell me who these people with you are?' Each focus group discussion was recorded and later transcribed by the researcher. These techniques were piloted and results previously published (Martin and Murtagh 2015b).

6.4.2 Teacher perceptions

Teachers were asked to complete a questionnaire consisting of open ended questions adapted from the ToyBox study (Androutsos *et al.* 2014) which addressed areas such as: teacher and student enjoyment, teaching and learning, factors which supported or inhibited the implementation of the intervention, difficulties or challenges they faced, their perceptions on the effectiveness and sustainability of the programme and their suggestions on how to the programme could be improved. A sample of questionnaire items are outlined in Appendix P.

6.5 Data Analysis

The analysis of qualitative data gathered through focus group discussions, drawings and written texts was guided by the phases of thematic analysis as outlined by Braun and Clarke (2006). This process of thematic analysis is not linear but recursive with movement forwards and backwards throughout the phases particularly as themes are identified, reviewed, defined and refined to ensure that each theme and all of the themes in combination accurately represent the data set (Braun and Clarke 2006). The six steps applied in the thematic analysis were: 1. Familiarisation with the data, 2. Generation of initial codes, 3. Search for themes, 4. Review of themes, 5. Definition and naming of themes and 6. Production of the report. Further details are outlined in Figure 6.4.

The primary researcher immersed herself in the data through transcribing the focus group and written data verbatim (Smith *et al.* 2009), reading and re-reading the transcripts and taking notes of initial ideas. A reflective diary was maintained enabling the researcher to acknowledge her impact on data analysis (Fade and Swift, 2011). This reflective diary allowed decisions and changes of direction and emphasis to be tracked. Interesting features of the data were coded in a systematic fashion across the entire data set and coding ceased when it no longer added anything substantial to the overall analysis (Braun and Clarke 2006). Data relevant to each code from both the student interviews and written statements were collated. Themes and sub-themes were then created using tables in Microsoft Excel 2010 to assist with data management. The themes are strongly linked to the data and were identified using the inductive approach (Patton 1990). Each theme was considered individually and in relation to the other themes generated. Thematic 'networks' of the analysis are presented graphically in Figure 6.1 below under the guidance outlined by Attride-Stirling (2001). Latent themes identifying underlying ideas, assumptions and conceptualisations that shape the content of the data were examined and a rich description of the data set is outlined in the results section below. Where opposing cases existed they were documented and compared against the data and existing literature.

Teacher satisfaction and sustainability of the programme were evaluated using open-ended questionnaire items. Responses to these qualitative questions were coded and themed using the process outlined above. Direct quotations are reported in the results to illustrate emergent themes.

6.6 Results

6.6.1 Participants

All participating classroom teachers in each of the five primary schools (1 per school) randomly allocated to the intervention group, participated in the evaluation of the 'Active Classrooms' programme. This group consisted of 3 male and 2 female Irish Caucasian teachers ranging in age from 25-35 years. All 5 teachers in the intervention group returned completed teacher evaluations. One hundred and thirty one students in the intervention group (69 boys, 62 girls) returned signed consent and assent forms to participate. The average age of the students was 8.9 years (± .95). The ethnicity of participating students was as follows: Irish 91.5%, UK 0.9%, other European 4.8%, Asian 1.3%, US/Canadian 0.7%, African 0.5%, Australian 0.1%, Latino 0.1% and other 0.2%. One hundred and twenty nine students (69 boys, 60 girls) completed the write and draw task post-intervention. Twenty students (4 per class, 9 boys and 11 girls) participated in focus group discussions.

6.6.2 Student Perspectives

All children participating in the study completed the draw and write task at baseline. Similar data were presented by students in the control and intervention groups with the majority of students drawing images of themselves seated at their desks while completing written work in books or copybooks. Their written descriptions mention words such as "sitting down", "boring", "reading", "writing" and "doing sums" (see Figure 6.3 [image a & b, both female students]). A small number of students wrote that they "liked" or "enjoyed" aspects of their English and Mathematics lessons and some stated that the content of their English lessons was "fun" or "interesting" or that they were "good" at a particular topic in Mathematics (see Figure 6.3 [image c, male student]) and see Figure 6.2 [image b, female student]). Few of the baseline drawings illustrate engagement or interaction with their peers (see Figures 6.2 and 6.3 [images a, b and c]). This perspective of English and Mathematics lessons changed at post intervention with students in the intervention group predominantly presenting themselves happily engaging in some form of PA with their peers while learning (see Figure 6.3). The students' illustrations presented in Figure 6.2 and Figure 6.3 clearly depict this change in students' attitudes towards English and Mathematics lessons from baseline to post-intervention. It is evident through the drawings that enjoyment for the students extended beyond satisfaction with the content of the lessons as identified at baseline to delight with the way in which the content was taught through active methods (see Figure 6.2 [image e, female student]). The children's drawings provide great insight into how the movement integration lessons were conducted and managed by classroom teachers. The integration of PA and subject content is clearly evident in most illustrations (see Figure 6.2 [images h and I, both female students] and Figure 6.3 [image h, male student]). Images of the children playing in groups (Figure 6.2 [images e and h, both female students]), exercising on the floor (Figure 6.3 [image d, female student]), instructions written on the white board and classroom furniture moved to the side/background are clear portrayals of the teachers' classroom management and planning (see Figure 6.2 [images h and I, both female students] and Figure 6.3 [image h, male student]). These images provide rich data of the students' experiences of the programme which extends far beyond written or verbal description.

Data from the five student focus group discussions (n = 20, 9 boys and 11 girls) and the draw and write tasks completed by 129 students (69 boys, 60 girls) in intervention classes were combined and analysed using the thematic analysis process outlined above to evaluate student perceptions of the programme post-intervention. Focus group interviews ranged in duration from 15 to 30 minutes. Feedback was obtained from the participants by checking back (Greene and Hogan 2005) with them during discussions to ensure that their opinions and intentions were accurately presented. One researcher coded and analysed the data. Themes which emerged were 1. a sense of change from previous lessons, 2. enjoyment, 3. enhanced learning, 4. feeling energised and healthy and 5. social interaction. Connections between each of these themes were very clear throughout the data. For example, the students expressed that enhanced learning was a result of enjoyment experienced through the lessons, socially interacting with their peers, engaging in PA, as well as being interested and excited about the lessons. Similarly, student enjoyment was a result of peer social interaction, variety in the lessons, and engagement in PA. Therefore, although these themes will be discussed individually in detail below, they don't completely stand-alone but interconnect with one another. Figure 6.1 illustrates the interconnectivity between the themes.

1. A sense of change from previous lessons: Students expressed how they used to "just sit down" and do their Maths and English but that "we don't sit to do our English anymore. We are up out of our seats doing activities like push ups…" (student 1, male). Another child expressed how "I think English lessons have got way better because there is more exercise in them!" and "The maths lessons really improved" (student 2, female). Many of the students agreed that "we used to sit down and do sums and writing in our copies" (student 3, male) and that "lessons before Active

Classrooms...were boring" (student 4, male), "…hard … and long" (student 5, female).

2. Enjoyment: A recurrent theme amongst the students was a sense of enjoyment of the Active Classrooms' lessons. Some students expressed enjoyment of the lessons and engaging in PA making statements such as "I like doing active classrooms. I like everything about it, the jumping jacks, running on the spot, everything" (student 6, male) and "we started having way more fun because of all the exercise" (student 7, female). Others expressed how their enjoyment of the lessons motivated them to learn "it made you want to do more English because you were doing the exercises. It made it fun … so the next day when you go in to school your like "oh yes!, English time", we get to do the activities" (student 8, female). Many children experienced enjoyment from the variety and novelty the lessons presented. A student commented that the group were "happy and excited for the next lesson to see what we would be doing…next. We really enjoyed it" (student 9, male). Others acknowledged the enjoyment experienced while learning. "You were learning but it was fun. It was a fun way to learn it" (student 10, female). Another group of students agreed that "nearly everyone in the class loved the English lessons" and "…lots of people liked the maths because it is still fun to do the sum and then do the exercise" (students 11-13, female, male, male). This was echoed in several discussions and written texts with students writing "we love doing the English lessons" (student 14, male) and "I loved every exercise in Maths, especially 'the ball game'. I'd say my whole class favoured that one because it's fun even when you have to do 9 squat jumps. I enjoyed …these 8 weeks of exercises" (student 15, female). Enjoyment of the lessons is clearly depicted throughout the drawings with big smiles drawn on students' faces (see Figure 6.2).
3. Enhanced learning: The participants on the whole expressed how the active lessons contributed to their learning with comments such as "I really liked doing these maths. They were so fun. It really helped me improve on my maths" (student 16, male) and "…you learn it quickly when you're being active" (student 10, female). They found that "when you're being active your brain is doing one thing and its already active and getting the signals better than it would be if you were just sitting down writing with a pencil" (student 12, male) and "your brain responds a bit more and it's a lot easier to do your sums" (student 17, male). Others commented on how the lessons helped them focus "…it made you concentrate more on your work and definitely in maths too because it made you think more about your tables" (student 8, female),

"you really had to think about the answers because you had to do an activity to go with it" (student 9, male). Other students emphasised the enjoyment experienced and the learning that occurred as a result with statements such as "it helps us learn in a fun way" (student 17, male), "it made it easier for us to learn our maths because we were having fun" (student 9, male), "you were learning but it was fun. It was a fun way to learn it" (student 12, male). An interesting perspective arose from one of the focus groups (student 10, female) in which a student stated that "they [the lessons] were trying to trick kids into learning Maths because some of them were so fun" and another agreed that "ya some of them were half fun and half maths and you don't really know it but they're actually teaching you more than you will know" (student 14, male). Others commented on how the active lessons motivated them to learn "it made us like maths more because now we like doing them and we get our maths done quicker" (student 18, male), "It's not that fun when you're looking at a blank page and everyone is so bored so they try not to do it. But when you're exercising you want to finish because you're learning it in a fun way" (student 19, female) and "it made our lessons more interesting" (student 20, female). One student made a recommendation to further develop the programme saying "I thought it was a really good idea to start the exercises mixture with Maths and English and if you made easier ones the little children would really enjoy it because it's actually helping them learn and they would find it really fun with the activities and stuff" (student 16, male).

4. Feeling energised and healthy: Many of the students recognised the health benefits of the active lessons. Students made comments such as "I love doing Maths and exercise together. It's good for your brain and body" (student 21, male [see Figure 6.3, image e]), "we were getting exercise and that was the best thing about it" (student 7, female). They identified that "it's really good to keep fit" (student 8, female), and that by being active in the lessons "you get much better exercise and fitter" (student 9, male). They associated being active in the lessons with enjoyment and felt that they were exercising without even realising it. One participant said "my favourite exercise is the ball game because it's really fun and it doesn't really feel like your exercising" (student 22, female [see Figure 6.3, image f]). Regarding the same ball game another student wrote "this is my favourite lesson of all time. It helped me to do lots of exercise. I like this game" (student 23, male). The students also reported that they felt energised after the active lessons. Two students in different focus groups commented on how the active lessons benefitted their playtime and the other children in their groups joined in in agreement. One student stated "now after the active classrooms

it's [playtime] a lot better because your legs are already warmed up, your muscles and stuff [are warm] and you can run properly" (student 10, female). Others felt that they "…had energy after the exercises" (student 1, 3 and 18, all male) and that "it made you feel like you wanted to do it again" (students 1 and 3, both male). Many students also expressed that they were "tired" and "thirsty" (students 2, 5, 11, 14, 19 and 20, male and female) after the active lessons but one student clarified that "it was in a good way like we had done exercise and my heart was pumping really fast" (student 2, female). Overall the students claimed that they "love to do all of the exercises" and that they found "the games very fun!!!" (student 24, female [see Figure 6.2, image d]).

5. Social interaction and influence: Many students drew images of themselves in the lessons with their peers and many of them commented on the interaction with them (see Figure 6.2 [image e and h, both female]). They reported how engaging with their friends added enjoyment to the learning and exercise experiences presented through the active lessons. Students made the following statements: "In maths it's fun because we do some group work and I love to do it with my friends" (student 25, female), "Me and my friends love doing jumping jacks" (student 26, female), "I drew a picture of me and my best friend Claire doing jumping jacks" (student 27, female [see Figure 6.2, image i]). "I am doing jumping jacks with my class. It is very fun" (student 28, male), "Here the class are pretending to canoe…all of us are having fun" (student 29, female [see Figure 6.2, image e]) and "I had so much fun with my friends" (student 30, female). Further to this, another group of students explained how they took it upon themselves to extend the activities to the playground, including other groups of students who were not participants in this study. The students said that "sometimes we did the activities ourselves out in the playground and other children from other classes would join in and it made break time even more fun" (student 4, male).

Overall the students reported very positive attitudes towards the programme with one group concluding that "all we can say is we're happy and want to keep on going and maybe even add an Irish one" (student 13, male).

6.6.3 Teacher Satisfaction

Four themes emerged from the data provided by teachers in their responses to the open-ended questions. These include 1. academic benefits, 2. sustainability of the programme,

3. student enjoyment and 4. difficulties/challenges faced. Each of these will be explored in the following paragraphs.

1. Academic benefits: *Improved teaching*: Teachers expanded on their satisfaction with the 'Active Classrooms' programme explaining that they were pleased with how the lessons improved their teaching by adding variety and providing them with new ideas for integrating PA into academic lessons. One teacher stated that "I find that it is a great way to break up the maths lesson…" (Teacher 1, male) and another stated that "…the Active Classrooms gave me great ideas for various strands [of the curriculum]" (Teacher 2, male).

   Enhanced learning: The teachers also appraised the programme highly with regard to student learning and facilitators of learning such as time-on-task and concentration. One teacher explained how the "children were learning without even knowing. Tables can be boring for them but they loved the games" (Teacher 3, female). Other teachers also agreed that "children take in more information when they are active as their concentration levels rise" and that active lessons "help to keep the children motivated" (Teacher 1, male). Another also stated that the students were "more focused for the rest of the day" (Teacher 4, male).

   Reinforced curricular content: Teachers found that the lessons were useful to supplement and reinforce what they were covering in class stating that "there were great ways to practice our tables in fun ways" (Teacher 3, female), "it is a great way to revise over topics previously learned e.g. grammar" (Teacher 1, male) and "I liked to use the lessons to supplement the topics we were covering" (Teacher 5, female).

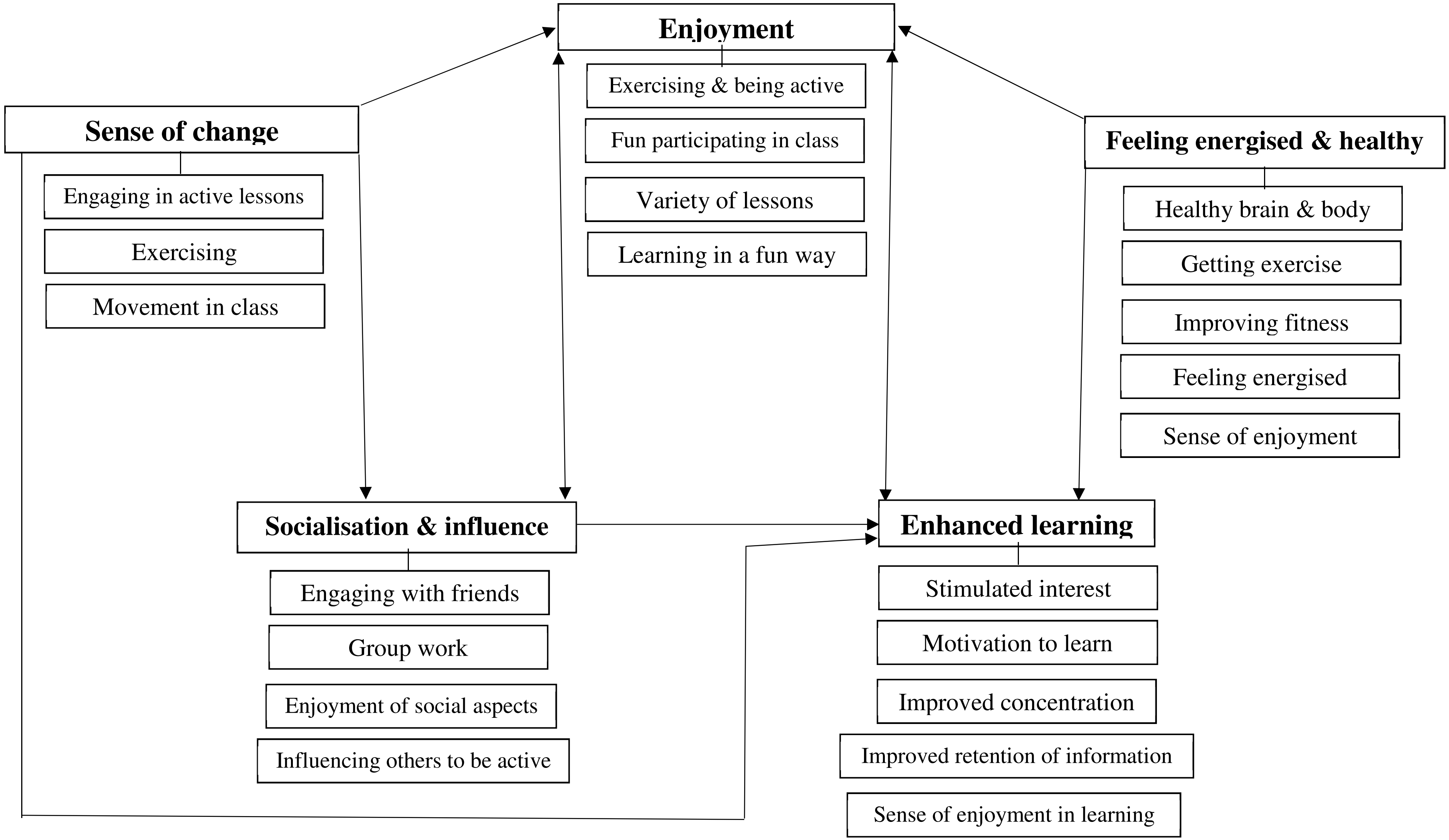


Figure 6.1 Themes and subthemes identified in student data and interconnectivity between them

2. Sustainability of the programme: Teachers highlighted their satisfaction with the programme and their intentions to continue using it, making statements such as "…it is an excellent programme and one which I will continue to use throughout the year" (Teacher 1, male) and "I will include PA as part of maths regularly" (Teacher 2, male). *Approval of the lessons and resources provided:* Teachers indicated their favourite lessons with the following statements: "I really liked some of the oral language lessons" (Teacher 5, female), "I loved the fun activities for Maths" (Teacher 3, female). Teachers expanded further on their approval with the format, content, adaptability and application of the programme stating that the "activities are easy to differentiate for classes/groups (Teacher 5, female) and that they "will certainly use the format of the lessons and apply them to other stories etc." (Teacher 2, male). They found that the lessons were "very well laid out and easy" to "follow" and "implement" (Teacher 1, 2 and 5). One teacher stated that the lessons were "perfectly pitched" to the class level (Teacher 2, male). Teachers were impressed with the provision of plentiful resources stating that there were "very good supplies" and "ample lessons to choose from" (Teacher 5, female) and that the "resource cards etc. made teaching lessons quite easy" (Teacher 2, male).
3. Student enjoyment: The teachers acknowledged their students' enjoyment of the programme highlighting that the children "loved" (Teacher 3, female) and "enjoyed the lessons" (Teacher 4, male) and that they "really looked forward to the various activities" (Teacher 1, male). Some teachers specified which lessons the children favoured mentioning that "the children loved the spelling lessons" (Teacher 5, female) and "creative writing lessons" (Teacher 3, female). They also found that students were highly active during the lessons with Teacher 5 (female) stating that "the children really enjoyed it and they were much more active".
4. Difficulties/ challenges faced: *Time, space and regaining control*: Although the teachers expressed great satisfaction with the programme they also identified difficulties they experienced. Four out of the five teachers mentioned time or space constraints. Two teachers claimed that both time and space were issues with Teacher 5 (female) stating that "some weeks were just too busy…space was also an issue, although we have a large room, it's a large class so we needed to move rooms for some activities" and Teacher 3 (female) reiterating this stating "I had 2 challenges. First was space in the classroom and second was trying to fit them in everyday". Two teachers claimed that time was their only challenge with statements such as "The only problem I faced was time constraints" (Teacher 1, male) and "the time needed for

English lessons posed a challenge at times … trying to get everything covered and active lessons was a challenge" (Teacher 2, male). One teacher mentioned that adapting the lesson posed a challenge maintaining that "sometimes it takes a bit of thinking as to how to integrate/ adapt the lesson" (Teacher 2, male). Regaining classroom control was the final challenge which emerged. One teacher suggested that "trying to settle children after active lessons was challenging" (Teacher 4, male).

The evidence presented illustrates that overall the teachers were very satisfied that the 'Active Classrooms' programme enhanced their teaching and students' learning. A recommendation which emerged is to "maybe introduce more pair and/or group work activities as part of the lessons" but the general feeling from the teachers was that overall they "would change very little" (Teacher 2, male). Resources provided, adaptability of the lesson ideas and student enjoyment were highlighted by teachers as elements contributing to its success.

6.7 Discussion

The findings of the current study demonstrate that both teachers and students positively perceive the Active Classrooms intervention which integrates PA into the academic content of English and Mathematics lessons. Although not without its challenges, teachers were highly satisfied with the programme, specifically identifying student enjoyment, enhanced teaching and learning, improved PA levels, and provision of resources as its main strengths. Students reiterated their enjoyment of the programme with peer interaction, added variety, enhanced learning, and health benefits being repeatedly identified as contributors. Many of these outcomes are synonymous with findings from other studies which evaluated teacher and/or student perceptions of classroom based PA programmes (Benes *et al.* 2016, Finn and McInnis 2014, Hodges *et al.* 2015, McMullen *et al.* 2014, Riley *et al.* 2016). Presentation of the students' perceptions in its raw format contributes to the uniqueness of this study.

The high level of student enjoyment reported by both teachers and students who participated in the 'Active Classrooms' study is an important finding. Enjoyment has also been linked to students' academic motivation (Vazou *et al.* 2012) and student attitudes towards participating in PA (Dishman *et al.* 2005). On evaluating the perceptions of two teachers and 47 female students involved in the Active Science Curriculum, Finn and McInnis (2014) reported the emphasis teachers placed on how their students 'loved the activities'. This enjoyment was also highlighted by the students themselves. The authors concluded that enjoyment experienced as a result of participating in the Active Science Curriculum promoted positive attitudes towards using PA in the classroom and towards exercise in general. High enjoyment levels and positive attitudes towards participating in PA were also experienced by students in the EASY Minds study (Riley *et al.* 2016). Our findings that students enjoyed the lessons in the Active Classrooms study confirms these previous results from studies implemented in the United States and Australia demonstrating that movement integration can enhance the experience of students in the classroom. As student enjoyment has been mentioned throughout the literature with respect to teacher acceptability and sustainability of such programmes (Howie *et al.* 2014, McMullen *et al.* 2014, Stylianou *et al.* 2016) it should be seen as a notable finding.

Both teachers and students in the 'Active Classrooms' study acknowledged that integrating movement into English and Mathematics lessons enhanced teaching and learning in the classroom. Teachers reiterated how the active lessons increased their students' engagement with academic content and made learning more interesting and enjoyable for the children, therefore resulting in better concentration, enhanced learning and increased academic motivation. This is supported by many of the students' expressions of how English and Maths lessons became more "exciting" and "interesting" with the integration of PA. Students expressed how "happy" they were with the change and how much they enjoyed the activities. Similar findings were evident in previous studies which evaluated teacher and/or student perceptions of such programmes (Benes *et al.* 2016, Finn and McInnis 2014, Hodges *et al.* 2015, Riley *et al.* 2016). Both Finn and McInnis (2014) and Riley *et al.* (2016) highlighted the positive effect the programme had on students' attitudes towards the academic subject which integrated movement and Hodges *et al.* (2015) reported that teachers noticed positive improvements in their students' ability to learn. This illustrates that engaging students in physically active academic lessons may be a vital approach in tackling student disengagement and subsequently leading to improved academic performance (Doig 2005). Enhanced learning is reported to be a product of students perceiving active lessons to be more interesting and enjoyable (Martin and Murtagh 2015b, Riley *et al.* 2016, Vazou *et al.* 2012). Therefore, despite many teachers' beliefs that engaging students in PA in the classroom may detract from their academic performance (Morgan and Hansen 2008), research indicates that lessons such as the 'Active Classrooms' which engage children in movement can result in greater learning outcomes. Students who participated in three years of Physical

Activity Across the Curriculum (PAAC) achieved significantly higher scores in standardised tests than the comparison group (Donnelly and Lambourne 2011). Similarly, engagement in the Texas I-CAN! active lessons also produced moderate significant benefits for students' academic achievement (Bartholomew and Jowers 2011). These are strong grounds for movement integration in classrooms, and since enhanced learning and student enjoyment have a large impact on teacher acceptability of physically active academic programmes these outcomes should continue to be considered with respect to such interventions.

Students in our 'Active Classrooms' study highlighted health benefits they perceived they were achieving from the lessons, and these health benefits were regarded as an important element contributing towards their participation in and satisfaction with the programme. A previous study which evaluated student perspectives of the 'Active Science Curriculum' also reports similar findings (Finn and McInnis 2014). Other studies which have evaluated the effect of perceived health benefits on students' PA found that changes in perceived health benefits are related to changes in PA (Dishman *et al.* 2004, Haerens *et al.* 2008, Taymoori and Lubans 2008). Identification of this element by the students themselves is a noteworthy finding since it may be a factor which contributes to their 'buy-in' of such classroom-based PA interventions.

An aspect which emerged through the student data which was not mentioned by teachers, was the students' enjoyment of engaging with their friends while participating in the active lessons. This finding did not emerge in other studies which evaluated teacher or student perceptions of movement integration interventions however, it was the dominant theme emerging from a study which examined children's views, experiences and perceptions of recess (Knowles *et al.* 2013). The importance of peer interaction was also highlighted in a study which evaluated students' perspectives of PA promoting school environments (Banville *et al.* 2016). Banville et al. (2016) found that through students participating in common PA experiences at school, communities of practice for healthy behaviours were established. Social interactions with their peers have been regarded as one of the major reasons for children enjoying recess and engagement in PA (Blatchford *et al.* 1990, Coulter and Woods 2011, Evans 1996, Jago *et al.* 2011). Through these social interactions students are enabled to develop friendships, and social skills (Murray and Ramstetter 2013) which have been deemed essential for their cognitive performance, social development and adjustment to school (Pellegrini and Bohn 2005). Our finding in the present study illustrates the importance of peer interaction for student engagement with programmes. The social interaction experienced by the students during the active lessons could possibly bring about gains which extend beyond enjoyment to cognitive functioning, socialisation and positive attitudes towards school.

The provision of lesson ideas, resources and training on how to implement active academic lessons added to teacher acceptability of the 'Active Classrooms' programme. Teachers commented on how useful it was to be provided with lesson ideas and how easy it was to adapt and implement them since the resources were readily available. Many researchers agree that for such interventions to be successful, training for teachers is essential (Benes *et al.* 2016, Carson *et al.* 2014, Naylor *et al.* 2006, Riley *et al.* 2016). However, the provision of resources to teachers has caused some debate in the literature. In the study by Benes *et al.* (2016), teachers suggested that until materials along with professional development training are provided, integrating movement would not likely occur. Other researchers argue that providing teachers with pre-prepared lessons and materials removes their autonomy (Riley *et al.* 2016). For the present study, when analysing teacher behaviour through the BCW framework (Michie *et al.* 2011) in advance of developing the intervention (Martin and Murtagh 2015a), it emerged that teacher preferences for traditional instruction are partly due to the belief that active methods require much more preparatory time, and the lack of quality teaching and learning resources available for implementing active lessons (Niemi 2002). To overcome this barrier both lesson ideas and resources were provided to the teachers in our study. However, it is worth noting that the teachers mentioned that they adapted the lessons to suit their teaching needs and the needs of their students, therefore illustrating that they had adopted the practice and were able to apply it in other lessons. To further investigate this issue future research could compare a movement integration programme which provides teachers with prepared lesson materials and a programme which focuses on teaching teachers the skills required to adapt their existing lessons.

Many previous studies which examine teacher perceptions of classroom based PA interventions identify time, space and regaining classroom control as challenges faced by teachers (Benes *et al.* 2016, Cothran *et al.* 2010, Stylianou *et al.* 2016). Each of these were mentioned as challenges in the current study however, they did not emerge as major issues for the teachers. A statement by one teacher in the current study that "trying to get everything covered and active lessons was a challenge" suggests that some teachers may have seen the lessons as additional to their classroom work. However, it is clear from their comments that most teachers used the lessons to “reinforce”, “revise”, “supplement” and “practice” what they were already teaching in the classroom. This adjustment to their behaviour may be owing to the emphasis, in the teacher training workshop, on substituting inactive with active methods to teach their existing academic lessons. As suggested by previous studies, the use of the teacher training session to adequately prepare them to manage movement in the classroom (McMullen *et al.* 2014, Webster *et al.* 2015) was incorporated into the design of the ‘Active Classrooms’ study. Although one teacher mentioned that it was difficult to resettle the children after the lessons it was not a prevalent problem in the current study. Finally, since classrooms in Ireland can be very over-crowded with large class sizes and furniture, it is not surprising that two teachers in the current study identified space as an issue. Many of the ‘Active Classrooms’ lessons were designed to be implemented in tight spaces but, to add variety and accommodate for larger classroom spaces, others involved more locomotor type movements and these were most likely the lessons which teachers stated had to be carried out outside of the classroom. Future development of the programme should consider including lesson ideas suited to both small and medium classroom spaces.

6.8 Limitations

This study has a number of limitations that warrant attention. Firstly, although the schools were randomly selected, teachers in the study are those who agreed to participate and may have been positively disposed to promoting PA in the school setting. Secondly, teachers participating in the study were aware that the primary researcher who conducted the workshops also developed the ‘Active Classrooms’ programme and resources. This may have influenced teacher responses. However, the use of questionnaires, rather than face-to-face interviews, with teachers is likely to have allowed them to objectively evaluate the programme.

6.9 Conclusions

This study illustrates that integrating movement into academic lessons was well received by both students and teachers. ‘Active Classrooms’ has been shown to both improve PA levels in the classroom (Martin and Murtagh 2015b, Martin and Murtagh in press) and enhance students’ attitudes towards academic lessons and classroom PA. Students expressed great enjoyment of participating in the programme, highlighting their satisfaction with the activities, perceived health benefits and social interactions during the lessons. Teachers identified enhanced teaching and learning which occurred as a result of student enjoyment, improved concentration and motivation to participate. They also felt that since training, lesson ideas and teaching materials were provided, it was feasible to integrate PA into their classrooms, subsequently improving PA levels without sacrificing students' academic performance. Therefore, this study demonstrates that when designing and evaluating programmes which integrate movement into the classroom, teacher satisfaction and student enjoyment are essential components for researchers to consider.

By integrating PA into the school setting through changes in behaviour and education the 'Active Classrooms' study supports public health policy at national (Department of Health 2013) and international level (WHO 2008). This study supports the contention that pedagogies can be modified by teachers and teacher educators to include movement integration in the classroom as an approach to improve students' overall health and wellbeing. Changing teacher behaviour towards using physically active methods in teaching academic content may be an approach to promote both health and academic benefits for students. Training for teachers is a vital component to ensure that they are equipped with the skills, knowledge, materials and confidence required.

Future research should directly evaluate learning and academic performance outcomes as a result of teaching using physically active methods. Additionally, a large-scale community-based trial should examine the effects of the programme where teacher workshops are delivered by trained facilitators as part of a continuous professional development service rather than solely by researchers.

6.10 Acknowledgements

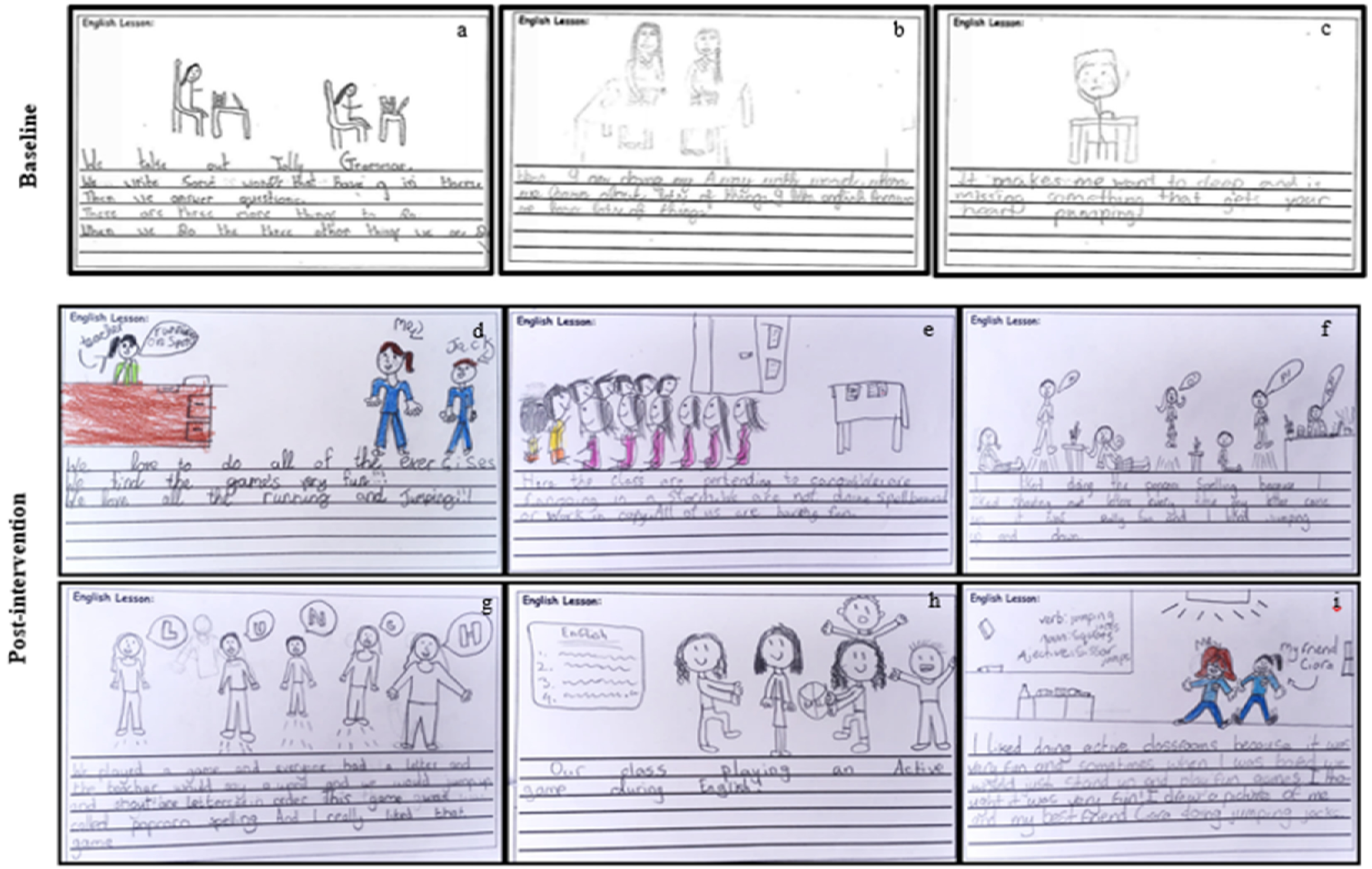
We sincerely thank the principals, schools, teachers, students and their parents for participating and for making the Active Classrooms study possible. We thank Dr. Deirdre Ní Chróinín and Richard Bowles of Mary Immaculate College for advice on thematic analysis, the draw and write technique and focus group discussions with children. We also thank Séamus Martin for assistance with technical issues.

6.11 Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6.12 Chapter Conclusion

The article presented above clearly demonstrates that both teachers and students were highly satisfied with the 'Active Classrooms' intervention. Elements of the intervention design which they expressed satisfaction with such as teacher training, are identified. This study provides great support to the PA results outlined in Chapter 5 as it demonstrates that positive PA outcomes may be influenced by both teacher and student acceptability of the programme. Further links between elements of the research design and outcomes of the studies reported in this thesis are discussed in Chapter 7.



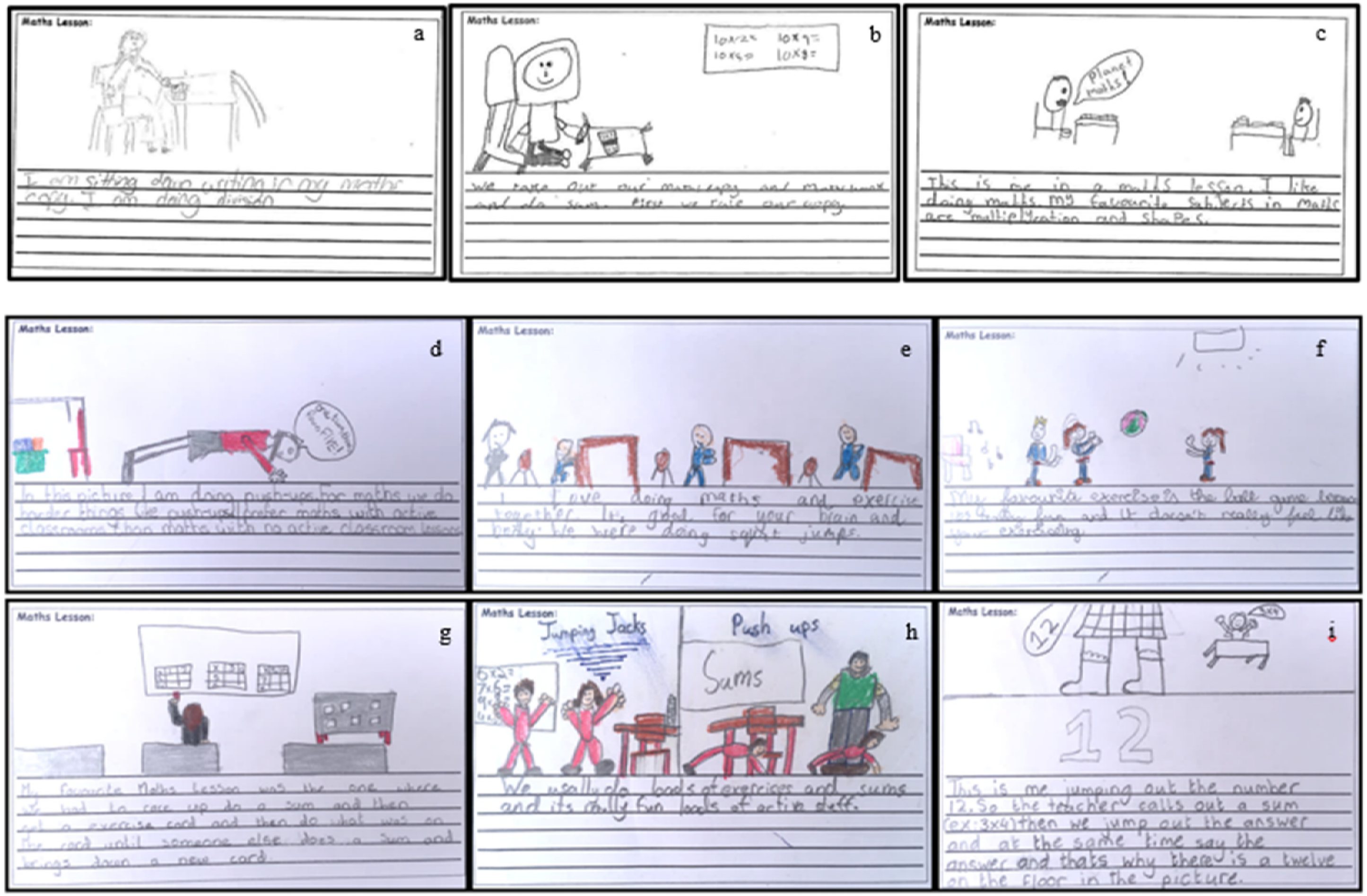
* **Note**: The following clarifies the children's written statements which accompany the drawings:

a. We take out 'Jolly Grammar'. We write some words that have g in them. Then we answer questions. There are three more things to do. When we do the three other things we are done.
b. Here I am doing my 'Away with Words' where we learn about lots of things. I like English because we learn lots of things.
c. It makes me want to sleep and is missing something that gets your heart pumping.
d. We love to do all of the exercises. We find the games very fun!!! We love all the running and jumping!!!
e. Here the class are pretending to canoe. We are canoeing in a storm. We are not doing 'Spellbound' or work in a copy. All of us are having fun.
f. I liked doing 'popcorn spelling' because I liked shouting out letters every time my letter came up. It was really fun and I liked jumping up and down.
g. We played a game and everyone had a letter and the teacher would say a word and we would jump up and shout our letters in order. This game was called 'popcorn spelling' and I really liked that game.
h. Our class playing an active game during English.
i. I liked doing Active Classrooms because it was very fun and sometimes when I was bored we would just stand up and play fun games. I thought it was very fun! I drew a picture of me and my best friend Claire doing jumping jacks.

Figure 6.2 Samples of the children's illustrations and descriptions of themselves in English lessons at baseline and post-intervention*

Baseline

Post-intervention



* **Note**: The following clarifies the children's written statements which accompany the drawings:

a. I am sitting down writing in my maths copy. I am doing division.
b. We take out our maths copy and maths book and do sums. First, we rule our copy.
c. This is me in a maths lesson. I like doing maths. My favourite subjects [topics] in maths are multiplication and shapes.
d. In this picture, I am doing push-ups. For maths we do harder things like push-ups. I prefer maths with 'Active Classrooms' than maths with no 'Active Classrooms' lessons.
e. I love doing maths and exercise together. It's good for your brain and body. We were doing squat jumps.
f. My favourite exercise is the ball game because it's really fun and it doesn't really feel like you're exercising.
g. My favourite maths lesson was the one where we had to race up to do a sum and then get an exercise card and do what was on the card until someone else does a sum and brings down a new card.
h. We usually do loads of exercises and sums and it's really fun [doing] loads of active stuff.
i. This is me jumping out the number 12. So, the teacher calls out a sum (e.g. 3 x 4) then we jump out the answer and at the same time say the answer. That's why there is a 12 on the floor in the picture.

Figure 6.3 Samples of the children's illustrations and descriptions of themselves in Maths lessons at baseline and post-intervention*

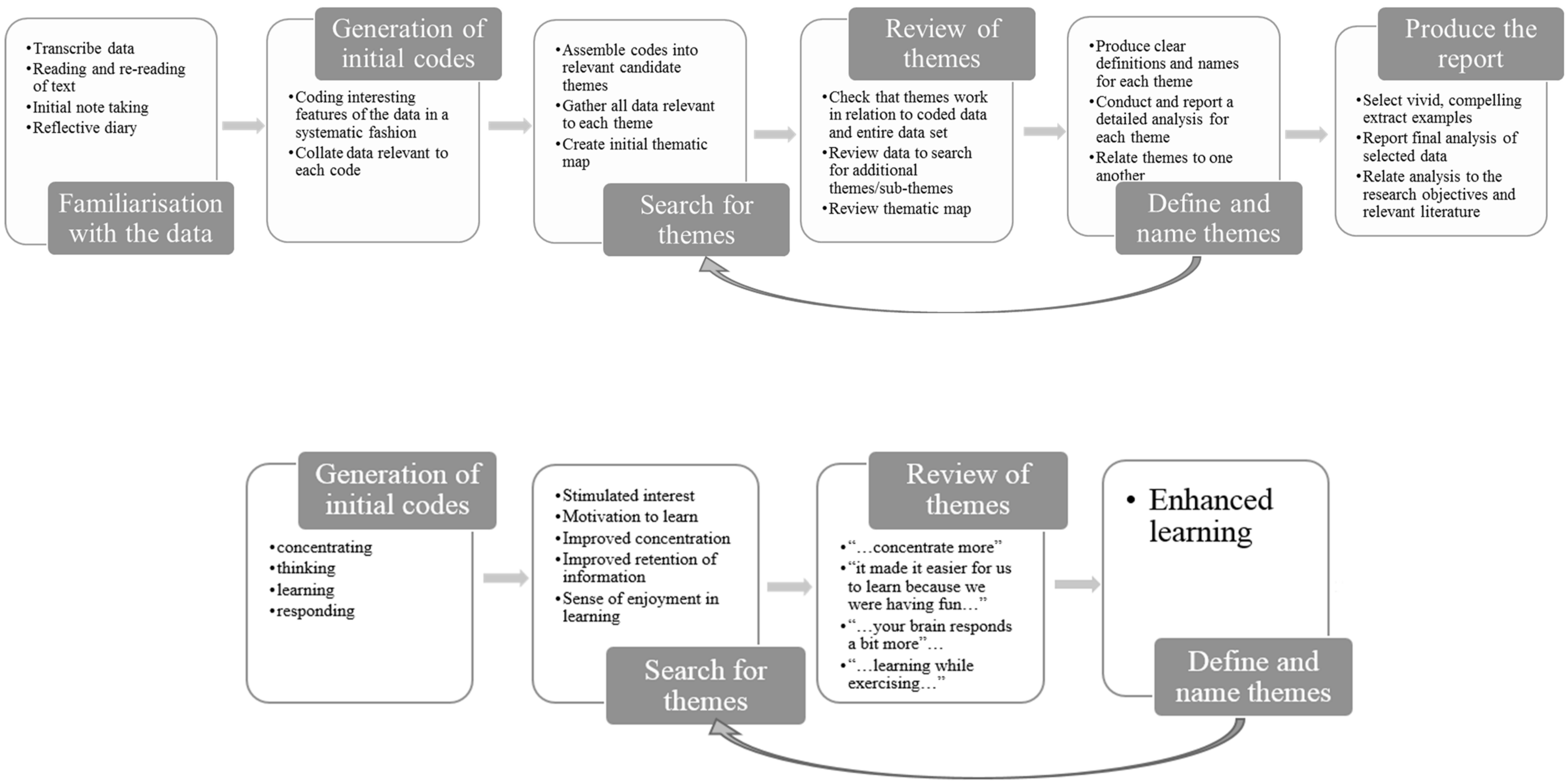


Figure 6.4 Thematic Analysis Flow Chart based on Braun and Clarke (2006) and its application in the development of the 'enhanced learning' theme

6.13 References

Androutsos, O., Apostolidou, E., Iotova, V., Socha, P., Birnbaum, J., Moreno, L., De Bourdeaudhuij, I., Koletzko, B., & Manios, Y. (2014). 'Process evaluation design and tools used in a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study', *Obesity Reviews,* 15 Suppl 3*,* 74-80.

Attride-Stirling, J. (2001) 'Thematic networks: an analytic tool for qualitative research', *Qualitative Research*, 1(3), 385-405.

Azzarito, L. (2016). '" Moving in My World": From school PE to participants-centered art exhibitions', *Journal of Teaching in Physical Education,* 35(1), 38-53.

Banville, D., Kulinna, P. H., Dyson, B., Stylianou, M., Colby, R., & Dryden, C. (2016). 'Feeling refreshed Aotearoa/New Zealand students' perspectives of the role of healthy behaviours in schools', *European Physical Education Review*, 0, 1-19.

Bartholomew, J. B. and Jowers, E. M. (2011) 'Physically active academic lessons in elementary children', *Preventive Medicine*, 52 Suppl 1, S51-4.

Benes, S., Finn, K. E., Sullivan, E. C. and Yan, Z. (2016) 'Teachers' Perceptions of Using Movement in the Classroom', *Physical Educator*, 73(1), 110-135.

Blatchford, P., Creeser, R. and Mooney, A. (1990) 'Playground games and playtime: the children's view', *Educational Research*, 32(3), 163-174.

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), 77-101.

Burrows, C., Eves, F. and Cooper, D. (1999) 'Children's perceptions of exercise-are children mini-adults?', *Health Education*, 99(2), 61-69.

Carson, R. L., Castelli, D. M., Kuhn, A. C. P., Moore, J. B., Beets, M. W., Beighle, A., Aija, R., Calvert, H. G. and Glowacki, E. M. (2014) 'Impact of trained champions of comprehensive school physical activity programs on school physical activity offerings, youth physical activity and sedentary behaviors', *Preventive Medicine*, 69, S12-S19.

Centers for Disease Control and Prevention [CDC]. (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Christensen, P. and James, A. (2008) *Research with children: Perspectives and practices*, London, Routledge.

Cothran, D. J., Kulinna, P. H. and Garn, A. C. (2010) 'Classroom teachers and physical activity integration', *Teaching and Teacher Education*, 26(7), 1381-1388.

Coulter, M. and Woods, C. B. (2011) 'An exploration of children's perceptions and enjoyment of school-based physical activity and physical education', *Journal of Physical Activity and Health*, 8(5), 645.

de Greeff, J. W., Hartman, E., Mullender-Wijnsma, M. J., Bosker, R. J., Doolaard, S. and Visscher, C. (2016) 'Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children', *Health Education Research*, 31(2), 185-194.

Department of Health (2013) *Healthy Ireland: A framework for improved health and wellbeing 2013 – 2025*, Dublin, Stationery Office.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M. and Pate, R. R. (2004) 'Self-efficacy partially mediates the effect of a school-based physical-activity intervention among adolescent girls', *Preventive Medicine*, 38(5), 628-636.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M. and Pate, R. R. (2005) 'Enjoyment mediates effects of a school-based physical-activity intervention', *Medicine and Science in Sports and Exercise*, 37(3), 478-487.

Doig, B. (2005) *Research pointers to practice: A review of research to inform middle years mathematics teaching and learning*, Adelaide: Australian Association of Mathematics Teachers.

Donnelly, J. E., Greene, J. L., Gibson, C. A., Smith, B. K., Washburn, R. A., Sullivan, D. K., DuBose, K., Mayo, M. S., Schmelzle, K. H. and Ryan, J. J. (2009) 'Physical Activity Across the Curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine*, 49(4), 336-341.

Donnelly, J. E. and Lambourne, K. (2011) 'Classroom-based physical activity, cognition, and academic achievement', *Preventive Medicine*, 52 Suppl 1, S36-42.

Dunn, L. L., Venturanza, J. A., Walsh, R. J. and Nonas, C. A. (2012) 'An observational evaluation of Move-to-Improve, a classroom-based physical activity program, New York City schools, 2010', *Preventing Chronic Disease*, 9, e146.

Erwin, H., Abel, M., Beighle, A. and Beets, M. (2011a) 'Promoting children's health through physically active math classes: a pilot study', *Health Promotion Practice*, 12(2), 244-51.

Evans, J. (1996) 'Children's attitudes to recess and the changes taking place in Australian primary schools', *Research in Education*, 56, 49.

Fade, S. and Swift, J. (2011) 'Qualitative research in nutrition and dietetics: data analysis issues', *Journal of Human Nutrition and Dietetics*, 24(2), 106-114.

Finn, K. E. and McInnis, K. J. (2014) 'Teachers' and Students' Perceptions of the Active Science Curriculum: Incorporating Physical Activity Into Middle School Science Classrooms', *Physical Educator*, 71(2), 234-253.

Fullan, M. (2007) *The new meaning of educational change*, London, Routledge.

Goh, T. L., Hannon, J., Webster, C. A., Podlog, L. W., Brusseau, T. A. and Newton, M. (2014) 'Effects of a Classroom-Based Physical Activity Program on Children’s Physical Activity Levels', *Journal of Teaching in Physical Education*, 33(4), 558-572.

Greene, S. and Hogan, D. eds., (2005) *Researching children's experience: Approaches and methods*, London: Sage.

Haerens, L., Cerin, E., Maes, L., Cardon, G., Deforche, B. and De Bourdeaudhuij, I. (2008) 'Explaining the effect of a 1-year intervention promoting physical activity in middle schools: a mediation analysis', *Public Health Nutrition*, 11(05), 501-512.

Have, M., Nielsen, J. H., Gejl, A. K., Ernst, M. T., Fredens, K., Støckel, J. T., Wedderkopp, N., Domazet, S. L., Gudex, C. and Grøntved, A. (2016) 'Rationale and design of a randomized controlled trial examining the effect of classroom-based physical activity on math achievement', *BMC Public Health*, 16(1), 304-314.

Hill, L. J., Williams, J. H., Aucott, L., Thomson, J. and Mon-Williams, M. (2011) 'How does exercise benefit performance on cognitive tests in primary-school pupils?', *Developmental Medicine and Child Neurology*, 53(7), 630-5.

Hodges, M. G., Hodges-Kulinna, P., & Kloeppel, T. A. (2015). 'Fitness for life primary: stakeholders' perceptions', *Physical Education and Sport Pedagogy*, 20(3), 299-313.

Holt, E., Bartee, T. and Heelan, K. (2013) 'Evaluation of a Policy to Integrate Physical Activity Into the School Day', *Journal of Physical Activity & Health*, 10(4), 480-487.

Howie, E. K., Newman-Norlund, R. D. and Pate, R. R. (2014) 'Smiles Count but Minutes Matter: Responses to Classroom Exercise Breaks', *American Journal of Health Behavior*, 38(5), 681-689.

Inchley, J., Currie, D., Young, T., Samdal, O., Torsheim, T., Augustson, L., Mathison, F., Aleman-Diaz, A., Molcho, M., Weber, M. and Barnekow, V. (2016) *Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-aged Children (HBSC) study: international report from the 2013/2014 survey.* Copenhagen: WHO Regional Office for Europe.

Jago, R., Macdonald-Wallis, K., Thompson, J. L., Page, A. S., Brockman, R. and Fox, K. R. (2011) 'Better with a buddy: influence of best friends on children's physical activity', *Medicine & Science in Sports & Exercise*, 43(2), 259-265.

Knowles, Z. R., Parnell, D., Ridgers, N. and Stratton, G. (2013) 'Learning from the experts: exploring playground experience and activities using a write and draw technique', *Journal of Physical Activity and Health*, 10(3), 406.

Koekoek, J., Knoppers, A. and Stegeman, H. (2009) 'How do children think they learn skills in physical education', *Journal of Teaching in Physical Education*, 28(3), 310-332.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W., & Chen, C. (2007). Report on childhood obesity in China (6). 'Evaluation of a classroom-based physical activity promotion program', *Biomedical and Environmental Sciences,* 20(1), 19-23.

Lubans, D. R., Foster, C. and Biddle, S. J. (2008) 'A review of mediators of behavior in interventions to promote physical activity among children and adolescents', *Preventive Medicine*, 47(5), 463-470.

MacPhail, A., Kinchin, G. and Kirk, D. (2003) 'Students' Conceptions of Sport and Sport Education', *European Physical Education Review*, 9(3), 285-299.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). 'Effects of a classroom-based program on physical activity and on-task behavior', *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Martin, R. and Murtagh, E. M. (2017) 'Active Classrooms: A cluster randomised controlled trial evaluating the effects of a movement integration intervention on the physical activty levels of primary school children', *Journal of Physical Activity and Health*, 14, 290-300 http://dx.doi.org/10.1123/jpah.2016-0358

Martin, R. and Murtagh, E. M. (2015a) 'An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191.

Martin, R. and Murtagh, E. M. (2015b) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education*, 52, 113-127.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). ‘Physical activity opportunities during the school day: Classroom teachers’ perceptions of using activity breaks in the classroom’, *Journal of Teaching in Physical Education, 33*(4), 511-527.

Michie, S., van Stralen, M. M. and West, R. (2011) 'The behaviour change wheel: a new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), 42-52.

Morgan, P. J. and Hansen, V. (2008) 'Physical education in primary schools: Classroom teachers' perceptions of benefits and outcomes', *Health Education Journal*, 67(3), 196-207.

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S. and Visscher, C. (2015) 'Improving Academic Performance of School-Age Children by Physical Activity in the Classroom: 1-Year Program Evaluation', *Journal of School Health*, 85(6), 365-371.

Murray, R. and Ramstetter, C. (2013) 'The crucial role of recess in school', *Pediatrics*, 131(1), 183-188.

Naylor, P. J., Macdonald, H. M., Zebedee, J. A., Reed, K. E. and McKay, H. A. (2006) 'Lessons learned from Action Schools! BC--an 'active school' model to promote physical activity in elementary schools', *Journal of Science and Medicine in Sport*, 9(5), 413-23.

NCCA (1999) *Primary School Curriculum*, Department of Education and Science, Dublin, Ireland: Stationery Office.

Niemi, H. (2002) 'Active learning—a cultural change needed in teacher education and schools', *Teaching and Teacher Education*, 18(7), 763-780.

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O. and Stamatakis, E. (2015) 'Physically active lessons as physical activity and educational interventions: A systematic review of methods and results', *Preventive Medicine, 72,* 116-125.

Patton, M. Q. (1990) *Qualitative evaluation and research methods*, London: Sage.

Pellegrini, A. D. and Bohn, C. M. (2005) 'The role of recess in children's cognitive performance and school adjustment', *Educational Researcher*, 34(1), 13-19.

Pridmore, P. and Bendelow, G. (1995) 'Images of health: exploring beliefs of children using the'draw-and-write'technique', *Health Education Journal*, 54(4), 473-488.

Reed, J. A., Einstein, G., Hahn, E., Hooker, S. P., Gross, V. P. and Kravitz, J. (2010) 'Examining the impact of integrating physical activity on fluid intelligence and academic performance in an elementary school setting: a preliminary investigation', *Journal of Physical Activity & Health*, 7(3), 343-351.

Riley, N., Lubans, D. R., Holmes, K. and Morgan, P. J. (2014) 'Rationale and study protocol of the EASY Minds (Encouraging Activity to Stimulate Young Minds) program: cluster randomized controlled trial of a primary school-based physical activity integration program for mathematics', *BMC Public Health*, 14(1), 816-825.

Riley, N., Lubans, D. R., Holmes, K. and Morgan, P. J. (2016) 'Findings From the EASY Minds Cluster Randomized Controlled Trial: Evaluation of a Physical Activity Integration Program for Mathematics in Primary Schools', *Journal of Physical Activity & Health*, 13(2), 198-206.

Riley, N., Lubans, D. R., Morgan, P. J. and Young, M. (2015) 'Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial', *Journal of Science and Medicine in Sport*, 18(6), 656-661.

Smith, J. A., Larkin, M. H. and Flowers, P. (2009) *Interpretative phenomenological analysis: theory, method and research*, London: Sage.

Stylianou, M., Kulinna, P. H. and Naiman, T. (2015) '"… because there's nobody who can just sit that long':Teacher perceptions of classroom-based physical activity and related management issues', *European Physical Education Review*, 1356336X15613968.

Taymoori, P. and Lubans, D. R. (2008) 'Mediators of behavior change in two tailored physical activity interventions for adolescent girls', *Psychology of Sport and Exercise*, 9(5), 605-619.

Te One, S. (2007) 'Participatory-research methods with young children: Experiences from the field', *Early Childhood Folio*, 2007, 11, 21-26.

Thomson, P. (2009). *Doing visual research with children and young people*. London: Routledge.

Tong, A., Sainsbury, P. and Craig, J. (2007) 'Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups', *International Journal for Quality in Health Care*, 19(6), 349-357.

Trost, S. G., Kerr, L., Ward, D. S. and Pate, R. R. (2001) 'Physical activity and determinants of physical activity in obese and non-obese children', *International Journal of Obesity & Related Metabolic Disorders*, 25(6), 822-829.

van Stralen, M. M., Yildirim, M., te Velde, S. J., Brug, J., van Mechelen, W. and Chinapaw, M. J. (2011) 'What works in school-based energy balance behaviour interventions and what does not? A systematic review of mediating mechanisms', *International Journal of Obesity*, 35(10), 1251-1265.

Vazou, S., Gavrilou, P., Mamalaki, E., Papanastasiou, A. and Sioumala, N. (2012) 'Does integrating physical activity in the elementary school classroom influence academic motivation?', *International Journal of Sport and Exercise Psychology*, 10(4), 251-263.

Veale, A. (2005) 'Creative methodologies in participatory research with children' in *Researching children's experience: Approaches and methods*, 253-272, London: Sage.

Webster, C., Russ, L., Vazou, S., Goh, T. and Erwin, H. (2015) 'Integrating movement in academic classrooms: understanding, applying and advancing the knowledge base', *Obesity Reviews*, 16(8), 691-701.

Woods, C. B., Tannehill, D. and Walsh, J. (2010) 'The children's sport participation and physical activity study (CSPPA)', *Fifth Physical Education, Physical Activity and Youth Sport (PE PAYS)*, 1.

World Health Organisation [WHO] (2010) *Global recommendations on physical activity for health*, Geneva, Switzerland: World Health Organisation.

World Health Organisation [WHO] (2008) *School policy framework: Implementation of the WHO global strategy on diet, physical activity and health*, Geneva, Switzerland: World Health Organisation.

World Health Organisation [WHO] (2016) 'EUR/RC65/9 Physical activity strategy for the WHO European Region 2016–2025', *Available from:* http://www.thehealthwell.info/node/927643, [Accessed: 9th July 2016].

CHAPTER 7

DISCUSSION AND CONCLUSIONS

Chapter 7: Discussion and Conclusions

7.1 Introduction

The purpose of this study was to design a PA intervention which integrates academic content of the Irish Primary School English and Maths curriculum, which could be taught by the classroom teacher during class time to improve the PA levels of their students. This thesis is novel in that it follows Medical Research Council (MRC) (Craig *et al.* 2008) guidance by giving adequate consideration to the development, piloting and practical implementation issues in advance of the main evaluation of the intervention. Existing literature in the field was examined through a systematic reviewing process. Gaps in the literature were identified and an intervention was developed using a theoretical framework. The intervention was designed based on the Behaviour Change Wheel framework (Michie *et al.* 2011b). Barriers to performing the desired behaviour were identified and an intervention which intended to incorporate solutions to these barriers was designed. A pilot study confirmed the ability of the active lessons to evoke moderate-to-vigorous intensity levels during class time. It also confirmed that the activities were enjoyable for the students, sensitive to the local context and practical for the teacher to implement. The importance of the inclusion of these elements has been emphasized by the MRC (Craig *et al.* 2008) to ensure that prior to implementation, the intervention is developed to a point where it can realistically be anticipated to have a meaningful effect. A cluster RCT involving ~250 students demonstrated the effectiveness of the intervention in improving MVPA levels of students.

The aims of the current chapter are to highlight and discuss the contributions of this study to the existing knowledge base, to present the strengths and limitations of the study, and to outline future recommendations for research and practice.

7.2 Contributions to the Knowledge Base

Schools have been identified as a primary location to implement PA interventions in order to promote PA and improve children's overall health (WHO 2010, WHO 2016). Results reported in the systematic review of the literature are of relevance to policy-makers, educational administrators, and teachers since evidence is provided for the valuable contribution that physically active teaching methods can make to school-based health promotion. The review revealed that physically active academic lessons can be effective in improving PA levels of primary school children. Potential benefits for learning, facilitators of learning (eg. enjoyment and on-task behaviour) and health (BMI) were also identified. It was found that few studies considered teacher and/or student acceptance of such classroom-based programmes and the need for well-designed and reported, high quality studies such as randomised controlled trials which adhere to the CONSORT standards (Schulz *et al.* 2010) was highlighted.

Considering the limitations in the existing literature, a randomised controlled trial was conducted to evaluate the 'Active Classrooms' intervention and is outlined in detail in the protocol paper (Chapter 4). The results are presented following the CONSORT guidelines in Chapter 5 and demonstrate that class time MVPA levels of students in the intervention group significantly improved over time and in comparison to the control group. As described in Chapter 6 both the teachers and the students expressed great satisfaction with the programme. It is proposed that these positive outcomes occurred as a result of the following elements of the 'Active Classrooms' intervention: 1. Effective implementation by teachers, 2. Teacher approval of the programme, 3. Targeting class time, 4. Focus on accumulation of MVPA and 5. Student enjoyment of the programme. These elements are discussed in the following sections.

7.2.1 Effective implementation by teachers

It has been acknowledged that the quality of intervention implementation influences the desired outcomes (Durlak and DuPre 2008, Meyers *et al.* 2012). Implementation science research has identified many barriers preventing evidence-based interventions from being effectively translated into common practice (Durlak and DuPre 2008). Among these barriers are failure to consider context, communities and needs and behaviours of individuals who deliver the interventions (Michie *et al.* 2011a, Meyers *et al.* 2012). The No Child Left Behind (NCLB) Education Act in the US is a prime example of a programme which proved to be scientifically effective in improving literacy and numeracy however, its "one-size-fits-all" approach towards educating all students across the US without regard for individual circumstances, needs, local setting or context has caused widespread educational failure (Brigham *et al.* 2004, Apple 2007, Strauss *et al.* 2012). The WHO (Peters *et al.* 2014) emphasises the importance of context-specific and evidence-informed decision-making if theory is to transfer effectively to real-world practice. Providing teachers in the current study with lesson ideas which were designed with consideration for implementation in the Irish primary school classroom context, and giving teachers autonomy to adapt the lessons to suit their needs, enabled the intervention to be implemented effectively.

Prior to designing the 'Active Classrooms' intervention, an evaluation of the literature was carried out to identify pre-existing barriers to implementing movement integration interventions in the classroom context. Lack of consideration for the needs of key-stakeholders involved in the implementation of such programmes was identified as a key barrier (see Chapter 4). This assessment of the needs and resources required by the implementers in the host setting, as well as collaboration and negotiation between all key stakeholders in the developmental phases, effective pre-implementation training for the implementers, ongoing monitoring and support and self-reflection by the implementers to inform future practice, have been emphasised in the Quality Implementation Framework (QIF) (Meyers *et al.* 2012) as critical steps and actions believed to constitute quality implementation. As quality implementation involves behaviour change on behalf of the implementer, behaviour change interventions are key to effective implementation (Michie *et al.* 2011b). The BCW framework (Michie *et al.* 2011b) applied in the current study outlines a systematic approach to designing behaviour change interventions, which links the science of behaviour change to practical and contextualised factors. Emphasis on analysing and understanding the behaviour to be changed in relation to context as the basis for designing the intervention, resulted in the incorporation of the quality implementation steps outlined above in addressing the pre-existing barriers to movement integration implementation (See Appendix L).

Although the ultimate goal of the 'Active Classrooms' study is to improve MVPA levels of students, the programme was designed to change teacher behaviour. It has been noted that when left to their own devices children are unlikely to achieve PA recommendations in school (Cale and Harris 2006). Therefore, initial evaluations of the literature were carried out to identify the primary intervention implementers who effectively address inactivity in primary schools. While some previous PA interventions were implemented by the research team or specialists (Sallis *et al.* 1997, Salmon *et al.* 2008), it is noted in school-based health promotion literature that it is predominantly teachers who serve as programme implementers (Han and Weiss 2005). Many advantages have been attributed to this approach such as economic sustainability and longevity of the interventions (Atkins *et al.* 1998). Classroom-based interventions reach large groups of children at one time (WHO 2008) and if they are effectively implemented by teachers they can be integrated into the general classroom curricula (Han and Weiss 2005). In studies which evaluated stakeholders' perceptions on responsibility for children's PA levels, teachers acknowledged their role and the responsibility of the school in addressing inactivity of their students (Cox *et al.* 2010, Benes *et al.* 2016). Teachers have been described as central change agents and vital stakeholders who can influence what happens in schools and classrooms and through providing children with frequent opportunities to engage in interventions can contribute to their positive development (Grossman *et al.* 1997, Benes *et al.* 2016). This is evident in the current study with changes in teacher behaviour facilitating positive improvements in their students' MVPA levels and enjoyment of the lessons.

The use of the BCW framework in designing the 'Active Classrooms' intervention ensured that factors which teachers deemed important to implementing active lessons in the classroom were included in the programme, for example connection to the academic curriculum, provision of training, and resources (Cothran *et al.* 2010, McMullen *et al.* 2014, Benes *et al.* 2016, McMullen *et al.* 2016). Few previous studies which integrate movement into the classroom included theoretical frameworks in the development of their interventions (Norris *et al.* 2015) (also see section 2.19.3 of Chapter 2). The Ecological model which places emphasis on the impact of community and surroundings on the behaviour of individuals (Erwin *et al.* 2011a), the theory of 'brain- based learning' which emphasises the grounding of teaching methods in the neuroscience of learning (Mullender-Wijnsma *et al.* 2015), and the RE-AIM framework which places emphasis on the "Reach, Effectiveness, Adoption, Implementation, and Maintenance" of the intervention programme (Reznik *et al.* 2015) are among those which have been used. However, interventions guided by behaviour change theories are proven to be more effective with more enduring results (Michie and Abraham 2004) than these previously used theories. The analysis of teacher behaviour with regard to capability, opportunity and motivation to teach using physically active methods in the classroom (COM-B) prior to the development of the intervention is a unique aspect of the BCW framework. This analysis ensured that barriers to performing the behaviour in real-world practice were identified. A systematic and theoretically guided method was then applied to identify the specific techniques anticipated to be effective in helping teachers overcome these barriers to adopt movement integration in their classroom settings. It is evident that under the guidance of the BCW framework many of the steps outlined in the QIF (Meyers *et al.* 2012) to ensure quality implementation were addressed in the development and implementation of the 'Active Classrooms' intervention. These are indicated clearly in Appendix K and Appendix L. Elements of the intervention which emerged as a result of applying the BCW framework such as adaptable lesson ideas, linkage to the academic curriculum, provision of resources, training which emphasised the integration of movement rather than additional lessons/exercise breaks and setting specific achievable goals (i.e. teach two active lessons for at least 10 minutes each day) were highlighted by teachers in their evaluations as contributing to the ease of implementing the programme. Therefore, arguments that context, communities and needs and behaviours of individuals who deliver the interventions should be considered if interventions are to be effectively implemented in practice are supported by findings of the current study.

7.2.2 Teacher approval of the programme

Teachers have been recognised as central change agents in classroom-based interventions (Grossman *et al.* 1997) and as outlined above effective implementation is unlikely unless their needs are addressed. Therefore, it is essential to provide teachers with interventions they approve of, if fidelity and sustainability are to be guaranteed (Han and Weiss 2005, Cothran *et al.* 2010). Evaluations provided by the teachers contextualise and explain the outcome data by highlighting elements the teachers deemed essential for successful implementation of the programme. These are explained in more detail below.

7.2.2.1 Connection to the Academic Curriculum

Teachers in the present study highlighted the use of the active lessons to support their teaching and reinforce academic content they were currently teaching. In many previous studies which evaluated teachers' perceptions, teachers considered movement integration to be in addition to or to complement their pre-existing teaching demands (Cothran *et al.* 2010, McMullen *et al.* 2014, McMullen *et al.* 2016). Take 10! has been criticised in the literature by studies examining teachers' attitudes to their implementation. Teachers have reported that the lessons lack integration with the curriculum and that activity is merely 'tacked onto' overly basic lessons (Bartholomew and Jowers 2011). This has been found to influence the frequency that the active lessons are implemented. An evaluation of Take 10! by teachers in the UK reported an average implementation of 1.5 sessions per week (Gately *et al.* 2013). Alternatively, teachers in the Moving to Learn Ireland study reported implementation of three movement lessons per week (McMullen *et al.* 2016). The researchers attributed this to meaningful connection of the active lessons to the academic curriculum. Teachers in the current study reported that they implemented numeracy lessons an average of 4.2 days and literacy an average of 3.8 days per week. This is higher than averages reported in previous studies and from data which emerged from the teachers' evaluations can be attributed to direct connection of the lessons to the strands and strand units of the academic curriculum and provision of concrete resources to teach the lessons. It has been acknowledged in the literature that teachers value concrete and practical ideas, which integrate with the academic curriculum and have little interference with day-to-day classroom procedures (Fullan and Miles 1992, Harrell *et al.* 2005). Therefore, the provision of resources which integrate movement into the curriculum in a meaningful way, contributes to teacher approval of the programme as it allows them to overcome the "lack of time" barrier by ensuring that the children are learning academic content while being active. This is a key factor in motivating teachers to implement new programmes and consequently influences intervention outcomes.

7.2.2.2 Enhanced teaching and learning

Teachers in the current study expressed that the active lessons enhanced their teaching and their students' learning. Using movement in the classroom has often been recommended to improve academic success. It is accepted that active and kinaesthetic teaching styles result in increased learning outcomes for all students regardless of their individual learning preferences (Jensen 2000, Coffield *et al.* 2004, Lengel and Kuczala 2010). Active learning is reported to support retention of academic material, provide enjoyable experiences for students, be age-appropriate, intelligence independent and therefore reach more learners than traditional teaching styles (Jensen 2000). Given this evidence it must be questioned why all teachers have not adopted such practices. Guskey (2002) explains that in order for teachers to change their beliefs and attitudes they must go through a process which begins with an attempt to implement the new strategy. If this attempt results in positive change in student learning/behavioural/motivational outcomes, it will lead to a change in teacher belief systems, which is a requirement for change in practice (Guskey 2002). Teachers who implemented the 'Active Classrooms' programme revealed that there were improvements in their students' concentration, focus, enjoyment, motivation, learning and participation in the classroom. According to Guskey's model of teacher change (Guskey 2002), this evidence of improvement in student learning outcomes and the experience of successful implementation is likely to have positively shaped the teachers' attitudes and beliefs. Teachers approved of the programme because they experienced it and witnessed the benefits of it for their students. Previous studies which evaluated teacher perceptions of implementing new programmes also reported that teacher acceptability was influenced by positive changes to student learning outcomes

(Cothran *et al.* 2010, Hodges *et al.* 2015, Benes *et al.* 2016, McMullen *et al.* 2016, Stylianou *et al.* 2016). Given the findings of the present study, it is contended that student learning should be at the heart of programmes designed for implementation in classroom settings, as it is the key element which influences approval and 'buy in' of teachers, who are the chief implementers.

7.2.3 Targeting class time

It has been acknowledged that schools and classrooms are the primary locations where effective PA interventions targeting children have taken place (van Sluijs *et al.* 2007). As mentioned above teachers accept their role in improving PA levels of their students (Benes *et al.* 2016). Given that instructional class time has been recognised as one of the most sedentary periods of a child's day (Bailey *et al.* 2012, Fairclough *et al.* 2012, Hegarty *et al.* 2013) it has been recommended that effective interventions should be implemented during this time (Centers for Disease Control and Prevention 2013, Kohl and Cook 2013). Additionally, classroom-based interventions and movement integration in particular have been found to reach large numbers of children at one time (Donnelly *et al.* 2009, Reznik *et al.* 2015, Riley *et al.* 2016). This is attributed to the fact that in the classroom during class time, children are a captive audience for classroom-based interventions. The majority of children present in the classroom are facilitated to participate since they are under the direction of the teacher (Belton *et al.* 2010). Data from the pilot study was used to calculate the percentage of total MVPA accumulated, by the same group of children, taught by the same classroom teacher, during segmented periods of the school day (Chapter 3). This illustrates that 33% of the students' school day MVPA throughout the week was accumulated during the intervention lessons. This is a considerable percentage of MVPA to accumulate during class time as it almost matches the time the students spent in MVPA during break and lunch times (37.8%) and it exceeds the percentage of school day MVPA accumulated during traditional lessons and P.E. combined (29%). Therefore, targeting class time with MI interventions results in increased MVPA because this is a period with great scope for improvement and groups of children participate in the exercises since they are instructed to do so by their teachers as part of their academic learning. In the current study, teachers' classroom instruction influenced the intensity and duration of activity achieved by their students depending on the lessons and exercises chosen, frequency of implementation and time allowed to complete tasks.

7.2.4 Focus on accumulation of moderate-to-vigorous intensity PA

The primary outcome measure for the current study was students' MVPA which could be accumulated through active lessons interspersed throughout the school day. This was the focus of the study since current WHO (2016) recommendations emphasise PA of at least moderate intensity for health benefits, and that children should accumulate at least 60 minutes of moderate-to-vigorous intensity PA daily. A systematic review of the health benefits of PA in school-aged children revealed that moderate and vigorous intensity activities are connected with many health benefits, such as the prevention of many chronic diseases (e.g. cardiovascular disease, cancer, diabetes, obesity, hypertension and depression) and that low intensity activities may not have the same benefits (Janssen and LeBlanc 2010). The WHO (2016) also recognise that children achieve similar health benefits by accumulating the recommended amount of MVPA in relatively short bouts (Barr-Anderson *et al.* 2011) as short bouts are deemed to be more realistic and achievable especially for less active children (Janssen and LeBlanc 2010).

Results of the current study illustrate that children in the 'Active Classrooms' study accumulated >22% more MVPA than the control group post-intervention. Previous studies did not report improvements of this magnitude (Erwin *et al.* 2011a, Riley *et al.* 2016). Improvement in MVPA levels reported in the 'Active Classrooms' study is likely due to a number of reasons such as discussions of intensity levels with teachers during workshops (as previously mentioned in Chapter 5) combined with a pilot study which confirmed that MVPA could be elicited from the activities provided. Discussing intensity levels with the teachers stimulated an awareness that the aim was not only to encourage their students to move, but to encourage them to move at moderate-to-vigorous intensity levels. The pilot study included in the current thesis (Chapter 3) illustrates that the active lessons successfully facilitated PA levels of moderate-to-vigorous intensity. The findings of this thesis suggest that to achieve positive results in improving students' MVPA levels both teacher training on PA intensity and confirmation of intensity generated during the lesson activities provided must be included.

7.2.5 Enjoyment experienced by the students

Students in the current study clearly demonstrated their enjoyment of the programme through their drawings, written texts and focus group discussions (Chapter 6). The children highlighted how participating in the active lessons benefitted their health and learning. They expressed how they were learning in a 'fun' and 'exciting' way and they noted how being active contributed to their health. Engaging with their friends and with their peers were identified as prominent factors contributing to their enjoyment. These have also been acknowledged as motivational factors encouraging girls and least active children to participate in PA (Bailey *et al.* 2005, Webber *et al.* 2008, Knowles *et al.* 2013). The themes which emerged from the students' drawings and written texts were reinforced by data from the student focus group interviews as well as from the data provided by the teachers.

As discovered through the systematic literature review few previous similar studies evaluated student perceptions (Finn and McInnis 2014, Riley *et al.* 2015, Benes *et al.* 2016). The importance of student enjoyment of health promoting initiatives cannot be overemphasised since it has been regarded as a critical determinant of intervention use (Cyr *et al.* 2006). Enjoyment has been found to contribute to people's willingness to engage in certain activities (Reeve 1989). Various other fields of health promotion are considering the power of enjoyment in order to encourage participant engagement with programmes. A school-based intervention designed to reduce risk factors for eating disorders concluded that pilot testing is necessary to ensure positive student perceptions if programmes are to be effective (Wade *et al.* 2002). Interest and enjoyment were investigated to evaluate their effect on internet-delivered health promoting interventions on Dutch adult internet users (Crutzen *et al.* 2014). Interest was found to direct attention and initiate participation, while enjoyment maintains engagement once people are interested (Crutzen *et al.* 2014). A strong correlation has previously been reported between interest and enjoyment (Tulis and Ainley 2011). Interest has been described as a product of novelty, complexity and student potential to master the challenges the lessons pose (Silvia 2008). Although interest was not a formal outcome of the current study, it is relevant since many students commented on how English and Maths lessons became 'more interesting' during the intervention. According to Silvia (2008)'s "ingredients for interest", it could thus be implied that the 'Active Classrooms' lessons were innovative, complex and within the students' ability range which had an impact on their enjoyment and played a central role in their learning, motivation and education. Given their interrelated importance, enhancing influences of enjoyment and interest to maximise their potential power on intervention use (Crutzen *et al.* 2014) should be considered in future studies.

Aside from the design and content of classroom-based interventions, another factor which has been found to influence student enjoyment is the teaching style used to deliver the lessons (Wade *et al.* 2002). Interactive, student-centred methods have been found to enhance student enjoyment, engagement and learning (Hill and Hill 1990). Lessons in the 'Active Classrooms' programme were designed to involve the students in their learning through engagement in movement. Although observations of teaching methods were not carried out, the level of PA generated during class time combined with illustrations by the children depicting themselves engaging in the lessons lend support to the assumption that interactive, student-centred teaching methods were used.

Student enjoyment of intervention programmes influence teachers' attitudes towards and decisions regarding PA (McMullen *et al.* 2014, McMullen *et al.* 2016) which, as described above, impact implementation and effectiveness of such interventions (Fullan 2007). Teachers in the current study expressed their approval of the programme and their intentions to continue using it since the students enjoyed the lessons. Improvement in class time PA levels of the intervention group was maintained at follow-up, hence confirming that teachers did indeed continue using the programme. The high level of enjoyment experienced by students in the current study is a notable finding and highlights the need for its consideration in the development and evaluation of future PA interventions.

7.3 Strengths and Limitations:

The use of a cluster randomised controlled trial to evaluate the effectiveness of the 'Active Classrooms' programme is a strength of the current study as this design contributes to the quality of the findings and reduces the potential for bias and misleading conclusions being drawn. Randomisation is regarded as the most robust method of preventing selection bias and clustering of the children within classrooms, within schools ensured that contamination of the control group was avoided (Craig *et al.* 2008). Following the CONSORT guidelines (Schulz *et al.* 2010) in designing, conducting and reporting the research ensures standardisation and transparency.

Drawing conclusions from multiple data sources is an additional strength of the current study. Accelerometers provide objective PA data which allowed the effects of the active lessons to be identified within the intervention group from pre- to post- intervention, and between the intervention and control groups over time. Through including teachers' and students' perspectives the researcher was able to gain insights into what may have contributed to increased accumulation of PA during class time. Strengths and weaknesses of implementing the programme, such as connection to the academic curriculum, provision of training and resources, and lack of space for some of the lessons were also identified by participating teachers. It has been acknowledged that many intervention programmes have not been transferred from experimental studies to larger scale implementation (Reis *et al.* 2016) therefore, gaining qualitative insights may inform adaptation of the programme to suit the needs of the main stakeholders.

In addition to the limitations stated in sections 3.17, 5.7 and 6.7 the following additional limitations should be noted. Firstly, teachers included in the current study volunteered to participate, which may indicate that they may already have had particular interest in PA promotion. It is possible that they do not represent the population of primary school teachers who may have little intention of changing their instructional strategies. Given the number of schools approached to recruit the required number of teachers, it could be argued that it is in this proportion of teachers where the challenges of changing teacher behaviour towards movement integration lie. Secondly, although teachers and students indicated that the active lessons contributed to their learning and/or facilitators of learning, it must be noted that these outcomes were not objectively assessed in the current study. A third limitation of the current study is that implementation fidelity, and both teacher and student perceptions of the programme, were evaluated through data which was self-reported by the teachers and students. Combining this data with data gathered from formal observations of the lessons in practice would add to the robustness of the study.

7.4 Policy and Practice Implications

Physical inactivity has been acknowledged as a worldwide pandemic that requires global action (Kohl *et al.* 2012). The urgency for national and international action in combatting physical inactivity is reinforced by evidence of its effects on health and the economy. Physical inactivity attributed to health care costs greater than €49.4 billion, €12.6 billion in productivity losses, and 13.4 million disability- adjusted life years (DALYs) worldwide in 2013 (Ding *et al.* 2016). It is time to prioritise PA to reduce the economic and health burden of non-communicable diseases. To combat the major problem of physical inactivity it has been recommended that schools internationally develop policies to increase children's PA levels throughout the school day (Ward 2011). The 'Active

Classrooms' project can contribute to such policies while also supporting national (Department of Health (Ireland) 2009, National Physical Activity Guidelines Steering Group 2014) and international (WHO 2016) initiatives which aim to increase PA levels to improve overall health. The current study has demonstrated that integrating movement into class time has the potential to serve as one facet of a wider school-based intervention to move children towards achieving IOM (Kohl and Cook 2013) recommendations of 30-minutes in MVPA during school hours. For such interventions to be successful, findings from this thesis recommend that health and education professionals formulating the programmes must consider the needs of key stakeholders i.e. students and teachers, with intentions of improving PA levels through enjoyable experiences while also maintaining educational value.

Since movement integration is a relatively inexpensive source of PA and classroom teachers can easily be trained to adopt this teaching strategy, a practical recommendation for the Department of Education and Skills (DES) is to incorporate movement integration into existing and new professional development training for teachers. During these training sessions emphasis should be placed on PA intensity (DuBose *et al.* 2008) and integration of movement by substituting inactive teaching methods for active ones. Teachers should be provided with adaptable lesson ideas linked to the academic curriculum and the concrete resources required to teach them. Therefore, all Irish primary schools would be equipped with trained professionals, which would allow movement integration to be effectively included in the schools' formal plans to promote PA as recommended in DES circular (0013/2016) (Curriculum and Assessment Policy Unit 2016). Administrative staff must provide support to teachers to assist them with changing their practices (eg: reminders, announcements, time for planning, sharing ideas etc.) because this support has been found to increase teacher confidence, adherence to new programmes and willingness to try new ideas (Hodges *et al.* 2015).

Findings from the current thesis also have implications for teacher education programmes. All third-level teacher education institutions should facilitate modules which focus on MI so that student teachers are equipped with the knowledge and skills required to effectively implement MI in their future classrooms. MI is a teaching method which can be adapted to teach any subject to students of any age and since physical inactivity is an area of concern across all age profiles (WHO 2010) this practice should not be limited to teachers of primary level students but should also be extended to secondary and third level teachers.

As described in Chapter 4, twenty English and twenty Maths lessons linked to the strands and strand units of the Irish Primary School Curriculum were designed for the current study. To promote MI and encourage teachers nationally to integrate movement across the curriculum, it is recommended that the NCCA add movement integration lesson ideas to the strands and strand units of all subjects in the existing curriculum. Further to this, school book publishers could include a section with movement integration ideas to each topic or lesson within the book. These ideas could be printed on both pupil workbooks and teacher resource books. Finally, software developers could design interactive whiteboard resources and educational games which integrate movement and academic content.

7.5 Directions for Future Research

There is overwhelming evidence that PA benefits the health and well-being of students (Janssen and LeBlanc 2010). However, since movement integration is a relatively new topic there is little consensus in the literature regarding its impact on academic achievement from long term interventions. Although PA has been found to have a positive influence on cognitive functioning, and brain development and function, interventions have reported a range of results from positive effects to no effect for PA on academic achievement (Bailey *et al.* 2005, Norris *et al.* 2015, Donnelly *et al.* 2016, Resaland *et al.* 2016, Stylianou *et al.* 2016) (Chapter 2). Nevertheless, there is overall consensus that PA has not been found to have a negative impact on academic achievement (Norris *et al.* 2015, Donnelly *et al.* 2016) (Chapter 2). Researchers argue that more research is necessary to determine practical implementation strategies to transfer PA-related gains in brain function and cognition from the laboratory to school environments (Donnelly *et al.* 2016). In their recent review evaluating PA, fitness, cognitive function, and academic achievement in children, Donnelly *et al.* (2016) reported that classroom-based movement integration studies were found to have the most consistent positive associations for increased academic achievement compared to PA breaks, PE and sports interventions. The systematic literature review presented in the current thesis (see Chapter 2, Part B) also reports positive findings for MI lessons on learning outcomes as well as on-task behaviours. Another recent study concluded that MI was particularly effective for academically weak children (Resaland *et al.* 2016). Emerging evidence suggests that movement integration can promote academic learning as well as PA. However, to build a more convincing case additional well-designed studies are required to evaluate the effects of physically active lessons on academic achievement and retention of learning.

Integrating short bouts of PA into the classroom as described in the 'Active Classrooms' study may also make additional contributions to sedentary behaviour research. Classroom settings and traditional teaching and learning styles have previously been identified as contributing to children's overall sedentary behaviour, with children spending extended periods of time seated to receive instruction (Gibson *et al.* 2008). There is an emerging body of evidence which suggests that decreasing sedentary time is associated with reduced health risk in children aged 5-17 (Tremblay *et al.* 2011). Additionally, there is growing evidence that independent of total sedentary time and time in MVPA, interrupting sustained periods of sedentary behaviour may also promote health (Healy *et al.* 2008a, Barr-Anderson *et al.* 2011, Ekelund *et al.* 2016). The Australian Transform Us! (Salmon *et al.* 2011) study outlines a specific procedure to reduce sedentary behaviour during class time. This includes two features: 1. the modification of a 30 minute lesson per day so that teachers deliver the content while the children are standing up and 2. a two-minute light-intensity activity break every 30-minutes of seated class time (Salmon *et al.* 2011). Future classroom interventions targeting sedentary time could extend this concept further taking a dual approach of promoting MVPA and reducing sedentary behaviour though MI. Existing MI programmes such as the 'Active Classrooms' programme could be adapted and evaluated to examine its impact on reducing overall sedentary behaviour and interrupting sedentary bouts.

Many interventions have been proven to be effective in improving PA levels but few have been scaled up at population level (Reis *et al.* 2016). Maintaining quality implementation beyond the trial phase is critical for achieving positive student outcomes as intervention programmes are adopted and institutionalised by schools. Data which enables the implementation process to be evaluated can contextualize and explain outcome data. This in turn can allow interventions to be adapted and modified to best suit the needs of their implementers and facilitate wider implementation and increased effectiveness (Han and Weiss 2005). Examining factors that sustain a high level of implementation fidelity is important for the scaling up of programs (McLaughlin and Mitra 2001, Coburn 2003, Han and Weiss 2005). Given that the 'Active Classrooms' programme can successfully improve MVPA levels and it is acceptable by both students and teachers, a study which evaluates wide-scale implementation of the programme is warranted. Proctor *et al.* (2011) outline implementation outcomes which should be evaluated in order to advance understanding of the implementation process and ensure implementation fidelity in real world contexts. These outcomes include acceptability, adoption, appropriateness, feasibility, penetration (integration), cost, sustainability and fidelity of the intervention as it is applied in the real world.

Divergence in the literature has been highlighted in Chapter 5 regarding the provision of resources with some studies claiming that pre-prepared materials and resources would greatly assist the implementation of movement integration (Benes *et al.* 2016, McMullen *et al.* 2016), others claim that such resources would remove teacher autonomy (Riley *et al.* 2016). Since the provision of resources affects teacher implementation of classroom-based programmes, types of resources provided should be considered in this implementation evaluation. Therefore, it would be beneficial if a large scale three-arm community-based trial was conducted. This trial would examine implementation outcomes and the effects of the programme following teacher workshops delivered by trained facilitators as part of a continuous professional development service rather than by the researcher. The three arms of the trial would be as follows: group A: control, continue with regular practice; group B: teachers receive prescribed lessons and resources and are encouraged to use them to assist in teaching the content of their current academic lessons; and group C: teachers are taught the concept, then allowed autonomy to adapt their current lessons to integrate movement throughout the day. Results of this trial would inform intervention developers of best practice for implementation fidelity and sustainability in the development of a classroom-based intervention programme, which could be adapted for national and eventually international implementation to improve PA levels and overall health of students.

PA guidelines for children also include recommendations that muscle strengthening activities should be performed at least three days per week (WHO 2010). Research has demonstrated that increasing muscle strength in children positively benefits their cardiovascular fitness, body composition, mental health, metabolic rate, blood lipid profiles and bone mineral density (Faigenbaum 2000, Council on Sports and Fitness 2008). Resistance exercises and strength training activities have been reported to improve muscle strength as well as mobility, balance, control and body awareness, in children with cerebral palsy (Scholtes *et al.* 2010), and in healthy children and adolescents (Payne *et* *al.* 1997). Children as young as 7 years old can do resistance and strength activities such as squats, step ups, sit-ups, push-ups etc. as long as they are shown the correct techniques and perform the exercises safely (Council on Sports and Fitness 2008). Increases in muscle strength in children occur with training at least once a week over an 8-week period, and must be continued to maintain muscle strength and power (Faigenbaum *et al.* 2002). Using body weight is acknowledged as an appropriate amount of resistance, consequently strength activities can easily be done in the confined space of the classroom with little or no equipment. It would therefore be beneficial for future research to evaluate the effects of movement integration lessons on students' muscle strength since many of the lessons in the 'Active Classrooms' programme incorporate resistance exercises and strength training activities.

7.6 Conclusions

The series of papers presented in this thesis demonstrate that changing teacher behaviour towards integrating movement into academic lessons can be achieved and can be an effective strategy for improving students' PA levels once the programme is acceptable for teachers and enjoyable for students. Pedagogies can be modified by teachers and teacher educators to include movement integration in the classroom to improve students' overall health and well-being. The systematic literature review (Chapter 2, Part B) highlights the positive effects of MI on students' PA levels, learning, facilitators of learning and health outcomes. The pilot study (Chapter 3) demonstrates that the 'Active Classrooms' intervention lessons are sensitive to the local context and successful in eliciting PA of moderate-to-vigorous intensity in the classroom setting. The RCT (Chapters 4 to 6) provides evidence for 'Active Classrooms' as a successful, implementable strategy for increasing the PA levels of primary school students. The impact classroom teachers can have on class time PA levels of the students they teach is highlighted. Future work and advancements in movement integration pedagogies and their implementation will further expand the findings of this thesis and reinforce the role of teachers as central change agents in classroom-based PA programmes. Finally, in the words of the students, "...you learn quickly when you're being active" (student 10, female) and "it's good for your brain and body" (student 21, male).

REFERENCES

References

Ahamed, Y., Macdonald, H., Reed, K., Naylor, P., Liu-Ambrose, T. and McKay, H. (2007) 'School-based physical activity does not compromise children's academic performance', *Medicine & Science in Sports & Exercise*, 39, 371- 376.

Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S. and Anderssen, S. A. (2006) 'Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study)', *The Lancet*, 368(9532), 299-304.

Apple, M. W. (2007) 'Ideological Success, Educational Failure?: On the Politics of No Child Left Behind', *Journal of Teacher Education*, 58(2), 108-116.

Araújo-Soares, V., McIntyre, T., MacLennan, G. and Sniehotta, F. F. (2009) 'Development and exploratory cluster-randomised opportunistic trial of a theory-based intervention to enhance physical activity among adolescents', *Psychology and Health*, 24(7), 805-822.

Armstrong, N. and Welsman, J. R. (2006) 'The physical activity patterns of European youth with reference to methods of assessment', *Sports Medicine*, 36(12), 1067-1086.

Atkins, M. S., McKay, M. M., Arvanitis, P., London, L., Madison, S., Costigan, C., Haney, M., Hess, L., Zevenbergen, A. and Bennett, D. (1998) 'An ecological model for school-based mental health services for urban low-income aggressive children', *The Journal of Behavioral Health Services & Research*, 25(1), 64-75.

Bailey, D. P., Fairclough, S. J., Savory, L. A., Denton, S. J., Pang, D., Deane, C. S. and Kerr, C. J. (2012) 'Accelerometry-assessed sedentary behaviour and physical activity levels during the segmented school day in 10–14-year-old children: the HAPPY study', *European Journal of Pediatrics*, 171(12), 1805-1813.

Bailey, R., Wellard, I. and Dismore, H. (2005) 'Girls' participation in physical activities and sports: Benefits, patterns, influences and ways forward', *World Health Organization technical paper commissioned from ICSSPE in Physical Activty and Health Alliance*.

Baquet, G., Van Praagh, E. and Berthoin, S. (2003) 'Endurance training and aerobic fitness in young people', *Sports Medicine*, 33(15), 1127-1143.

Baranowski, T., Dworkin, R. J., Cieslik, C. J., Hooks, P., Clearman, D. R., Ray, L., Dunn, J. K. and Nader, P. R. (1984) 'Reliability and validity of self report of aerobic activity: Family Health Project', *Research Quarterly for Exercise and Sport*, 55(4), 309-317.

Baranowski, T., Mendlein, J., Resnicow, K., Frank, E., Cullen, K. W. and Baranowski, J. (2000) 'Physical activity and nutrition in children and youth: an overview of obesity prevention', *Preventive Medicine*, 31(2), S1-S10.

Barbeau, P., Johnson, M. H., Howe, C. A., Allison, J., Davis, C. L., Gutin, B. and Lemmon, C. R. (2007) 'Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls', *Obesity*, 15(8), 2077-2085.

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A. and Yancey, A. K. (2011) 'Integration of short bouts of physical activity into organizational routine: A systematic review of the literature', *American Journal of Preventive Medicine*, 40(1), 76-93.

Bartholomew, J. B. and Jowers, E. M. (2011) 'Physically active academic lessons in elementary children', *Preventive Medicine*, 52 Suppl 1, S51-4.

Bayne-Smith, M., Fardy, P. S., Azzollini, A., Magel, J., Schmitz, K. H. and Agin, D. (2004) 'Improvements in heart health behaviors and reduction in coronary artery disease risk factors in urban teenaged girls through a school-based intervention: the PATH program', *American Journal of Public Health*, 94(9), 1538-1543.

Belton, S., Brady, P., Meegan, S. and Woods, C. (2010) 'Pedometer step count and BMI of Irish primary school children aged 6-9 years', *Preventive Medicine*, 50(4), 189-92.

Benes, S., Finn, K. E., Sullivan, E. C. and Yan, Z. (2016) 'Teachers' Perceptions of Using Movement in the Classroom', *Physical Educator*, 73(1), 110-135.

Bershwinger, T. and Brusseau, T. A. (2013) 'The impact of classroom activity breaks on the school-day physical activity of rural children', *International Journal of Exercise Science*, 6(2), 6.

Biddle, S., Gorely, T. and Stensel, D. (2004) 'Health-enhancing physical activity and sedentary behaviour in children and adolescents', *Journal of Sports Science*, 22, 679 - 701.

Biddle, S. J. and Asare, M. (2011) 'Physical activity and mental health in children and adolescents: a review of reviews', *British Journal of Sports Medicine,* 45(11), 886-895.

Biddle, S. J. and Mutrie, N. (2007) *Psychology of physical activity: Determinants, well-being and interventions*, London: Routledge.

Blakemore, C. L. (2003) 'Movement is essential to learning', *Journal of Physical Education, Recreation & Dance*, 74(9), 22-25.

Boyle-Holmes, T., Grost, L., Russell, L., Laris, B., Robin, L., Haller, E., Potter, S. and Lee, S. (2010) 'Promoting elementary physical education: results of a school-based evaluation study', *Health Education & Behavior*, 37(3), 377-389.

Brigham, F. J., Gustashaw, W. E., Wiley, A. L. and Michele St. Peter, B. (2004) 'Research in the Wake of the No Child Left Behind Act: Why the Controversies Will Continue and Some Suggestions for Controversial Research', *Behavioral Disorders*, 29(3), 300-310.

Bull, F. C., Gauvin, L., Bauman, A., Shilton, T., Kohl, I. I. I. H. W. and Salmon, A. (2010) 'The Toronto Charter for Physical Activity: A Global Call for Action', *Journal of Physical Activity & Health*, 7(4), 421-422.

Caballero, B., Clay, T., Davis, S. M., Ethelbah, B., Rock, B. H., Lohman, T., Norman, J., Story, M., Stone, E. J. and Stephenson, L. (2003) 'Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren', *The American Journal Of Clinical Nutrition*, 78(5), 1030-1038.

Cale, L. and Harris, J. (2006) 'School-based physical activity interventions: effectiveness, trends, issues, implications and recommendations for practice', *Sport, Education and Society*, 11(4), 401-420.

Callaghan, M., Gavin, A., Keane, E., Nic Gabhainn, S., Molcho, M. and Kelly, C. (2015) 'The Irish health behaviour in school-aged children (HBSC) study 2014'.

Cardon, G., De Clercq, D., De Bourdeaudhuij, I. and Breithecker, D. (2004) 'Sitting habits in elementary schoolchildren: a traditional versus a “Moving school”', *Patient Education and Counseling*, 54(2), 133-142.

Centers for Disease Control and Prevention [CDC] (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Centers for Disease Control and Prevention [CDC] (2013) *Comprehensive school physical activity programs: A guide for schools*, 500, 5-49, Atlanta, GA: US Department of Health and Human Services.

Christodoulos, A., Douda, H., Polykratis, M. and Tokmakidis, S. (2006) 'Attitudes towards exercise and physical activity behaviours in Greek schoolchildren after a year long health education intervention', *British Journal of Sports Medicine*, 40, 367 - 371.

Cirignano, S. M., Du, L. and Morgan, K. T. (2010) 'Promoting youth physical activity in the classroom through a comprehensive walking program', *Family and Consumer Sciences Research Journal*, 39(2), 161-172.

Coburn, C. E. (2003) 'Rethinking scale: Moving beyond numbers to deep and lasting change', *Educational Researcher*, 32(6), 3-12.

Coffield, F., Moseley, D., Hall, E. and Ecclestone, K. (2004) *Learning styles and pedagogy in post 16 learning: A systematic and critical review*, London: The Learning and Skills Research Center.

Coleman, K. J., Tiller, C. L., Sanchez, J., Heath, E. M., Sy, O., Milliken, G. and Dzewaltowski, D. A. (2005) 'Prevention of the epidemic increase in child risk of overweight in low-income schools: the El Paso coordinated approach to child health', *Archives of Pediatrics & Adolescent Medicine*, 159(3), 217-224.

Colin-Ramirez, E., Castillo-Martinez, L., Orea-Tejeda, A., Vergara-Castaneda, A., Keirns-Davis, C. and Villa-Romero, A. (2010) 'Outcomes of a school-based intervention (RESCATE) to improve physical activity patterns in Mexican children aged 8-10 years', *Health Eduction Research*, 25(6), 1042-9.

Cothran, D. J., Kulinna, P. H. and Garn, A. C. (2010) 'Classroom teachers and physical activity integration', *Teaching and Teacher Education*, 26(7), 1381-1388.

Council on Sports, M. and Fitness (2008) 'Strength Training by Children and Adolescents', *Pediatrics*, 121(4), 835.

Cox, M., Schofield, G. and Kolt, G. S. (2010) 'Responsibility for children's physical activity: Parental, child, and teacher perspectives', *Journal of Science and Medicine in Sport*, 13(1), 46-52.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I. and Petticrew, M. (2008) 'Developing and evaluating complex interventions: the new Medical Research Council guidance', *The BMJ*, 337, a1655.

Crutzen, R., Ruiter, R. A. and de Vries, N. K. (2014) 'Can interest and enjoyment help to increase use of Internet-delivered interventions?', *Psychology & Health*, 29(11), 1227-1244.

Curriculum and Assessment Policy Unit (2016) *Circular 0013/2016: Promotion of healthy lifestyles in primary schools*, Dublin, Ireland: Department of Education and Skills.

Currie, R., Gabhainn, S.N., Godeau, E., Roberts, C., Smith, D., Picket, W., Richter, M., Morgan, A. and Barnekow, V., (2008) 'Inequalities in young people's health: HBSC international report from the 2005/2006 Survey', *Child and Adolescent Health Research Unit CAHRU*, World Health Organisation.

Currie, R., Gabhainn, S. N., Godeau, E. and Committee, I. H. N. C. (2009) 'The Health Behaviour in School-aged Children: WHO Collaborative Cross-National (HBSC) study: origins, concept, history and development 1982–2008', *International Journal of Public Health*, 54(2), 131-139.

Cyr, D., Head, M. and Ivanov, A. (2006) 'Design aesthetics leading to m-loyalty in mobile commerce', *Information & Management*, 43(8), 950-963.

Das, P. and Horton, R. (2012) 'Rethinking our approach to physical activity', *The Lancet*, 380(9838), 189-190.

de Greeff, J. W., Hartman, E., Mullender-Wijnsma, M. J., Bosker, R. J., Doolaard, S. and Visscher, C. (2016) 'Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children', *Health Education Research*, 31(2), 185-194.

de Meij, J. S., Chinapaw, M. J., van Stralen, M. M., van der Wal, M. F., van Dieren, L. and van Mechelen, W. (2011) 'Effectiveness of JUMP-in, a Dutch primary school-based community intervention aimed at the promotion of physical activity', *British Journal of Sports Medicine*, 45(13), 1052-1057.

Department of Children and Youth Affairs (2012) *Growing up in Ireland: Physical activity and obesity among 13 year olds [online]*, Dublin: *Available from*: http://www.growingup.ie/fileadmin/user_upload/Conference_2012/GUI_KF_A4_2_obesity.pdf, [Accessed: 26th August 2015]

Department of Education and Skills (2011) *Literacy and Numeracy for Learning and Life: The National Strategy to Improve Literacy and Numeracy Among Children and Young People, 2011-2020*, Ireland: Department of Education and Skills.

Department of Health (2013) *Healthy Ireland: A framework for improved health and wellbeing 2013 – 2025*, Dublin: Stationery Office.

Department of Health (Ireland) (2009) *Get Ireland Active: The National Guidelines on Physical Activity for Ireland* [online], Dublin: *Available from*: http://www.thehealthwell.info/node/773722, [Accessed: 10th November 2016].

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., van Mechelen, W. and Pratt, M. (2016) 'The economic burden of physical inactivity: a global analysis of major non-communicable diseases', *The Lancet*, 388(10051), 1311-1324.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). 'Enjoyment mediates effects of a school-based physical-activity intervention', *Medicine and Science in Sports and Exercise, 37*(3), 478-487.

Doak, C., Visscher, T., Renders, C. and Seidell, J. (2006) 'The prevention of overweight and obesity in children and adolescents: a review of interventions and programmes', *Obesity Reviews*, 7(1), 111-136.

Dobbins, M., De Corby, K., Robeson, P., Husson, H. and Tirilis, D. (2009) 'School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18', *Cochrane Database of Systematic Reviews*, 2009/01/23(1), CD007651.

Dobbins, M., Husson, H., DeCorby, K. and LaRocca, R. L. (2013) 'School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18', *Cochrane Database of Systematic Reviews*, 2013(2), CD0076512.

Dombrowski, S. U., Sniehotta, F. F., Avenell, A. and Coyne, J. C. (2007) 'Towards a cumulative science of behaviour change: do current conduct and reporting of behavioural interventions fall short of best practice', *Psychological Health*, 22(8), 869-874.

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., Dubose, K., Mayo, M., Schmelzle, K., Ryan, J., Jacobsen, D. and Williams, S. (2009) 'Physical activity across the curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine*, 49, 336 - 341.

Donnelly, J., Greene, J., Gibson, C., Sullivan, D., Hansen, D., Hillman, C., Poggio, J., Mayo, M., Smith, B., Lambourne, K., Herrmann, S., Scudder, M., Betts, J., Honas, J. and Washburn, R. (2013) 'Physical activity and academic achievement across the curriculum (A + PAAC): rationale and design of a 3-year, cluster-randomized trial', *BMC Public Health*, 13(1), 307.

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K. and Szabo-Reed, A. N. (2016) 'Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review', *Medicine & Science in Sports & Exercise*, 48(6), 1197-1222.

Drummy, C., Murtagh, E. M., McKee, D. P., Breslin, G., Davison, G. W. and Murphy, M. H. (2016) 'The effect of a classroom activity break on physical activity levels and adiposity in primary school children', *Journal of Paediatrics and Child Health,* 52(7), 745-749.

DuBose, K., Mayo, M., Gibson, C., Green, J., Hill, J., Jacobsen, D., Smith, B., Sullivan, D., Washburn, R. and Donnelly, J. (2008) 'Physical activity across the curriculum (PAAC): rationale and design', *Contemporary Clinical Trials*, 29(1), 83 - 93.

Duncan, M., Birch, S. and Woodfield, L. (2012) 'Efficacy of an integrated school curriculum pedometer intervention to enhance physical activity and to reduce weight status in children', *European Physical Education Review*, 18(3), 396-407.

Duncan, M. J. and Eyre, E. L. (2008) 'Physical activity and self-esteem', *Sport and Exercise Psychology*, 173-188.

Dunn, L. L., Venturanza, J. A., Walsh, R. J. and Nonas, C. A. (2012) 'An observational evaluation of Move-to-Improve, a classroom-based physical activity program, New York City schools, 2010', *Preventing Chronic Disease*, 9, e146.

Durlak, J. A. and DuPre, E. P. (2008) 'Implementation Matters: A Review of Research on the Influence of Implementation on Program Outcomes and the Factors Affecting Implementation', *American Journal of Community Psychology*, 41(3), 327-350.

Eather, N., Morgan, P. J. and Lubans, D. R. (2013) 'Improving the fitness and physical activity levels of primary school children: results of the Fit-4-Fun group randomized controlled trial', *Preventive Medicine*, 56(1), 12-9.

Ekeland, E., Heian, F., Hagen, K. and Coren, E. (2005) 'Can exercise improve self esteem in children and young people? A systematic review of randomised controlled trials', *British Journal of Sports Medicine*, 39(11), 792.

Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A. and Lee, I. M. (2016) 'Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women', *The Lancet*, 388(10051), 1302-1310.

Ernst, M. P. and Pangrazi, R. P. (1999) 'Effects of a physical activity program on children's activity levels and attraction to physical activity', *Pediatric Exercise Science*, 11, 393-405.

Erwin, H., Abel, M., Beighle, A. and Beets, M. (2011a) 'Promoting children’s health through physically active math classes: a pilot study', *Health Promotion Practice*, 12(2), 244-251.

Erwin, H., Beighle, A., Morgan, C. and Noland, M. (2011b) 'Effect of a Low-Cost, Teacher-Directed Classroom Intervention on Elementary Students' Physical Activity', *Journal of School Health*, 81(8), 455-461.

Erwin, H., Fedewa, A., Beighle, A. and Ahn, S. (2012) 'A Quantitative Review of Physical Activity, Health, and Learning Outcomes Associated With Classroom-Based Physical Activity Interventions', *Journal of Applied School Psychology*, 28(1), 14-36.

European Commission/EACEA/Eurydice. (2013) *Physical Education and Sport at School in Europe Eurydice Report*, Luxembourg: European Commission.

Fahey, T., Delaney, L., Gannon, B., Economic and Social Research, I. (2005) *School children and sport in Ireland*, Dublin: Economic and Social Research Institute.

Faigenbaum, A. D. (2000) 'Strength training for children and adolescents', *Clinics in Sports Medicine*, 19(4), 593-619.

Faigenbaum, A. D., Milliken, L. A., Loud, R. L., Burak, B. T., Doherty, C. L. and Westcott, W. L. (2002) 'Comparison of 1 and 2 days per week of strength training in children', *Research Quarterly for Exercise and Sport*, 73(4), 416-424.

Fairclough, S. and Stratton, G. (2005) '‘Physical education makes you fit and healthy’. Physical education's contribution to young people's physical activity levels', *Health Education Research*, 20(1), 14-23.

Fairclough, S. J., Beighle, A., Erwin, H. and Ridgers, N. D. (2012) 'School day segmented physical activity patterns of high and low active children', *BMC Public Health*, 12(1), 406.

Ferguson, M., Gutin, B., Le, N., Karp, W., Litaker, M., Humphries, M., Okuyama, T., Riggs, S. and Owens, S. (1999) 'Effects of exercise training and its cessation on components of the insulin resistance syndrome in obese children', *International Journal of Obesity*, 23(8), 889-895.

Finn, K. E. and McInnis, K. J. (2014) 'Teachers' and Students' Perceptions of the Active Science Curriculum: Incorporating Physical Activity Into Middle School Science Classrooms', *Physical Educator*, 71(2), 234-253.

Fullan, M. (2007) *The new meaning of educational change*, London: Routledge.

Fullan, M. G. and Miles, M. B. (1992) 'Getting reform right: What works and what doesn't', *Phi Delta Kappan*, 73(10), 745-752.

GAPA (2010) 'NCD Prevention: Investments that Work for Physical Activity', *Health Promotion*, 17(2), 5-15.

Gately, P., Curtis, C. and Hardaker, R. (2013) 'An evaluation in UK schools of a classroom-based physical activity programme - TAKE 10! ®: A qualitative analysis of the teachers' perspective', *Education and Health*, 31(4), 73-78.

Gentile, D. A., Welk, G., Eisenmann, J. C., Reimer, R. A., Walsh, D. A., Russell, D. W., Callahan, R., Walsh, M., Strickland, S. and Fritz, K. (2009) 'Evaluation of a multiple ecological level child obesity prevention program: Switch® what you Do, View, and Chew', *BMC Medicine*, 7(1), 49.

Gibson, C., Smith, B., DuBose, K., Greene, J. L., Bailey, B., Williams, S., Ryan, J., Schmelzle, K., Washburn, R., Sullivan, D., Mayo, M. and Donnelly, J. (2008) 'Physical activity across the curriculum: year one process evaluation results', *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 36.

Goh, T. L., Hannon, J., Webster, C. A., Podlog, L. W., Brusseau, T. A. and Newton, M. (2014) 'Effects of a Classroom-Based Physical Activity Program on Children's Physical Activity Levels', *Journal of Teaching in Physical Education*, 33(4), 558-572.

Gorely, T., Nevill, M. E., Morris, J. G., Stensel, D. J. and Nevill, A. (2009) 'Effect of a school-based intervention to promote healthy lifestyles in 7–11 year old children', *International Journal of Behavioral Nutrition and Physical Activity*, 6(1), 1.

Grieco, L. A., Jowers, E. M. and Bartholomew, J. B. (2009) 'Physically active academic lessons and time on task: The moderating effect of body mass index', *Medicine & Science in Sports & Exercise*, 41(10), 1921-1926.

Grossman, D. C., Neckerman, H. J., Koepsell, T. D., Liu, P.-Y., Asher, K. N., Beland, K., Frey, K. and Rivara, F. P. (1997) 'Effectiveness of a violence prevention curriculum among children in elementary school: A randomized controlled trial', *JAMA*, 277(20), 1605-1611.

Guskey, T. R. (2002) 'Professional development and teacher change', *Teachers and Teaching: Theory and Practice*, 8(3), 381-391.

Haerens, L., De, B., Maes, L., Cardon, G. and Deforche, B. (2007) 'School-based randomized controlled trial of a physical activity intervention among adolescents', *Journal of Adolescent Health*, 40, 258 - 265.

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U. and Group, L. P. A. S. W. (2012) 'Global physical activity levels: surveillance progress, pitfalls, and prospects', *The Lancet*, 380(9838), 247-257.

Hamilton, M., Healy, G., Dunstan, D., Zderic, T. and Owen, N. (2008) 'Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior', *Current Cardiovascular Risk Reports*, 2(4), 292-298.

Han, S. S. and Weiss, B. (2005) 'Sustainability of Teacher Implementation of School-Based Mental Health Programs', *Journal of Abnormal Child Psychology*, 33(6), 665-679.

Hardman, C. A., Horne, P. J. and Rowlands, A. V. (2009) 'Children's Pedometer-determined Physical Activity During School-time and Leisure-time', *Journal of Exercise Science & Fitness*, 7(2), 129-134.

Harrell, J. S., McMurray, R. G., Bangdiwala, S. I., Frauman, A. C., Gansky, S. A. and Bradley, C. B. (1996) 'Effects of a school-based intervention to reduce cardiovascular disease risk factors in elementary-school children: the Cardiovascular Health in Children (CHIC) study', *The Journal of Pediatrics*, 128(6), 797-805.

Harrell, T. K., Davy, B. M., Stewart, J. L. and King, D. S. (2005) 'Effectiveness of a school-based intervention to increase health knowledge of cardiovascular disease risk factors among rural Mississippi middle school children', *Southern Medical Journal*, 98(12), 1173-1181.

Harrington, D. M., Murphy, M., Carlin, A., Coppinger, T., Donnelly, A., Dowd, K. P., Keating, T., Murphy, N., Murtagh, E. and O'Brien, W. (2016) 'Results From Ireland North and South's 2016 Report Card on Physical Activity for Children and Youth', *Journal of Physical Activity and Health*, 13(11 Suppl 2), S183-S188.

Harrison, M., Burns, C., McGuinness, M., Heslin, J. and Murphy, N. (2006) 'Influence of a health education intervention on physical activity and screen time in primary school children: 'Switch Off-Get Active'', *Journal of Science and Medicine in Sport*, 9, 388 - 394.

Health Service Executive and Department of Health and Children (2009) *The national guidelines on physical activity for Ireland*, Dublin: Department of Health & Children.

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z. and Owen, N. (2008a) 'Breaks in sedentary time beneficial associations with metabolic risk', *Diabetes Care*, 31(4), 661-666.

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z. and Owen, N. (2008b) 'Objectively measured sedentary time, physical activity, and metabolic risk the Australian Diabetes, Obesity and Lifestyle Study (AusDiab)', *Diabetes Care*, 31(2), 369-371.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F. and Brownson, R. C. (2012) 'Evidence-based intervention in physical activity: lessons from around the world', *The Lancet*, 380(9838), 272-281.

Hegarty, D., Murtagh, E. M. and Ní Chróinín, D. (2013) 'An evaluation of Irish primary school children's physical activity during the segmented school-day', *Proceedings of the seventh physical education, physical activity and youth sport forum: Youth Sport: understanding, intervening and prolonging engagement in youth sport, physical education and physical activity*, DCU(June 2013), 115-121.

Hegarty, L. M., Mair, J. L., Kirby, K., Murtagh, E. and Murphy, M. H. (2016) 'School-based Interventions to Reduce Sedentary Behaviour in Children: A Systematic Review', *AIMS Public Health*, 3(3), 520-541.

Heidorn, B. D., Hall, T. J. and Carson, R. L. (2010) 'Comprehensive School-Based Physical Activity Program', *Strategies: A Journal for Physical and Sport Educators*, 24(2), 33.

Hill, S. and Hill, T. (1990) *The collaborative classroom: A guide to co-operative learning*, UK: Heinemann Educational Publishers.

Hind, K. and Burrows, M. (2007) 'Weight-bearing exercise and bone mineral accrual in children and adolescents: a review of controlled trials', *Bone*, 40(1), 14-27.

Hodges, M. G., Hodges-Kulinna, P. and Kloeppel, T. A. (2015) 'Fitness for life primary: stakeholders' perceptions', *Physical Education and Sport Pedagogy*, 20(3), 299-313.

Holt, E., Bartee, T. and Heelan, K. (2013) 'Evaluation of a Policy to Integrate Physical Activity Into the School Day', *Journal of Physical Activity & Health*, 10(4), 480-487.

Horne, P. J., Hardman, C. A., Lowe, C. F. and Rowlands, A. V. (2009) 'Increasing children's physical activity: a peer modelling, rewards and pedometer-based intervention', *European Journal of Clinical Nutrition*, 63(2), 191-8.

Howard, J., Bindler, R., Synoground, G. and Van Gemert, F. (1996) 'A cardiovascular risk reduction program for the classroom', *The Journal of school nursing: the official publication of the National Association of School Nurses*, 12(4), 4-11.

Huberty, J. L., Siahpush, M., Beighle, A., Fuhrmeister, E., Silva, P. and Welk, G. (2011) 'Ready for recess: a pilot study to increase physical activity in elementary school children', *Journal of School Health*, 81(5), 251-257.

Inchley, J., Currie, D., Young, T., Samdal, O., Torsheim, T., Augustson, L., Mathison, F., Aleman-Diaz, A., Molcho, M., Weber, M. and Barnekow, V. (2016) *Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-aged Children (HBSC) study: international report from the 2013/2014 survey.* , Copenhagen: WHO Regional Office for Europe.

International Committee of Medical Journal Editors [ICMJE] (2014) 'Defining the role of authors and contributors', *Available from:* http://www. *icmje. org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors. html*. [Accessed 7th January 2017]

Iqbal, M. M. (2000) 'Osteoporosis: epidemiology, diagnosis, and treatment', *Southern Medical Journal*, 93(1), 2-18.

Jackson, M., Crawford, D., Campbell, K. and Salmon, J. (2008) 'Are parental concerns about children's inactivity warranted, and are they associated with a supportive home environment?', *Research Quarterly for Exercise and Sport*, 79(3), 274-282.

Janssen, I. and LeBlanc, A. (2010) 'Systematic review of the health benefits of physical activity and fitness in school-aged children and youth', *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 40.

Jensen, E. (2000) 'Moving with the brain in mind', *Educational Leadership*, 58(3), 34-38.

Jones, D., Hoelscher, D. M., Kelder, S. H., Hergenroeder, A. and Sharma, S. V. (2008) 'Increasing physical activity and decreasing sedentary activity in adolescent girls–The Incorporating More Physical Activity and Calcium in Teens (IMPACT) study', *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 1.

Jurg, M., Kremers, S., Candel, M., Wal, M. and De Meij, J. (2006) 'A controlled trial of a school-based environmental intervention to improve physical activity in Dutch children: JUMP-in, kids in motion', *Health Promotion International*, 21, 320 - 330.

Keeley, T. J. and Fox, K. R. (2009) 'The impact of physical activity and fitness on academic achievement and cognitive performance in children', *International Review of Sport and Exercise Psychology*, 2(2), 198-214.

Kelder, S., Hoelscher, D. M., Barroso, C. S., Walker, J. L., Cribb, P. and Hu, S. (2005) 'The CATCH Kids Club: a pilot after-school study for improving elementary students' nutrition and physical activity', *Public Health & Nutrition*, 8(02), 133-140.

Kibbe, D. L., Hackett, J., Hurley, M., McFarland, A., Schubert, K. G., Schultz, A. and Harris, S. (2011) 'Ten Years of TAKE 10!((R)): Integrating physical activity with academic concepts in elementary school classrooms', *Preventive Medicine*, 52 Suppl 1, S43-50.

Kilbourne, J. R. (2013) 'Moving physical education beyond the gymnasium: Creating activity permissible classrooms', *pelinks4u*, *Available from*: http://works.bepress.com/john_kilbourne/6/, [Accessed: 12th July 2016]

Kimm, S. Y., Glynn, N. W., Obarzanek, E., Kriska, A. M., Daniels, S. R., Barton, B. A. and Liu, K. (2005) 'Relation between the changes in physical activity and body-mass index during adolescence: a multicenter longitudinal study', *The Lancet*, 366(9482), 301-307.

Knowles, Z. R., Parnell, D., Ridgers, N. and Stratton, G. (2013) 'Learning from the experts: exploring playground experience and activities using a write and draw technique', *Journal of Physical Activity and Health*, 10(3), 406.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G. and Kahlmeier, S. (2012) 'The pandemic of physical inactivity: global action for public health', *The Lancet*, 380(9838), 294-305.

Kohl, H. W. and Cook, H. D., Eds.; Committee on Physical Activity and Physical Education in the School Environment; Food and Nutrition Board; Institute of Medicine. (2013) *Educating the student body: Taking physical activity and physical education to school*, Washington D.C.: National Academies Press.

Kriemler, S., Zahner, L., Schindler, C., Meyer, U., Hartmann, T., Hebestreit, H., Brunner-La Rocca, H. P., Van Mechelen, W. and Puder, J. J. (2010) 'Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial', *The BMJ*, 340, c785.

Lanningham-Foster, L., Foster, R. C., McCrady, S. K., Manohar, C. U., Jensen, T. B., Mitre, N. G., Hill, J. O. and Levine, J. A. (2008) 'Changing the school environment to increase physical activity in children', *Obesity (Silver Spring)*, 16(8), 1849-53.

Larun, L., Nordheim, L., Ekeland, E., Hagen, K. and Heian, F. (2006) 'Exercise in prevention and treatment of anxiety and depression among children and young people', *Cochrane Database of Systematic Reviews (Online),* 3(3), CD004691.

Layte, R. and McCrory, C. (2011) *Growing Up in Ireland National Longitudinal Study of Children. Overweight and obesity among 9-year-olds*, Dublin: Department of Children and Youth Affairs.

Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N. and Katzmarzyk, P. T. (2012) 'Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy', *The Lancet*, 380(9838), 219-229.

Lengel, T. and Kuczala, M. (2010) *The kinesthetic classroom: Teaching and learning through movement*, London: Corwin Press.

Li, Y. P., Hu, X. Q., Schouten, E. G., Liu, A. L., Du, S. M., Li, L. Z., Cui, Z. H., Wang, D., Kok, F. J., Hu, F. B. and Ma, G. S. (2010) 'Report on childhood obesity in China (8): effects and sustainability of physical activity intervention on body composition of Chinese youth', *Biomedical and Environmental Sciences*, 23(3), 180-7.

Lissau, I., Overpeck, M. D., Ruan, W. J., Due, P., Holstein, B. E. and Hediger, M. L. (2004) 'Body mass index and overweight in adolescents in 13 European countries, Israel, and the United States', *Archives of Pediatrics & Adolescent Medicine*, 158(1), 27-33.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W. and Chen, C. (2007) 'Report on childhood obesity in China (6) evaluation of a classroom-based physical activity promotion program', *Biomedical and Environmental Sciences*, 20(1), 19.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., Zhao, W. and Chen, C. (2008) 'Evaluation of a classroom-based physical activity promoting programme', *Obesity Reviews*, 9, 130-134.

Livingstone, M. (2001) 'Childhood obesity in Europe: a growing concern', *Public Health & Nutrition*, 4(1a), 109-116.

Lubans, D. and Morgan, P. (2008) 'Evaluation of an extra-curricular school sport programme promoting lifestyle and lifetime activity for adolescents', *Journal of Sports Sciences*, 26(5), 519-529.

Luepker, R. V., Perry, C. L., McKinlay, S. M., Nader, P. R., Parcel, G. S., Stone, E. J., Webber, L. S., Elder, J. P., Feldman, H. A., Johnson, C. C. and et al. (1996) 'Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group', *JAMA*, 275(10), 768-76.

MacCallum, L., Howson, N. and Gopu, N. (2012) *Designed to Move: A Physical Activity Action Agenda*, US: Nike Inc.

MacDonald, H. M., Kontulainen, S. A., Khan, K. M. and McKay, H. A. (2007) 'Is a School-Based Physical Activity Intervention Effective for Increasing Tibial Bone Strength in Boys and Girls?', *Journal of Bone and Mineral Research*, 22(3), 434-446.

MacKelvie, K., McKay, H., Petit, M., Moran, O. and Khan, K. (2002) 'Bone mineral response to a 7-month randomized controlled, school-based jumping intervention in 121 prepubertal boys: associations with ethnicity and body mass index', *Journal of Bone and Mineral Research*, 17(5), 834-844.

MacKelvie, K. J., McKay, H. A., Khan, K. M. and Crocker, P. R. (2001) 'A school-based exercise intervention augments bone mineral accrual in early pubertal girls', *The Journal of Pediatrics*, 139(4), 501-508.

MacKelvie, K. J., Petit, M. A., Khan, K. M., Beck, T. J. and McKay, H. A. (2004) 'Bone mass and structure are enhanced following a 2-year randomized controlled trial of exercise in prepubertal boys', *Bone*, 34(4), 755-764.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). 'Effects of a classroom-based program on physical activity and on-task behavior', *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Manios, Y., Kafatos, I., Kafatos, A. and Team, N. C. R. (2006) 'Ten-year follow-up of the Cretan Health and Nutrition Education Program on children's physical activity levels', *Preventive Medicine*, 43(6), 442-446.

Martin, R. and Murtagh, E. M. (2015) 'An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191.

McKay, H., MacLean, L., Petit, M., MacKelvie-O'Brien, K., Janssen, P., Beck, T. and Khan, K. (2005) '"Bounce at the Bell": a novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children', *British Journal of Sports Medicine*, 39(8), 521-526.

McKenzie, T., Alcaraz, J., Sallis, J. and Faucette, F. (1998) 'Effect of a physical education program on children's manipulative skills', *Journal of Teaching in Physical Education*, 17, 327 - 341.

McKenzie, T. L., Nader, P. R., Strikmiller, P. K., Yang, M., Stone, E. J., Perry, C. L., Taylor, W. C., Epping, J. N., Feldman, H. A. and Luepker, R. V. (1996) 'School physical education: effect of the Child and Adolescent Trial for Cardiovascular Health', *Preventive Medicine*, 25(4), 423-431.

McLaughlin, M. W. and Mitra, D. (2001) 'Theory-based change and change-based theory: Going deeper, going broader', *Journal of Educational Change*, 2(4), 301-323.

McManus, A. M., Masters, R. S., Laukkanen, R. M., Clare, C., Sit, C. H. and Ling, F. C. (2008) 'Using heart-rate feedback to increase physical activity in children', *Preventive Medicine*, 47(4), 402-408.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). 'Physical activity opportunities during the school day: Classroom teachers' perceptions of using activity breaks in the classroom', *Journal of Teaching in Physical Education, 33*(4), 511-527.

McMullen, J. M., Martin, R., Jones, J. and Murtagh, E. M. (2016) 'Moving to learn Ireland–Classroom teachers' experiences of movement integration', *Teaching and Teacher Education*, 60, 321-330.

McNeil, D. A., Wilson, B. N., Siever, J. E., BEd, M. R. and Mah, J. K. (2009) 'Connecting children to recreational activities: results of a cluster randomized trial', *American Journal of Health Promotion*, 23(6), 376-387.

Meyers, D. C., Durlak, J. A. and Wandersman, A. (2012) 'The Quality Implementation Framework: A Synthesis of Critical Steps in the Implementation Process', *American Journal of Community Psychology*, 50(3), 462-480.

Michie, S. and Abraham, C. (2004) 'Interventions to change health behaviours: evidence-based or evidence-inspired?', *Psychology & Health*, 19(1), 29-49.

Michie, S., Abraham, C., Eccles, M. P., Francis, J. J., Hardeman, W. and Johnston, M. (2011a) 'Strengthening evaluation and implementation by specifying components of behaviour change interventions: a study protocol', *Implementation Science*, 6(10), 10.

Michie, S., Atkins, L. and West, R. (2014) *The behaviour change wheel: a guide to designing interventions*, UK: Silverback.

Michie, S., Fixsen, D., Grimshaw, J. M. and Eccles, M. P. (2009) 'Specifying and reporting complex behaviour change interventions: the need for a scientific method', *Implementation Science*, 4(1), 1.

Michie, S., van Stralen, M. M. and West, R. (2011b) 'The behaviour change wheel: a new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), 42-52.

Mitchell, B., McLennan, S., Latimer, K., Graham, D., Gilmore, J. and Rush, E. (2013) 'Improvement of fundamental movement skills through support and mentorship of class room teachers', *Obesity Research in Clinical Practice*, 7(3), e230-4.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M. and Altman, D. G. (2010) 'CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials', *Journal of Clinical Epidemiology*, 63(8), e1-e37.

Morgan, P. J. and Hansen, V. (2008) 'Classroom teachers' perceptions of the impact of barriers to teaching physical education on the quality of physical education programs', *Research Quarterly for Exercise and Sport*, 79, 506 - 516.

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S. and Visscher, C. (2015) 'Improving Academic Performance of School-Age Children by Physical Activity in the Classroom: 1-Year Program Evaluation', *Journal of School Health*, 85(6), 365-371.

Murtagh, E., Mulvihill, M. and Markey, O. (2013) 'Bizzy Break! The Effect of a Classroom- Based Activity Break on In-School Physical Activity Levels of Primary School Children', *Pediatric Exercise Science*, 25(2), 300-307.

National Physical Activity Guidelines Steering Group (2014) *Get Ireland Active: The National Guidelines on Physical Activity for Ireland*, Dublin: Department of Health and Children and the Health Service Executive.

Naylor, P.-J., Macdonald, H. M., Warburton, D. E., Reed, K. E. and McKay, H. A. (2008) 'An active school model to promote physical activity in elementary schools: action schools! BC', *British Journal of Sports Medicine*, 42(5), 338-343.

Naylor, P. J., Macdonald, H. M., Zebedee, J. A., Reed, K. E. and McKay, H. A. (2006) 'Lessons learned from Action Schools! BC--an 'active school' model to promote physical activity in elementary schools', *Journal of Science and Medicine in Sport*, 9(5), 413-23.

Naylor, P. J. and McKay, H. A. (2009) 'Prevention in the first place: schools a setting for action on physical inactivity', *British Journal of Sports Medicine*, 43(1), 10-13.

Nettlefold, L., McKay, H., Warburton, D., McGuire, K., Bredin, S. and Naylor, P. (2011) 'The challenge of low physical activity during the school day: at recess, lunch and in physical education', *British Journal of Sports Medicine*, 45(10), 813-819.

Neumark-Sztainer, D., Haines, J., Robinson-O'Brien, R., Hannan, P. J., Robins, M., Morris, B. and Petrich, C. A. (2009) '‘Ready. Set. ACTION!’A theater-based obesity prevention program for children: a feasibility study', *Health Education Research*, 24(3), 407-420.

Neumark-Sztainer, D. R., Friend, S. E., Flattum, C. F., Hannan, P. J., Story, M. T., Bauer, K. W., Feldman, S. B. and Petrich, C. A. (2010) 'New moves—preventing weight-related problems in adolescent girls: a group-randomized study', *American Journal of Preventive Medicine*, 39(5), 421-432.

Nixon, G. M., Thompson, J. M., Han, D. Y., Becroft, D. M., Clark, P. M., Robinson, E., Waldie, K. E., Wild, C. J., Black, P. N. and Mitchell, E. A. (2008) 'Short sleep duration in middle childhood: risk factors and consequences', *Sleep*, 31(1), 71.

Nixon, G. M., Thompson, J. M., Han, D. Y., Becroft, D. M., Clark, P. M., Robinson, E., Waldie, K. E., Wild, C. J., Black, P. N. and Mitchell, E. A. (2009) 'Falling asleep: the determinants of sleep latency', *Archives of Disease in Childhood*, 94(9), 686-689.

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O. and Stamatakis, E. (2015) 'Physically active lessons as physical activity and educational interventions: A systematic review of methods and results', *Preventive Medicine,* 72, 116-125.

Olds, T., Dollman, J., Kupke, T., Cobiac, L., Bowen, J., Burnett, J., Syrette, J., Dempsey, J., Bailie, S. and Wilson, C. (2007) *Australian National Children's Nutrition and Physical Activity Survey*, Australian Government: Department of Health and Ageing.

Oliver, M., Schofield, G. and McEvoy, E. (2006) 'An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study', *The Journal of School Health*, 76(2), 74-79.

Opitz, M. F. (2011) 'Transcending the curricular barrier between fitness and reading with FitLit', *The Reading Teacher*, 64(7), 535-540.

Ortega, F. B., Ruiz, J. R., Castillo, M. J. and Sjostrom, M. (2007) 'Physical fitness in childhood and adolescence: a powerful marker of health', *International Journal of Obesity*, 32(1), 1-11.

Owens, S., Gutin, B., Allison, J., Riggs, S., Ferguson, M., Litaker, M. and Thompson, W. (1999) 'Effect of physical training on total and visceral fat in obese children', *Medicine & Science in Sports & Exercise*, 31, 143-148.

Palmer, S., Graham, G. and Elliott, E. (2005) 'Effects of a web-based health program on fifth grade children's physical activity knowledge, attitudes and behavior', *Journal of Health Education*, 36(2), 86-93.

Pangrazi, R. P., Beighle, A., Vehige, T. and Vack, C. (2003) 'Impact of Promoting Lifestyle Activity for Youth (PLAY) on children's physical activity', *Journal of School Health*, 73(8), 317-321.

Paradis, G., Lévesque, L., Macaulay, A. C., Cargo, M., McComber, A., Kirby, R., Receveur, O., Kishchuk, N. and Potvin, L. (2005) 'Impact of a diabetes prevention program on body size, physical activity, and diet among Kanien'keha: ka (Mohawk) children 6 to 11 years old: 8-year results from the Kahnawake Schools Diabetes Prevention Project', *Pediatrics*, 115(2), 333-339.

Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L. and Young, J. C. (2006) 'Promoting physical activity in children and youth: a leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing', *Circulation*, 114(11), 1214-24.

Pate, R. R., Saunders, R. P., Ward, D. S., Felton, G., Trost, S. G. and Dowda, M. (2003) 'Evaluation of a community-based intervention to promote physical activity in youth: lessons from Active Winners', *American Journal of Health Promotion*, 17(3), 171-182.

Payne, V. G., Morrow Jr, J. R., Johnson, L. and Dalton, S. N. (1997) 'Resistance training in children and youth: a meta-analysis', *Research Quarterly for Exercise and Sport*, 68(1), 80-88.

Peralta, L. R., Jones, R. A. and Okely, A. D. (2009) 'Promoting healthy lifestyles among adolescent boys: the Fitness Improvement and Lifestyle Awareness Program RCT', *Preventive Medicine*, 48(6), 537-542.

Peregrin, T. (2001) 'Take 10!: Classroom-based program fights obesity by getting kids out of their seats', *Journal of the Academy of Nutrition and Dietetics*, 101(12), 1409.

Petchers, M. K., Hirsch, E. Z. and Bloch, B. A. (1988) 'A longitudinal study of the impact of a school heart health curriculum', *Journal of Community Health*, 13(2), 85-94.

Peters, D. H., Tran, N. T. and Adam, T. (2014) *Implementation research in health: a practical guide*, Geneva, Switzerland: World Health Organization.

Physical Activity Guidelines Advisory Committee (2008) *Physical activity guidelines advisory committee report 2008*, Washington, DC: US Department of Health and Human Services, A1-H14.

Proctor, E., Silmere, H., Raghavan, R., Hovmand, P., Aarons, G., Bunger, A., Griffey, R. and Hensley, M. (2011) 'Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda', *Administration and Policy in Mental Health and Mental Health Services Research*, 38(2), 65-76.

Reed, J. A., Einstein, G., Hahn, E., Hooker, S. P., Gross, V. P. and Kravitz, J. (2010) 'Examining the impact of integrating physical activity on fluid intelligence and academic performance in an elementary school setting: a preliminary investigation', *Journal of Physical Activity & Health*, 7(3), 343-351.

Reeve, J. (1989) 'The interest-enjoyment distinction in intrinsic motivation', *Motivation and Emotion*, 13(2), 83-103.

Reis, R. S., Salvo, D., Ogilvie, D., Lambert, E. V., Goenka, S. and Brownson, R. C. (2016) 'Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving', *The Lancet*, 388(10051), 1337-1348.

Resaland, G. K., Aadland, E., Moe, V. F., Aadland, K. N., Skrede, T., Stavnsbo, M., Suominen, L., Steene-Johannessen, J., Glosvik, Ø. and Andersen, J. R. (2016) 'Effects of physical activity on schoolchildren's academic performance: The Active Smarter Kids (ASK) cluster-randomized controlled trial', *Preventive Medicine*, 91, 322-328.

Reznik, M., Wylie-Rosett, J., Kim, M. and Ozuah, P. O. (2015) 'A classroom-based physical activity intervention for urban kindergarten and first-grade students: a feasibility study', *Childhood Obesity,* 11(3), 314-324.

Riddoch, C., Bo, A., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L., Cooper, A. and Ekelund, U. (2004) 'Physical activity levels and patterns of 9- and 15-yr-old European children', *Medicine & Science in Sports & Exercise*, 36, 86 - 92.

Ridgers, N. D., Stratton, G., Fairclough, S. J. and Twisk, J. W. (2007) 'Long-term effects of a playground markings and physical structures on children's recess physical activity levels', *Preventive Medicine*, 44(5), 393-397.

Riley, N., Lubans, D. R., Holmes, K. and Morgan, P. J. (2016) 'Findings From the EASY Minds Cluster Randomized Controlled Trial: Evaluation of a Physical Activity Integration Program for Mathematics in Primary Schools', *Journal of Physical Activity & Health*, 13(2), 198-206.

Riley, N., Lubans, D. R., Morgan, P. J. and Young, M. (2015) 'Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial', *Journal of Science and Medicine in Sport*, 18(6), 656-661.

Robinson, T. N. (1999) 'Reducing children's television viewing to prevent obesity: a randomized controlled trial', *JAMA*, 282(16), 1561-7.

Sahota, P., Rudolf, M. C., Dixey, R., Hill, A. J., Barth, J. H. and Cade, J. (2001) 'Randomised controlled trial of primary school based intervention to reduce risk factors for obesity', *The BMJ*, 323(7320), 1029.

Saint-Maurice, P. F., Kim, Y., Welk, G. J. and Gaesser, G. A. (2016) 'Kids are not little adults: what MET threshold captures sedentary behavior in children?', *Eur J Appl Physiol*, 116, 29-38.

Sallis, J. F., McKenzie, T. L., Alcaraz, J. E., Kolody, B., Faucette, N. and Hovell, M. F. (1997) 'The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. Sports, Play and Active Recreation for Kids', *American Journal of Public Health*, 87(8), 1328-1334.

Salmon, J. (2010) 'Novel Strategies to Promote Children's Physical Activities and Reduce Sedentary Behavior', *Journal of Physical Activity & Health*, 7, S299-S306.

Salmon, J., Arundell, L., Hume, C., Brown, H., Hesketh, K., Dunstan, D. W., Daly, R. M., Pearson, N., Cerin, E. and Moodie, M. (2011) 'A cluster-randomized controlled trial to reduce sedentary behavior and promote physical activity and health of 8-9 year olds: The Transform-Us! Study', *BMC Public Health*, 11(1), 1.

Salmon, J., Ball, K., Hume, C., Booth, M. and Crawford, D. (2008) 'Outcomes of a group-randomized trial to prevent excess weight gain, reduce screen behaviours and promote physical activity in 10-year-old children: switch-play', *International Journal of Obesity*, 32(4), 601-612.

Salmon, J., Booth, M., Phongsavan, P., Murphy, N. and Timperio, A. (2007) 'Promoting physical activity participation among children and adolescents', *Epidemiology Reviews*, 29, 144 - 159.

Scholtes, V. A., Becher, J. G., Comuth, A., Dekkers, H., van Dijk, L. and Dallmeijer, A. J. (2010) 'Effectiveness of functional progressive resistance exercise strength training on muscle strength and mobility in children with cerebral palsy: a randomized controlled trial', *Developmental Medicine & Child Neurology*, 52(6), e107-e113.

Schulz, K. F., Altman, D. G. and Moher, D. (2010) 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials*, 11, 32.

Sherar, L. B., Esliger, D. W., Baxter-Jones, A. D. and Tremblay, M. S. (2007) 'Age and gender differences in youth physical activity: does physical maturity matter?', *Medicine & Science in Sports & Exerciseise*, 39(5), 830-5.

Silvia, P. J. (2008) 'Interest—The curious emotion', *Current Directions in Psychological Science*, 17(1), 57-60.

Simon, C., Wagner, A., DiVita, C., Rauscher, E., Klein-Platat, C., Arveiler, D., Schweitzer, B. and Triby, E. (2004) 'Intervention centred on adolescents' physical activity and sedentary behaviour (ICAPS): concept and 6-month results', *International Journal of Obesity*, 28, S96 - S103.

Smyth, E., Murray, A., Swords, L., O'Dowd, T., Doyle, E., O'Moore, A. M. E., Mc Coy, S., Nixon, E., Thornton, M. and Greene, S. and the Dept. of Health, Ireland (2009) *Growing up in Ireland: National longitudinal study of children. The lives of 9 year olds*, Dublin: Government Publications.

Ståhl, T., Wismar, M., Ollila, E., Lahtinen, E. and Leppo, K. (2006) *'Health in all policies', prospects and potentials.* Helsinki: Finnish Ministry of Social Affairs and Health.

Stewart, J. A., Dennison, D. A., Kohl, H. W. and Doyle, J. A. (2004) 'Exercise Level and Energy Expenditure in the TAKE 10!® In-Class Physical Activity Program', *Journal of School Health*, 74(10), 397-400.

Stone, E. J., Norman, J. E., Davis, S. M., Stewart, D., Clay, T. E., Caballero, B., Lohman, T. G. and Murray, D. M. (2003) 'Design, implementation, and quality control in the Pathways American-Indian multicenter trial', *Preventive Medicine*, 37, S13-S23.

Stratton, G. (2000) 'Promoting children's physical activity in primary school: an intervention study using playground markings', *Ergonomics*, 43(10), 1538-1546.

Stratton, G. and Mullan, E. (2005) 'The effect of multicolor playground markings on children's physical activity level during recess', *Preventive Medicine*, 41(5), 828-833.

Strauss, V., Guisbond, L., Neil, M. and Schaeffer, B. (2012) 'A decade of No Child Left Behind: Lessons from a policy failure', *The Washington Post*, 7th January 2012.

Strong, W., Malina, R., Blimkie, C., Daniels, S., Dishman, R., Gutin, B., Hergenroeder, A., Must, A., Nixon, P., Pivarnik, J., Rowland, T., Trost, S. and Trudeau, F. (2005) 'Evidence based physical activity for school-age youth', *Journal of Pediatrics*, 146, 732 - 737.

Stylianou, M., Kulinna, P. H. and Naiman, T. (2016) ''because there's nobody who can just sit that long': Teacher perceptions of classroom-based physical activity and related management issues', *European Physical Education Review*, 22(3), 390-408.

Stylianou, M., Kulinna, P. H., Van Der Mars, H., Mahar, M. T., Adams, M. A. and Amazeen, E. (2016) 'Before-school running/walking club: Effects on student on-task behavior', *Preventive Medicine Reports*, 3, 196-202.

Telford, A., Salmon, J., Timperio, A. and Crawford, D. (2005) 'Examining physical activity among 5-to 6- and 10-to 12-year-old children: The Children's Leisure Activities Study', *Pediatric Exercise Science*, 17(3), 266.

Tomporowski, P., Davis, C., Miller, P. and Naglieri, J. (2008) 'Exercise and children's intelligence, cognition, and academic achievement', *Educational Psychology Review*, 20(2), 111 - 131.

Touchette, É., Petit, D., Séguin, J. R., Boivin, M., Tremblay, R. E. and Montplaisir, J. Y. (2007) 'Associations between sleep duration patterns and behavioral/cognitive functioning at school entry', *Sleep*, 30(9), 1213-1219.

Tremblay, M. S., Barnes, J. D., González, S. A., Katzmarzyk, P. T., Onywera, V. O., Reilly, J. J. and Tomkinson, G. R. (2016) 'Global Matrix 2.0: report card grades on the physical activity of children and youth comparing 38 countries', *Journal of Physical Activity and Health*, 13(11 Suppl 2), S343-S366.

Tremblay, M. S., LeBlanc, A. G., Janssen, I., Kho, M. E., Hicks, A., Murumets, K., Colley, R. C. and Duggan, M. (2011a) 'Canadian Sedentary Behaviour Guidelines for Children and Youth', *Applied Physiology, Nutrition, and Metabolism*, 36(1), 59-64.

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G. and Gorber, S. C. (2011b) 'Systematic review of sedentary behaviour and health indicators in school-aged children and youth', *International Journal of Behavioral Nutrition & Physical Activity*, 8(1), 98.

Trost, S. G., Loprinzi, P. D., Moore, R. and Pfeiffer, K. A. (2011) 'Comparison of accelerometer cut points for predicting activity intensity in youth', *Medicine & Science in Sports & Exercise*, 43(7), 1360-1368.

Trudeau, F. and Shephard, R. (2008) 'Physical education, school physical activity, school sports and academic performance', *International Journal of Behavioral Nutrition & Physical Activity*, 5, 5 - 10.

Tulis, M. and Ainley, M. (2011) 'Interest, enjoyment and pride after failure experiences? Predictors of students' state-emotions after success and failure during learning in mathematics', *Educational Psychology*, 31(7), 779-807.

Twisk, J. W. R., Kemper, H. C. and van MECHELEN, W. (2000) 'Tracking of activity and fitness and the relationship with cardiovascular disease risk factors', *Medicine & Science in Sports & Exercise*, 32(8), 1455-1461.

US Department of Health and Human Services (2012) *Physical activity guidelines for Americans midcourse report: Strategies to increase physical activity among youth*, Washington, DC: US Department of Health and Human Services.

van Beurden, E., Barnett, L. M., Zask, A., Dietrich, U. C., Brooks, L. O. and Beard, J. (2003) 'Can we skill and activate children through primary school physical education lessons?"Move it Groove it"—a collaborative health promotion intervention', *Preventive Medicine*, 36(4), 493-501.

van Sluijs, E., McMinn, A. and Griffin, S. (2007) 'Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials', *The BMJ*, 335, 703.

van Sluijs, E. M., Skidmore, P. M., Mwanza, K., Jones, A. P., Callaghan, A. M., Ekelund, U., Harrison, F., Harvey, I., Panter, J. and Wareham, N. J. (2008) 'Physical activity and dietary behaviour in a population-based sample of British 10-year old children: the SPEEDY study (Sport, Physical activity and Eating behaviour: environmental Determinants in Young people)', *BMC Public Health*, 8(1), 388.

Verstraete, S., Cardon, G., De Clercq, D. and De Bourdeaudhuij, I. (2006) 'Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment', *European Journal of Public Health*, 16, 415 - 419.

Wade, T. D., Davidson, S. and O'Dea, J. A. (2002) 'Enjoyment and Perceived Value of Two School-based Interventions Designed to Reduce Risk Factors for Eating Disorders in Adolescents', *Australian e-Journal for the Advancement of Mental Health, The*, 1(2), 113-120.

Ward, D. (2011) *School policies on physical education and physical activity. A Research Synthesis*, Princeton, NJ: Active Living Research, a National Program of the Robert Wood Johnson Foundation. *Available from*: www.activelivingresearch.org, [Accessed: 6th June 2016].

Ward, D. S., Saunders, R. P. and Pate, R. (2007) 'Physical activity interventions in children and adolescents', *Pediatric Exercise Science*, 19, 493-494.

Waring, M., Warburton, P. and Coy, M. (2007) 'Observation of children's physical activity levels in primary school: Is the school an ideal setting for meeting government activity targets?', *European Physical Education Review*, 13(1), 25-40.

Warren, J., Henry, C., Lightowler, H., Bradshaw, S. and Perwaiz, S. (2003) 'Evaluation of a pilot school programme aimed at the prevention of obesity in children', *Health Promotion International*, 18(4), 287-296.

Webber, L. S., Catellier, D. J., Lytle, L. A., Murray, D. M., Pratt, C. A., Young, D. R., Elder, J. P., Lohman, T. G., Stevens, J. and Jobe, J. B. (2008) 'Promoting physical activity in middle school girls: Trial of Activity for Adolescent Girls', *American Journal of Preventive Medicine*, 34(3), 173-184.

Webster, C., Russ, L., Vazou, S., Goh, T. and Erwin, H. (2015) 'Integrating movement in academic classrooms: understanding, applying and advancing the knowledge base', *Obesity Reviews,* 16(8), 691-701.

Wechsler, H., Devereaux, R., Davis, M. and Collins, J. (2000) 'Using the school environment to promote physical activity and healthy eating', *Preventive Medicine*, 31 Suppl 2, s121 - s137.

Weeks, B. K., Young, C. M. and Beck, B. R. (2008) 'Eight months of regular in-school jumping improves indices of bone strength in adolescent boys and girls: the POWER PE study', *Journal of Bone and Mineral Research*, 23(7), 1002-1011.

Whitt-Glover, M. C., Ham, S. A. and Yancey, A. K. (2011) 'Instant Recess®: A practical tool for increasing physical activity during the school day', *Progress in Community Health Partnerships: Research, Education, and Action*, 5(3), 289-297.

Williamson, D. A., Copeland, A. L., Anton, S. D., Champagne, C., Han, H., Lewis, L., Martin, C., Newton, R. L., Sothern, M. and Stewart, T. (2007) 'Wise Mind Project: A School-based Environmental Approach for Preventing Weight Gain in Children', *Obesity*, 15(4), 906-917.

Woods, C. B., Tannehill, D. Quinlan, A., Moyna, N. and Walsh, J. (2010) *The children's sport participation and physical activity study (CSPPA). Research Report No. 1*, Dublin, Ireland: School of Health and Human Performance, Dublin City University and the Irish Sports Council.

Woods, C. B., Tannehill, D. and Walsh, J. (2012) 'An examination of the relationship between enjoyment, physical education, physical activity and health in Irish adolescents', *Irish Educational Studies*, 31(3), 263-280.

World Health Organisation [WHO] (2008) *School policy framework: Implementation of the WHO global strategy on diet, physical activity and health*, Geneva, Switzerland: World Health Organisation.

World Health Organization [WHO] (2003) *Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation*, Geneva, Switzerland: World Health Organisation.

World Health Organization [WHO] (2007) *Steps to health: A European framework to promote physical activity for health*, Geneva, Switzerland: World Health Organisation.

World Health Organisation [WHO] (2010) *Global recommendations on physical activity for health*, Geneva, Switzerland: World Health Organisation.

World Health Organization [WHO] (2016) EUR/RC65/9 Physical activity strategy for the WHO European Region 2016–2025, *Available from*: http://www.thehealthwell.info/node/927643, [Accessed: 9th July 2016].

Young, D. R., Johnson, C. C., Steckler, A., Gittelsohn, J., Saunders, R. P., Saksvig, B. I., Ribisl, K. M., Lytle, L. A. and McKenzie, T. L. (2006) 'Data to action: using formative research to develop intervention programs to increase physical activity in adolescent girls', *Health Education & Behavior*, 33(1), 97-111.

APPENDICES

Appendix A: Existing primary school-based PA interventions with PA as an outcome measure

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
1.	Ahamed *et al.* (2007) Macdonald *et al.* (2007) Naylor *et al.* (2008)	Action School British Columbia: jumping when bell rings and 15 mins PA	Classroom PA breaks	Cluster RCT; pre-test, post-test	16 months	10 Canadian Primary Schools (515 students)	Teacher report Self- report Pedometer
2.	Araújo-Soares *et al.* (2009)	2 classroom-based PA sessions	Active lessons in the classroom	Cluster RCT	12 weeks	1 Portugeuse school (n= 195)	International PA Questionnaire (diary)
3.	Barbeau *et al.* (2007)	Skill development, MVPA, toning & stretching	After school	RCT	10 months	1 US school (n= 201)	Self- report PA recall
4.	Bartholomew and Jowers (2011)	Texas I-CAN! (Initiatives for Children's Activity and Nutrition) Provided training for teachers to change their lesson plans to incorporate PA during academic time and provided them with sample lessons	PA integrated into the curriculum	Controlled trial	6 months	8 schools in Texas (4 intervention, 4 control) (47 teachers) (n=200, 3rd grade students)	Pedometer counts Subsample wore Actigraph Accelerometers Teacher questionnaire regarding implementation
5.	Bayne-Smith *et al.* (2004)	PATH programme of wellness with PA in PE	Classroom wellness lessons & PE classes	RCT	12 weeks	1 US school	Self-report

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
6.	Bershwinger and Brusseau (2013)	Teacher/student created activity breaks and their impact on step counts and MVPA during the school day was measured	Classroom PA breaks	Pre-test, post-test measures	2 weeks (1 baseline, 1 intervention)	USA 1 4th grade class (n= 18)	NL-1000 piezoelectric pedometer (Accelerometer)
7.	Boyle-Holmes *et al.* (2010)	Exemplary PE Curriculum (EPEC) to improve motor skills and physical fitness	PE lessons	Quasi experiment		US Schools (1,464 4th and 5th grade students)	Student survey, activity checklist, fitness assessments
8.	Caballero *et al.* (2003)	Pathways: Diet, PA: 3x 30 min PA sessions per week, 2x health lessons per week for 12 & 8 weeks, family component	Classroom lectures, PA breaks, family	RCT	3 years	41 US primary schools (n= 1704, grades 3-5)	Motion sensors for PA
9.	Cardon *et al.* (2004)	Moving School: 1x 30 min Maths/ language lesson daily- reduce sitting by dynamic sitting, standing & walking during lessons	Classroom environment	Controlled trial	18 months	USA (n= 47, 2nd grade: 8 year olds)	Accelerometer, Portable Ergonomic observation
10.	Christodoulos *et al.* (2006)	2x 45 min PE classes per week, goal setting, weekly classroom lectures on PA and health (attitudes towards PA)	PE lessons, classroom lectures, home	RCT	1 school year	2 Greek schools (n=78)	Planned behaviour theory questionnaire

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
11.	Cirignano *et al.* (2010)	School- and classroom-based walking program. *Fit Bits*- provided to teachers	School-, community- and classroom-based (PA breaks)	Not randomised, no control	6 weeks (1 baseline, 5 intervention)	1 US school (9 classes- 3 x 4th grade, 3 x 5th grade, 3 x 6th grade) (n=169 students)	Pedometer step counts Teacher and student interviews
12.	Coleman *et al.* (2005)	El Paso CATCH: Coordinated Approach To Child Health, Eat Smart: funding given to schools for PE equipment, teachers trained for CATCH	PE lessons, classroom health lectures, home components	Controlled trial	3 years	USA 8 primary schools (n=896 8-9 year olds)	SOFIT measured MVPA in PE classes
13.	Colin-Ramirez *et al.* (2010)	RESCATE programme: PA and nutritional components- Take 10!	Classroom lessons and exercise breaks, PE classes, Home	Cluster RCT	2 academic years	1 Mexican school (n= 500)	Self- report
14.	de Meij *et al.* (2011)	JUMP-in; 6 components including in class exercises	Classroom PA breaks, PE lessons, home	Controlled trial	2 academic years	Dutch schools (6-12 year olds)	Questionnaire, accelerometer
15.	Drummy *et al.* (2016)	5-minute activity break x 3 times daily	Classroom PA breaks	Controlled trial	12 weeks	7 Northern Ireland primary schools (n = 120)	Accelerometer
16.	Dunn *et al.* (2012)	Move-To-Improve: integrate PA in teaching academic content	PA integrated into the curriculum	Controlled trial	6 months	39 US primary schools, (5-9 year olds)	Observation (mins PA daily)

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
17.	Eather *et al.* (2013)	Fit-4-Fun: multicomponent: Health & PE lessons (60 mins per week), Home workbook & break time activities	PE lessons, Health lessons, home, break time	RCT	8 weeks & 6-month follow-up	4 Australian primary schools (n= 213, 10-11 year olds)	Pedometer
18.	Ernst and Pangrazi (1999)	Promoting lifestyle activity for youth (PLAY): 15 mins PA during school day & monitoring activity out of school	Classroom PA breaks	Quasi-experiment; pre- and post-test	12 weeks	1 US primary school (n= 28)	Self- report
19.	Erwin *et al.* (2011a)	Active maths lessons: 5-10 minutes PA in maths lessons	PA Integrated into Maths lessons	No control group	3 weeks	US (n = 75, 4th -5th grade)	Pedometer
20.	Erwin *et al.* (2011b)	PA breaks: provided teachers with 2 x 30 min training & Activity cards for 5-10min PA breaks	PA breaks in classroom	Controlled trial	8 months	2 US schools (n= 106, 3rd-5th grade) (9 teachers)	Pedometer, teacher activity log
21.	Fairclough and Stratton (2005)	Increased PA in PE class	1x 2hr PE lessons per week	RCT	5 weeks	UK (n = 33 girls aged 12)	Heart rate telemetry

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
22.	Gentile *et al.* (2009)	Switch- What you DO, View and Chew. Behaviour change intervention to change children's TV viewing habits, increase PA and increase fruit and vegetable consumption	School, home, community	RCT	6 months	10 US schools (1323 children)	Pedometer, BMI measures, self & parent report for television
23.	CA Gibson *et al.* (2008), Donnelly *et al.* (2009)	PAAC- Physical Activity Across the Curriculum: 10 mins PA, 9 times per week	PA integrated into classroom curriculum	Cluster RCT; pre-post test	3 years	24 US primary schools (N=454) (n=4905 2nd-5th grade)	Direct Observation (SOFIT), Accelerometers
24.	Goh *et al.* (2014)	Take 10!: 10 min PA integrated with core academic content	PA integrated into classroom curriculum	Pre- and Post-test	12 weeks	1 US school (n= 210, 8-12 year olds)	Pedometer steps, accelerometers
25.	Gorely *et al.* (2009)	Effect of Healthy lifestyle intervention- on eating fruit & vegetables, on PA, body composition, knowledge, psychological variables	Home, school (interactive website, CD-rom teaching resource)	Non randomised controlled study	10 months	8 primary schools (4 intervention, 4 control; 589 students aged 7-11)	Accelerometer, pedometer
26.	Grieco *et al.* (2009)	10-15 mins PA	Classroom PA breaks	Quasi-Experiment; pre-post test	9 months	1 US primary school (n= 97, 3rd grade students)	Pedometer

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
27.	Haerens *et al.* (2007)	PA and nutrition intervention. PA equipment provided to schools to encourage non-competitive PA	Break time & after school	Cluster RCT	2 years	Belgian schools (N=2434)	Self- report Flemish PA questionnaire
28.	Harrell *et al.* (1996)	CHIC: heart, food, exercise health lessons & 3x PA sessions per week	PA breaks and information lessons	RCT	8 weeks	21 US primary schools (n = 1274)	Questionnaire
29.	Harrison *et al.* (2006)	Switch off-get active! Health Ed lessons aimed at reducing TV viewing and increasing PA	10 x 30 min health lessons in the classroom	Controlled Trial	16 weeks	9 Irish Primary schools (n = 312)	Self- report PA
30.	Horne *et al.* (2009)	Fit n' Fun Dudes: rewards and pedometer feedback to increase PA. Rewards offered when they increase their step count by 1500 each day compared to their baseline	School, home, break time	Controlled Trial	12 weeks	2 Welsh primary schools (n = 100, 9-11 year olds)	Pedometer
31.	Howard *et al.* (1996)	Curriculum lectures on physiology, smoking, hypertension, diet, PA	1 x Class lecture per week	Controlled Trial	5 weeks	US (n = 96, aged 9-12 years)	Questionnaire

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
32.	Huberty *et al.* (2011)	Ready for Recess: Teacher training, playground markings, playground equipment to encourage PA at recess	Recess and break time	No control group	6 months	2 US schools (n= 93, 3-5th grade)	Accelerometer
33.	Jones *et al.* (2008)	IMPACT: health curriculum, PE programme, school food service	PE classes	Cluster RCT	1.5 school years	11 US schools (n = 606, aged 11-13 years)	Self-administered PA checklist (SAPAC) and Calcium, Osteoporosis & PA questionnaire (COPA)
34.	Jurg *et al.* (2006)	Jump In: 6 component programme including 3 mins jumping in the classroom, after school sports, parental involvement	Classroom break	Quasi-Experiment; pre-post test	9 months	6 Dutch primary schools (n = 510)	Self-report measures
35.	Kelder *et al.* (2005)	CATCH Kids Club- PA after school	After school programme	Controlled Trial	5 months	US (n = 258, 9 year olds)	Direct observation, self-report, focus group interviews (teachers)
36.	Kriemler *et al.* (2010)	KISS: 5 x 45 min PE lessons per week, active homework, 3-5 classroom PA breaks (2-5 mins)	PE, home, Classroom PA breaks	Cluster RCT	9 months	Swiss schools (n= 502)	Accelerometer

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
37.	Lanningham-Foster *et al.* (2008)	Activity Permissible School	Exercise balls & standing desks, neighbourhood design	Repeated measures	12 weeks	1 school (n=24 students)	Accelerometer
38.	Liu *et al.* (2008)	Happy 10: 10 mins PA	Classroom break	Quasi-Experiment; pre-post test	8 months	2 Chinese primary schools (n=753)	Self-report
39.	Luepker *et al.* (1996)	CATCH: Food, PE, classroom curriculum & family components	PE lessons, knowledge lessons in the classroom	Cluster RCT	3 years	US schools (n = 4000)	Self-report
40.	MacKelvie *et al.* (2001), MacKelvie *et al.* (2002)	10-12 min weight bearing PA twice a week	PE lessons	Cluster RCT, pre-post test	7 months	14 Canadian primary schools	Self-report questionnaires
41.	MacKelvie *et al.* (2004)	10-12 min weight bearing PA twice a week	PE lessons	Cluster RCT and pre-post test	20 months	14 Canadian primary schools	Self-report questionnaires
42.	Mahar *et al.* (2006)	Energisers: 10 mins PA breaks	Classroom breaks	Quasi-Experiment; pre-post test	12 weeks	1 US school (n= 243, K-5th grade)	Pedometer

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
43.	Manios *et al.* (2006)	Health & nutrition, fitness and PA components	2x45 min PE lessons per week & 4-6 hours classroom information lessons per year	Controlled Trial	6 school years	Greek schools (n= 1046 year 1 students)	Cardiovascular run test
44.	McKenzie *et al.* (1996)	CATCH (Child and Adolescent Trial for Cardiovascular Health): 3 groups: 1. 90min CATCH PE per week over 3 sessions, food service & in class CATCH curriculum, 2. School as above & home component (fun nights) 3. Control (PE classes, meal service)	PE classes, info sessions, home	RCT	3 years	USA 96 primary schools (n= 5106 gr 3-5)	SOFIT, SAPAC
45.	McManus *et al.* (2008)	Behaviour change programme providing information & goal setting for PA and heart rate monitoring	Information provided in class	Cluster RCT	2 years	China, (n = 210, 9-11 year olds)	Heart telemetry

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
46.	McNeil *et al.* (2009)	Outreach workers assigned to children in vulnerable areas to increase their participation in PA	School, home, community	Cluster RCT	1 year	16 US schools (grades 3-5)	Children's assessment of Participation and Enjoyment (CAPE) questionnaire
47.	McKay *et al.* (2005)	10 jumps when the bell rings 3 times daily	Break inside/outside	Quasi-Experiment; pre-post test	9 months	3 Canadian primary schools (n = 51)	Self-report
48.	Mitchell *et al.* (2013)	Instant recess- CD/DVD with stretches & exercises	Classroom break	Cluster RCT, delayed treatment, pre- and post-test	5 months	7 US primary schools (n = 1914 students)	Direct Observation SOFIT
49.	Mullender-Wijnsma *et al.* (2015)	Fit and academically proficient at school: combines PA and academic content (based on PAAC & Take 10!)	PA integrated into classroom curriculum	Pre- and Post-test	21 weeks	6 Dutch primary schools (n=228, 7-8 year olds)	Heart rate monitors
50.	Murtagh *et al.* (2013)	Bizzy Breaks: 10min classroom PA breaks	Classroom PA breaks	RCT	1 week	4 Irish primary schools (n= 90, 2nd -6th class)	Pedometer

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
51.	Neumark-Sztainer *et al.* (2009), Neumark-Sztainer *et al.* (2010)	Behavioural change intervention to encourage healthy behaviour	After school and home	Cluster RCT	16 weeks	US schools (n = 96)	PA recall
52.	Oliver *et al.* (2006)	'Virtual Walk': incorporated various subject areas e.g. English, Social studies, maths PE etc. to virtually walk a distance using pedometer step counts	Classroom: 4-week school curriculum unit based around pedometer use	No Control group	4 weeks	New Zealand (n= 78)	Pedometer
53.	Palmer *et al.* (2005)	Healthy Hearts 4 Kids: 2 x 50 min computer lab sessions per week	Web based prog: computer lab	Controlled Trial	1 month	US (n = 233, 5th grade students)	Self-report
54.	Pangrazi *et al.* (2003)	Promoting lifestyle activity for youth (PLAY): 15 mins PA during school day & monitoring activity out of school	Classroom breaks	Quasi-experiment; pre- and post-test	12 weeks	5 US primary schools (n = 28)	Pedometer
55.	Paradis *et al.* (2005)	KSDPP: diabetes prevention project: 10 x 45 min health lessons per year on healthy lifestyle topics	Classroom lectures, community components	Controlled Trial	6 years	Canadian primary schools (n= 443 6-7 year olds)	Self-report

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
56.	Pate *et al.* (2003)	Active Winners: 4 components: active kids: after school & summer prog, active school: making PA more accessible, active home: info for families, active community: active events	School, home, community	Controlled Trial	18 months	Australia (n = 436, 5th grade, 9-11 year olds)	PDPAR, heart rate monitors
57.	Peralta *et al.* (2009)	1x 60 min classroom session to promote PA and healthy eating, and 2 x 20 min lunch time PA sessions each week	Classroom information lessons and break time PA	RCT	16 weeks	Australian school (n = 32)	Accelerometer
58.	Petchers *et al.* (1988)	Chicago Heart Health Curriculum Programme: Cardiovascular system, smoking, nutrition, exercise, risk factors	Classroom information lessons	RCT	1 school year	US schools (n= 325)	Self- report
59.	Reed *et al.* (2010)	Activity integrated into core curriculum subjects	PA integrated into classroom curriculum	Cluster RCT	3 months	1 US school (n= 155, 9-11 year olds)	PDPAR
60.	Reznik *et al.* (2015)	CHAM JAM: Audio CD of 10 min, education focused aerobic activities 3 times daily	PA integrated into classroom curriculum	Cluster RCT	8 weeks	4 US schools (n= 988, 5-6 year olds)	Pedometer

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
61.	Ridgers *et al.* (2007)	Effect of playground markings on children's PA during recess and lunch	Break and lunch time	Non randomised controlled trial	6 week, 6 month follow up	15 intervention schools, 11 control schools	Accelerometer, heart rate monitor
62.	Riley *et al.* (2016)	E.A.S.Y. (Encouraging Activity to Stimulate Young) Minds curriculum-based PA integration programme in the primary school (3 x 60 min sessions per week)	PA integrated into the maths curriculum	RCT	6 weeks	8 Australian schools (n= 240) Grades 5-6	Accelerometer
63.	Robinson (1999)	Limiting TV time	Classroom lessons on limiting TV and gaming	Cluster RCT	6 months	US schools (n = 192)	Self-report PA checklist
64.	Sahota *et al.* (2001)	APPLES- Active Program promoting lifestyle education in schools: resource box given, teacher training, to promote PA and healthy eating, change school meals, school action plans to promote PA and healthy eating	Health classes given in class	RCT	1 academic year	10 UK primary schools (n = 636, 8 year olds)	Questionnaire for PA

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
65.	Sallis *et al.* (1997)	SPARK: 3 groups: 1. Specialist led PE classes 3 x 30 mins per week and 1 x 30 min self-management session 2. Teacher led 3. Control	PE classes and information sessions in classroom	RCT	2 years	7 US primary schools (n = 1538, 9 year olds, 4-5th grade)	Self-report questionnaire, accelerometer
66.	Salmon *et al.* (2008)	Behavioural modification and Fundamental Motor skills lessons	Classroom by intervention specialist teacher	Cluster RCT	1 school year	Australian schools (n = 268)	Accelerometer
67.	Simon *et al.* (2004)	ICAPS: promoting PA during lunch, break and after school	Break and lunch time	Cluster RCT	4 school years	French schools (n = 954)	Self- report
68.	Stewart *et al.* (2004)	Take 10! 10 minute PA breaks	Classroom break	Uncontrolled; post-test only	5 months	1 US primary school (n= 71)	Pedometer, Accelerometers
69.	Stone *et al.* (2003)	Food service, skills based classroom curriculum, family, PE: based on SPARK	PA occurred in PE lessons	Cluster RCT	3 years (12 weeks per year)	US (n = 1279)	Accelerometers

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
70.	Stratton (2000), Stratton and Mullan (2005)	Painted playground markings to encourage PA and MVPA, markings and equipment, markings and ball	Recess and lunch	RCT and Controlled Trial		UK primary schools (n = 120, n = 60)	Heart rate telemetry
71.	van Beurden *et al.* (2003)	Move it Groove it: Increase MVPA and fundamental movement skills in PE lessons	PE lessons	Controlled Trial	1 year	18 Australian primary schools (n= 1045, 7-10 year olds)	Pre- & post-observation surveys
72.	Verstraete *et al.* (2006)	Children provided with game equipment and activity cards to play outside	Break and lunch time	Cluster RCT	3 months	Belgium (n = 235)	Accelerometers
73.	Warren *et al.* (2003)	Be Smart: PA and nutrition	1x 25 min lesson per week in class	RCT	14 months (20 weeks)	3 UK schools (n=218, 5-7 year olds)	Parent questionnaires
74.	Webber *et al.* (2008)	TAAG: Health education and PA, changing behaviour that influences PA	Classroom health education lessons and PE lessons	Cluster RCT	2 years	36 US schools	Accelerometers
75.	Weeks *et al.* (2008)	10 mins jumping activities before PE classes	PE lessons	RCT	8 months	Australian schools (n = 81)	Bone specific PA questionnaire

Appendix A: Existing primary school-based physical activity interventions with PA as an outcome measure (cont'd)

	Study	Intervention	Type	Study Design	Duration	Participants	PA Measurement
76.	Whitt-Glover *et al.* (2011)	Instant Recess: 10 min PA breaks on the teacher's schedule	Classroom PA Breaks	RCT	6 months	8 US primary schools (grades 3-5)	Direct observation
77.	Williamson *et al.* (2007)	Healthy Eating and Exercise (HEE): to prevent weight gain. Schools given equipment, lessons and posters to promote active play	PA breaks during class time and break time	Cluster RCT	2 years	US schools (n = 586)	SAPAC
78.	Young *et al.* (2006)	Class lectures and discussions on how to become more P Active; problem solving, goal setting skills. Also aimed to increase PA in PE lessons	PE lessons and classroom info sessions	RCT	1 school year	US school (n = 200)	Student PA logs

Abbreviations: PA physical activity; PE physical education; RCT randomised controlled trial; Pedometer, PDPAR Previous day physical activity recall; SAPAC Self- administered PA checklist; SOFIT System for observing fitness instruction time

Appendix B: Physically active academic lessons evaluating PA only

Author	Intervention	Design	Sample	Methods	Findings
Dunn *et al.* (2012)	Move-To-Improve: integrate PA in teaching academic content	CT	Primary schools (n = 39), 150 classrooms (n = 72 intervention), aged 5-9 years	Observation: Minutes in PA per day	Intervention classes spent significantly more time (7.1mins) in PA than control classes ($p < 0.001$), PA decreased significantly as grade level increased ($p = 0.02$), PA was significantly lower in classrooms with > 25 students than in classrooms with < 25 students ($p < 0.01$)
Erwin *et al.* (2011a)	Physically active maths classes: 10 mins once a day	P&PT	1 school (n = 75) 8 -12 years, Subgroup (n = 7)	1. Pedometer (Walk4Life, LS 2505), 2. Subgroup: Accelerometer (Actigraph GT1M)	1. Significantly more steps in intervention classes than baseline ($p < 0.001$) 2. Significantly greater PA counts ($p < 0.01$), no difference in MVPA pre- and post- intervention
Goh *et al.* (2014)	Take 10!: 10 min PA integrated with core academic content	PM&PT No control	1 school (n = 210), 8-12 years, Subgroup (n = 64)	1. Pedometer (Yamax, CW-600 Digiwalker) step counts, 2. Accelerometers (ActiGraph GT1M and GT3x) MVPA	1. Significant increase in daily step counts from baseline to mid-intervention (672 steps, $p < 0.001$). No significant difference baseline to end-intervention. 2. MVPA significantly increased from baseline to end-intervention (2mins, $p < 0.01$)

Appendix B: Physically active academic lessons evaluating PA only (cont'd)

Author	Intervention	Design	Sample	Methods	Findings
Oliver *et al.* (2006)	Virtual Walk around New Zealand	P&PT No control	1 school (n = 61), 8-10 years	Pedometer (Yamax SW-200 Digiwalker)	No difference in steps between baseline and intervention, least active girls significantly increased steps by 131.4% during intervention ($p = 0.02$). Significant changes between baseline and intervention for both boys and girls who were accumulating < 15,000 steps daily (Boys 12,793 to 14,498, $p = 0.04$), (Girls 10,399 to 13668, $p = 0.01$)
Reznik *et al.* (2015)	CHAM JAM: Audio CD of 10 min, education focused aerobic activities 3 times daily	C RCT: P&PT	4 schools (n = 500 intervention, n = 488 control), 5 - 6 years	Pedometer steps (Yamax SW-200 Digiwalker)	Intervention group took significantly more steps than control group post-intervention (294, $p = 0.0048$)

Abbreviations: CHAM JAM Children's Hospital at Montefiore Joining Academics and Movement; Conv sample Convenience sample; C RCT Cluster Randomised Controlled Trial; CSA Computer Science Applications; CT Controlled Trial; EE Energy expenditure; MET Metabolic Equivalent; MVPA Moderate-to-vigorous physical activity; PA Physical activity; P&PT Pre & Post- test; PM&PT Pre, Mid & Post- test; RCT Randomised Controlled Trial

Appendix C: Physically active academic lessons evaluating learning, facilitators of learning or health outcomes only

Author	Intervention	Study Design	Sample	Methods	Findings
				Facilitators of Learning	
Finn and McInnis (2014)	Active Science Curriculum: exercising as a method of active learning and using the PA data in the science curriculum (2 x 90 min classes per week)	Exploratory research design	1 school ($n = 47$ students), 10 - 11 years, female, Subsample: $n = 8$, 2 science teachers	1. Teachers' perceptions: interviews:, 2. Student perceptions: questionnaires adapted from PACES (Likert format) Subsample: student focus groups	1. Teachers felt it was feasible to incorporate PA into the lessons, programme improved students' science knowledge and inquiry skills, exposed them to the use of technology, integrated fun and interactive PAs into class, 2. Students enjoyed incorporating PA into science lessons, learned science content and skills, used technology within the curriculum
				Learning	
Lee and Thomas (2011)	Use of commercial physical activity data (PAD) sensors to support Maths and Science enquiry based on PA	Non-randomised delayed treatment controlled trial, P&PT	1 school ($n = \sim 60$), subgroup ($n = 16$) primary school	1. Written test: reading displays of data, computation or identification of measures of centre 2. Structured interview	1. Both groups made learning gains from pre- to post- intervention, no significant difference between DTC group and intervention group post-intervention ($p > 0.80$) 2. Intervention group had a significantly greater gain in reasoning with contextualised data ($p < 0.05$), DTC group scored significantly higher after receiving intervention ($p < 0.05$)

Appendix C: Physically active academic lessons evaluating learning, facilitators of learning or health outcomes only (cont'd)

Author	Intervention	Study Design	Sample	Methods	
				Health	
Li et al. (2010)	Happy 10!: Adapted from Take 10!10 minutes of daily exercise integrated into academic content in the classroom	C RCT: P&PT	20 primary schools (n = 10 intervention), 4700 students (n = 2329 intervention), 8 - 11 years	BMI	BMI increased in both groups, significantly less increase in the intervention group ($p < 0.05$), intervention group had significantly higher % of children who maintained or reduced their BMI z score at year 1 ($p = 0.008$) and year 2 ($p = 0.04$)

Abbreviations: BMI Body mass index; C RCT Cluster Randomised Controlled Trial; DTC Delayed treatment control; PA Physical activity; PACES Physical Activity Enjoyment Scales; P&PT Pre & Post- test; n/c no comparative group

Appendix D: Physically active academic lessons evaluating multiple outcomes

Author	Intervention	Design	Sample	MVPA	Learning	Health
Donnelly et al. (2009)	PAAC: Physical Activity Across the Curriculum: 2 - 10 minutes PA each day	C RCT: P&PT	24 schools (n = 14 intervention (814), n = 10 control (713)), 7 - 9 years, Subgroups: PA n = 167 (n = 77 intervention students, n = 90 control students), WIAT-II assessment n = 203	Subgroup PA: Accelerometer (Actigraph 7164) Intervention group more active during school day (12% p = 0.01), More MVPA (27%, p < 0.001)	WIAT-II-A standardised academic achievement test Moderate intensity PA lessons significantly increased performance of the intervention group by 6% compared to a decrease of 1% for the control group (p < 0.02)	BMI: No significant difference between control and intervention group for change in BMI (p = 0.83). Dose response relationship: schools with > 75min PAAC/week significantly less increase in BMI at 3 years than schools with < 75 min PAAC/week (BMI 1.8 ± 1.8 compared to 2.4 ± 2.0, p < 0.00)

Author	Intervention	Design	Sample	MVPA	Health
Liu et al. (2007)	Happy 10!: Adapted from Take 10!10 minutes activities at least once a day	Non-RCT; P&PT	2 schools n = 753 (n = 328 intervention, n = 425 control), 6 - 12 years, Sub group n = 80	1. PA questionnaire 2. Subgroup: Zhi-Ji UX-01 activity monitor Significant difference in change of EE and PA duration between the groups (no p value supplied)	BMI: Boys' BMI in intervention & control groups increased significantly post-intervention, BMI of girls in intervention group decreased significantly & there was a significant difference in change of BMI between intervention and control girls (no p values supplied)

Appendix D: Physically active academic lessons evaluating multiple outcomes (cont'd)

Author	Intervention	Design	Sample	MVPA	Learning
Reed et al. (2010)	Activity integrated into core curriculum subjects	C RCT; P&PT	1 school (n = 155) (n = 80 intervention, n = 75 control), 9 - 11 years	1.Pedometer (Digiwalker SW-200) (n = 80 intervention group only) 2. PDPAR (both intervention (n = 80) and control group (n = 75): children's perceptions of PA) 1. Intervention group = average of 1,146 steps each day) (SD = 356) 2. PDPAR: no significant difference between groups at baseline (exp = 29, control = 31) nor post- intervention (both groups = 49) both groups increased PA but due to seasonal change (1st test = Jan, 2nd test = April) ($p > 0.05$)	1. Fluid intelligence: SPM test 2. Academic Achievement: PACT tests 1. Intervention group had significantly higher average fluid intelligence ($p < 0.05$) 2. Intervention had significantly higher social studies scores ($p = 0.004$) No difference in Maths, Science or English

Appendix D: Physically active academic lessons evaluating multiple outcomes (cont'd)

Author	Intervention	Design	Sample	MVPA	Learning	Facilitators of Learning
Mullender-Wijnsma et al. (2015)	Fit and academically proficient at school: combines PA and academic content (based on PAAC & Take 10!)	Q-exp with control: P&PT	6 primary schools, n = 228 (n = 58 intervention, n = 62 control), 7 - 8 years	Heart Rate Monitors 64% of the lesson time was spent in MVPA Significant difference between Grades 2 and 3 for MVPA ($p = 0.03$)	Maths (Tempo-Test-Rekenen) and Reading (1-Minute test) assessments Post-test maths & reading results of 3rd grade intervention group were significantly higher than control (both $p < 0.05$), post-test maths results of 2nd grade intervention group were significantly lower than control ($p < 0.05$)	Observations: Student on task behaviour On task behaviour was above 70% during active lessons No significant difference between Grades 2 and 3 for on-task basic exercise or off task ($p > 0.05$), significant difference between the grades for specific exercise on-task ($p = 0.03$)

Appendix D: Physically active academic lessons evaluating multiple outcomes (cont'd)

Author	Intervention	Design	Sample	MVPA	Facilitators of Learning
Mahar et al. (2006)	Energizers: 10 min activities once a day	C RCT: P&PT Multi-B to assess on-task	1 school ($n = 243$: $n = 135$ intervention, $n = 108$ control), 5 - 11 years, Subgroup $n = 87$, 8 - 11 years)	Pedometer (Yamax SW-200 Digiwalker) Significantly more steps during intervention ($p < 0.005$)	Subgroup: On-task behaviour: 10 observations Increased by 8% in intervention group post-intervention ($p < 0.017$)
Riley et al. (2015)	EASY Minds Study: integrating PA into Maths curriculum: 3x 60 min sessions per week	RCT	1 school, 2 classes ($n = 54$),($n = 27$ intervention, $n = 27$ control), 10 - 12 years	Accelerometers (ActiGraph, GT3X): school-based MVPA levels Significant intervention effects on MVPA levels for the intervention group during Maths classes (9.7 %, $p \leq 0.001$) and across the whole school day (8.7%, $p \leq 0.001$)	1. On task behaviour: momentary time sampling observation, 2. Student Enjoyment Levels: Evaluation survey, 3. Teacher satisfaction 1. Significantly greater on task behaviour across the intervention period with 19.9% mean diff between the groups ($p \leq 0.03$), 2. Students found the programme highly enjoyable rating it 4.0 - 4.9 out of 5 on 20 items, 3. Teachers were highly satisfied with the programme (4.9 ± 0.1) and its impact (4.5 ± 0.2)

Abbreviations: BMI Body mass index; C RCT Cluster Randomised Controlled Trial; EE Energy expenditure; ES Effect Size (Cohen's d); Multi-B Multiple Baseline; PAAC Physical Activity Across the Curriculum; PACT Palmetto Achievement Challenge Test; PDPAR Previous Day Physical Activity Recall; P&PT Pre & Post- test; Q-exp Quasi experimental design; RCT Randomised Controlled Trial; SPM Standard Progressive Matrices; WIAT-II Wechsler Individual Achievement Test-2nd Edition

Appendix E: Sample English lessons

Lesson Code: E9

Subject: English (Story)

Class Level: 1st - 3rd Class

Strand: Competence and confidence in using language

Strand Unit: Writing: Develop competence and confidence and the ability to write independently

Oral Language: Developing receptiveness to oral language

Linkage: Reading: developing strategies

Integration: P.E., Drama, S.E.S.E.

Activity: Going on a Bear Hunt – Students will listen to the story then retell the story while performing physical activities. Students will make up their own stories using a similar format and perform using the exercises they suggest.

Time: 30 minutes (can be shortened/ extended if desired)
Class Formation: students stand at their desks

Equipment: Going on a Bear Hunt by Michael Rosen and Oxenbury, pencils and paper

Directions:

1. Teacher will read the story "Going on a Bear Hunt" or class can watch the author telling the story on https://www.youtube.com/watch?v=0gyI6ykDwds
2. Have students pay attention and listen for the different obstacles the character goes through.
3. Beside their desk, students will demonstrate the ways they can travel like the characters: Run / Hop through the forest, Skip through the field, Climb the mountain, other activities...
4. Discuss the format of the story and have the students suggest other obstacles the characters may have had to go through and how they would get through them.
5. Allow the children to write their own version of the story.
6. Split the children into groups of 3 and encourage each child to retell their own story with expression and demonstration of the actions. The other members of the group can join in the actions with the storyteller.

Appendix E: Sample English lessons (cont'd)

Sample English lesson (2)

Lesson Code: E1
Subject: English (Grammar)
Class Level: 1^{st} - 4^{th} Class
Strand: Competence and confidence in using language
Strand Unit: Writing: developing competence, confidence and the ability to write independently
Linkage: Developing cognitive abilities through language
Integration: P.E., Drama

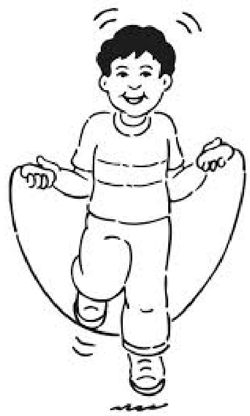
Activity: Action Verbs - This activity teaches the children about verbs and adverbs by encouraging them to perform the action verbs according to the selected adverb.

Time: 10 minutes (can be extended if desired)

Class Formation: sit/stand in a circle or at their desks
Equipment: verb and adverb flashcards (See Copymaster 1)

Directions:

1. Introduce action verbs as words that indicate some form of action (e.g. jump, run, squat). Then introduce "adverb" as a modifier that tells how/when the action is performed (e.g. quickly, powerfully, repeatedly).
2. Pass out index cards or spread them on the ground. Have the students each pick one card.
3. They must then decide if the word that is written on the card is an action verb or an adverb.
4. The children will each partner up with someone who has the other type of word and the whole class act out each phrase in turn (e.g.: hop quickly, squat powerfully, skip repeatedly). The words must make sense together. After all pairs have been acted out the cards can be reshuffled, the children can make different pairings with the verbs and adverbs, and the activity can be repeated.



Variations:

1. Have students each pick out one card (verb or adverb) and then ask them to find as many matches to act out as they can in one minutes time. The students will be bouncing, crawling, clapping, and other actions for the entire time.

Appendix F: Sample Mathematics lessons

Lesson Code: M20
Subject: Mathematics
Class Level: 3rd – 6th Class
Strand: Number
Strand Unit: Operations: multiplication and division
Linkage: Problem Solving
Integration: P.E.

Activity: Moving multiples – Students will work out division problems while counting up in multiples of a given divisor to a given number while performing a physical activity

Time: 10 minutes (can be extended if desired)
Class Formation: students standing at their desks
Equipment: Exercise cards (Copymaster 3), division flashcards (Copymaster 2)

Directions:

1. Have the students standing by their desks or in a circle.
2. Teacher selects two students- the first student pulls an exercise card (e.g. scissor jumps) while the other student pulls a division flashcard (e.g. 24 ÷ 4 =).
3. The class must perform the exercise while counting up in multiples of the divisor (4) to the dividend (24).
4. When the students have finished, the teacher selects one student to say how many repetitions he/she had to do to find the answer (6). If the rest of the class agree with the answer they do 3 vertical jumps, if they disagree they do 3 squats.
5. Repeat with a new exercise card and division flashcard.

Variations:

1. Teacher could assign one exercise card to each number 1-10 (1= jumping jacks, 2= high knees etc.) and the children perform 10 repetitions of the exercise corresponding to the correct answer. Example the flashcard drawn is 6 ÷ 3 =. The students would perform 10 high knee exercises to show that the answer is 2.

Appendix F: Sample Mathematics lessons (cont'd)

Sample Mathematics lesson (2)

Subject: Maths

Class Level: 2^{nd} and 3^{rd} Class

Strand: Number

Strand Unit: Counting and Numeration, Operations (Addition)

Linkage: Algebra (Number Sentences)

Integration: Physical Education

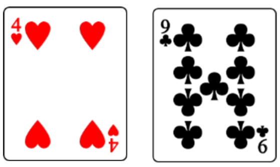
Activity: Jump the Deck- This activity requires the children to add the total of two playing cards while performing the corresponding number of moderate to vigorous physical activities.

Time: 10 minutes (teacher can extend if desired)

Class Formation: children are standing at their desks

Equipment: 1 deck of cards

Directions:
1. Teacher places a deck of cards on a table in front of the class.
2. Have one student select 2 cards and all of the students will do the corresponding activity (outlined below) for each suit, repeated the number of times that appears on each card while adding the total.
   - *Heart:* touch opposite elbow to opposite knee while bouncing on the grounded foot (alternate with each elbow to knee touch)
   - *Diamond:* high knee/ tuck jumps in place
   - *Club:* modified push up or burpies
   - *Spade:* jumping jacks or scissors
3. Teacher can write corresponding activities on the board for each suit.

Example:  = 4 elbow to knee touches + 9 push ups = 13

4. Provide other students opportunity to pick cards from the deck and repeat activity.

Variations:
1. Picture cards can represent the number 10.
2. To challenge the students you could vary the value of the picture cards.
3. The children could be asked to add more than 2 numbers while doing the corresponding activities.
4. Children could be further challenged by completing multiplication with the activities.

Appendix G: Range of lessons provided to the teacher

English Lessons:

Lesson Title	**Strand**	**Strand Unit**
Action Verbs	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Stop & Scribble	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
As if	Receptiveness to Language	Oral Language: Developing Receptiveness to Oral Language
Frozen Vocabulary	Receptiveness to Language	Oral Language: Developing Receptiveness to Oral Language
Spelling Tag	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Spelling Bee Bounces	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Language Lights	Competence and confidence in using language	Oral language: developing competence, confidence in using oral language
Popcorn Spelling	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
'Going on a Bear Hunt'	Competence and confidence in using language Receptiveness to Language	Writing: Developing competence, confidence and the ability to write independently Oral Language: Developing Receptiveness to Oral Language
'Marvin K. Mooney Will You Please Go Now?'	Competence and confidence in using language Receptiveness to Language	Oral language: developing competence, confidence in using oral language Oral Language: Developing Receptiveness to Oral Language
Space Jam	Developing cognitive abilities through language, Emotional and Imaginative development through language	Reading: Developing interests, attitudes, information retrieval skills and the ability to think Reading: Responding to text
Power Punctuation	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently

Appendix G: Range of lessons provided to the teacher (cont'd)

English Lessons (cont'd)

Lesson Title	Strand	Strand Unit
Up-down spelling relay	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Memory relay	Receptiveness to Language	Oral Language: Developing Receptiveness to Oral Language
Action letters	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Sentence shape up	Competence and confidence in using language	Oral Language: Developing competence and confidence in using oral language
Story starters	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Vocab Bounces	Receptiveness to Language	Reading: Developing strategies
Exercise Procedures	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently
Scrabble	Competence and confidence in using language	Writing: Developing competence, confidence and the ability to write independently

Appendix G: Range of lessons provided to the teacher (cont'd)

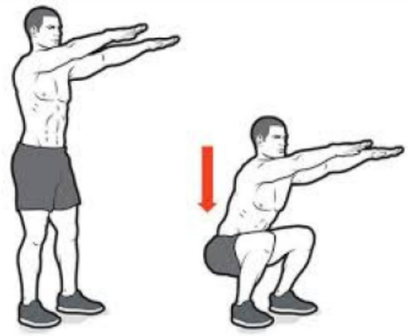
Maths Lessons:

Lesson Title	Strand	Strand Unit
Hit the Deck	Number	Counting and Numeration, Operations (Addition)
Tables Freeze	Number	Operations: Addition & Subtraction
The 12 Days of Fitness	Number	Operations: Subtraction
Silent Signs	Shape and Space	Spatial Awareness
Odd or Even	Algebra	Extending and using patterns, Number patterns and Sequences
Hop the answer	Number	Operations: Addition, Subtraction, Multiplication, Division
What's the number, Mr. Wolf?	Number	Operations: Addition, Subtraction, Multiplication, Division
Maths stations active rotation	Various	Various
Rounding to the nearest 10	Number	Operations: Addition, Subtraction, Multiplication, Division
Pac the fraction	Number	Fractions
Rock, paper, scissors multiplication	Number	Operations: Multiplication
Money exercises	Measures	Money
Table exercises	Number	Operations: Addition, Subtraction, Multiplication, Division
Musical Odds and Evens	Algebra	Number patterns
Beating hearts	Measures, Data	Time, Representing and interpreting data
Active problem solving	Number	Operations: Addition, Division
Active factors	Number	Operations: Addition, Division
Hit the Deck 2	Number	Operations: Addition, Division
Tables race	Number	Operations: Addition, Multiplication,
Moving multiples	Number	Operations: Multiplication, Division

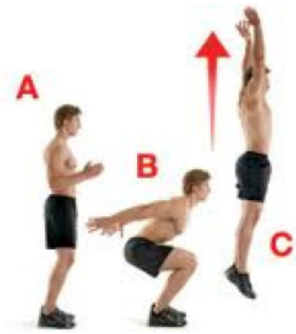
Appendix H: Sample of resources provided

Active Classrooms: MVPA Activity Flashcards — Copymaster 3

burpees

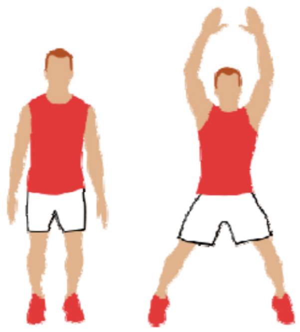


squats



squat jumps

power lunges



jumping jacks

high knees

Copymaster 6

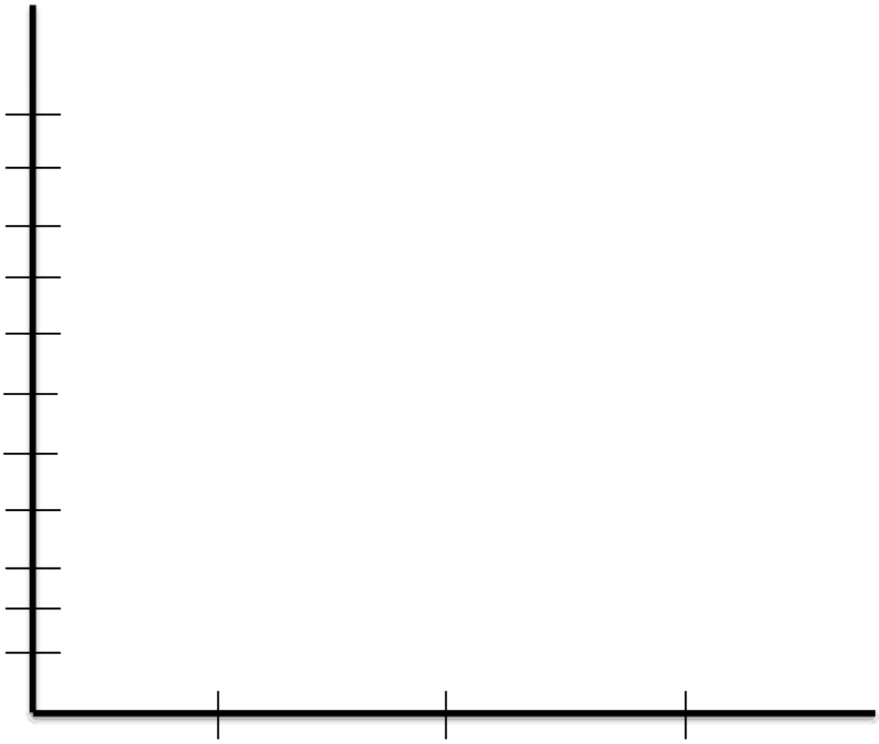
Heart Rate Record Sheet

Name: ____________________

Fill in the table below to record your heart beat at rest and after exercise:

Activity	Beats per minute
Resting	
After Walking for 2 minutes	
After running on the spot for 2 minutes	

Now graph your heartbeat after each activity on the chart below:



Appendix I: Ethical approval form

For Office Use Only Application Reference Number:	A14-006 Resubmission

COLÁISTE MHUIRE GAN SMÁL
MARY IMMACULATE COLLEGE

Mary Immaculate College Research Ethics Committee

MIREC-4: MIREC Chair Decision Form

1	Title of Research Project
	The development of a low-cost classroom-based physical activity intervention, which integrates academic content, and the objective examination of its effects on the physical activity levels of boys and girls in primary schools.

2 Applicant	
Name	Rosemarie Martin
Department / Centre / Other	Faculty Education - Department Arts Education & Physical Education
Position	Structured PhD Student

3	Decision of MIREC Chair
	Ethical clearance through MIREC is required
	Ethical clearance through MIREC is not required and therefore the researcher need take no further action in this regard
X	Ethical clearance is required and granted. Referral to MIREC is not necessary
	Ethical clearance is required but the full MIREC process is not. Ethical clearance is therefore granted if required for external funding applications and the researcher need take no further action in this regard.
	Insufficient information provided by applicant / Amendments required

4	Reason(s) for Decision
	Application fulfils MIREC requirements. It is recommended that the applicant add a comment to the relevant documents on how the height and weight measurements will be taken – other adult present, privacy of results (weight especially) where other children are not gathered round observing and commenting, etc.

5 Declaration	
Name (Print)	**Áine Lawlor** *MIREC Chair*
Signature	Áine Lawlor *MIREC Chair*
Date	**30/09/2014**

MIREC-4 Rev 2 Page 1 of 1

Appendix J: Participant information sheets and consent forms

Letter to Principal Seeking Expression of Interest

Principal,

Some Primary School,

Limerick.

Dear Principal,

My name is Rosemarie Martin and I am a primary teacher in Donoughmore N.S. I am currently undertaking a Structured Ph. D in Education in Mary Immaculate College under the supervision of Dr. Elaine Murtagh (Lecturer in Physical Education, MIC). My area of research is integrating physical activity into the classroom. The aim of my research is to develop and evaluate a classroom intervention to improve children's physical activity levels, during the school day, by teaching literacy and numeracy using physically active methodologies. The study will be carried out over 9 consecutive weeks in third class.

At this stage I am writing to a number of primary schools looking for an expression of interest with the ultimate goals of recruiting 8 suitable schools to partake in the study. Four schools will be assigned to the intervention group and 4 will serve as a delayed-treatment control and will receive the intervention materials after data has been collected. It is envisaged that the study will start this November with baseline data collection followed by the intervention which will run over 8 consecutive school weeks. Follow-up data will be collected for a week 4 months after commencement of the programme. Some of the particulars of the study are outlined in the attached document.

Partaking in this study is a unique opportunity and will offer many benefits to your students and teachers. Not only will the selected schools be helping greatly with the development of a physical activity intervention which integrates academic content but their students will engage in kinaesthetic lessons and their teachers will use active methodologies to teach literacy and numeracy lessons. The idea of the intervention is to increase physical activity levels of the students without interrupting teaching and learning time, while also enhancing the teaching and learning of these subjects.

There has been much talk in the media recently about the so called 'childhood obesity epidemic' and the health and physical activity levels of Irish young people and children in particular. Sedentary school environments and inactive teaching methods have been pin pointed as contributing factors and this is where my research project comes in. The planned intervention will encourage physically active classroom environments and kinaesthetic teaching methodologies which will produce effects that will impact on the current and future health of the boys and girls while also equipping the teachers with new teaching skills.

I would appreciate it if you would discuss this opportunity with the pertinent staff members and return the Expression of Interest form by Wednesday 8th of October 2014.

Appendix J: Participant information sheets and consent forms (cont'd)

Once I receive this form I will contact you and arrange a meeting where we can discuss the project and any issues which might arise in more detail. The final schools will then be chosen using a set of pre-established criteria.

If you have any questions or require further information about the project and your possible role in it please do not hesitate to contact me or my project supervisor (details attached).

In expressing interest in this project you are taking the first proactive step in helping to change the health of your students and impacting on their lives.

Yours sincerely,

____

Rosemarie Martin M.Ed, B.Ed

____

Dr. Elaine Murtagh B.A., D.I.S., P.G.C.E.,Ph.D. (University of Ulster), Specialist Dip (UL), Lecturer in Physical Education, Department of Arts Education & Physical Education, MIC.

Appendix J: Participant information sheets and consent forms (cont'd)

Expression of Interest Form

Active Classrooms: A classroom intervention to improve the physical activity levels of children.

I ___________________________ principal of _______________________________ primary school hereby express my interest in involving this school in the above mentioned research project.

Contact person in the school: ____________________________

Contact details email/phone no.: ___________________________ ________________

Number of children in 3rd class: ______________

Please return this form to:
Ms Rosemarie Martin,
c/o Donoughmore N.S.,
Donoughmore,
Co. Limerick

Signature: _______________________________ Date: _________________

Appendix J: Participant information sheets and consent forms (cont'd)

School Information Sheet

Active Classrooms

A classroom intervention to improve the physical activity levels of children.

Rosemarie Martin M.Ed, B.Ed
Mary Immaculate College, Limerick.

School Information Sheet

Invitation to Participate

Rosemarie Martin a Structured Ph.D. in Education student from Mary Immaculate College is conducting a study to explore the impact of a physical activity intervention in primary school classrooms. Your school is being asked to participate.

What is the study about?

I am interested in finding out how a programme that involves integrating physical activity into English and Maths lessons affects the physical activity levels of children. If assigned to the intervention, your school will be asked to implement an 8-week classroom-based physical activity programme in third class, which integrates the aims of the primary school curriculum, during usual class time. The programme is designed to improve the physical activity levels of children in the classroom and reduce sedentary behaviour. Delayed-treatment control schools will continue teaching as normal, and will receive the intervention materials after all data has been collected.

Why is the study being undertaken?

In order to maintain good health, children are advised to accumulate at least 60 minutes of moderate-vigorous intensity physical activity each day. Recent studies have indicated that many Irish children are not meeting these guidelines. Schools play a key role in promoting physical activity for children. The results of the study will help develop a classroom-based programme to improve children's physical activity levels.

What happens if my school takes part?

Step 1: The Researcher will arrange a short meeting with the principal and subsequently interested class teachers, in your school, at a time which is convenient for you, to discuss participation in full detail.

Step 2: We need to identify 3rd classes whose teachers are willing to participate in the study.

Step 3: Once the classes have been selected your school will be asked to distribute information materials, provided by the Study Researcher, to the parent(s)/guardian(s) of each study child and to the classroom teacher of each participating class. This will include a leaflet giving a detailed explanation of the study as well as a consent form for the children, parent(s) and teacher to sign.

Step 4: The researcher will visit your school at a convenient time to administer a brief training session for the participating teacher on how to use the accelerometers and how to implement the active intervention lessons.

Step 5: Participating classes will then take part in an 8-week programme.

School Information Sheet (cont'd)

Physical Activity Intervention Programme:

Participating class teachers will be asked to implement an 8-week physical activity programme which integrates the aims of the primary school curriculum, in their classrooms during usual class time. Prior to the first week baseline data will be collected as well as during the last week and at four months follow-up. The researcher will come to the school after the first week to deliver brief training to the class teacher on how to use the intervention materials, and how to implement English and Maths lessons using active methodologies. Each consenting child will have once off height and weight measures taken at the beginning of the study for norm comparisons and will be asked to wear an accelerometer during the school day on data collection weeks (as mentioned above). They will also be asked to write and draw about their experiences of English and Maths lessons both pre- and post- intervention. Some consenting children will be randomly selected to engage in a focus group discussion about their experiences of the programme with the researcher. After the 8-weeks participating teachers will be asked to complete a short questionnaire to evaluate the effectiveness and sustainability of the programme. The teacher may also be selected to discuss their experience with the researcher after the programme. The programme is designed to improve the physical activity levels of children and reduce sedentary behaviour in the classroom without reducing academic teaching time.

Delayed- Treatment Control Group:

Participating class teachers will continue teaching as normal. Once off height and weight measures will be collected from the children for norm comparisons. The researcher will explain how the accelerometers should be worn and consenting children will wear them each school day for a week at baseline data collection, 8 weeks later and at 4 months follow- up. The class teacher is asked to distribute the accelerometers each day and collect them at the end of each day during the 3 measurement weeks. Teachers in the delayed- treatment control group will receive the intervention materials once all data has been collected.

Who will carry out the research?

The study will be conducted by Rosemarie Martin a Ph.D. research student from Mary Immaculate College who will train the teachers on how to carry out the intervention lessons in the classroom. The researcher is required to sign acceptance of the Mary Immaculate College Child Protection Guidelines and to be familiar with the Child Protection Guidelines/Policies of the school.

What are the risks?

There are no risks in this research greater than those involved in everyday practices.

What are the benefits?

This study may have health benefits for the children both now and into the future. All schools will receive information on the results of the study.

What happens to the information?

The Information will be used to form the results section of a Ph.D. thesis. Summary data only will be used; individual children's data will not be shown. The study will be published as a research paper in a peer-reviewed journal and presented at a research conference.

How will confidentiality be kept?

Any personal identification will be omitted so that the children, teachers and schools will not be identifiable in the written analysis. Only the research team will have access to the data. The study has been approved by the Research Ethics Committee at Mary Immaculate College (MIREC).

School Information Sheet (cont'd)

What if I do not want my school to take part?

Participation is voluntary. Your school does not have to participate in this study. If you agree for your school to be in this study, but later change your mind, you may withdraw your school at any time. There are no consequences of any kind if you decide you do not want your school to participate.

What do I do next?

The Researcher will be in contact with you in the coming days. She will discuss in more detail the participation of your school and will be able to answer any questions which you may have in relation to the study.

If you have questions about the study or do not understand something, you may contact:

Rosemarie Martin
Tel: 083 4188726
Email: rgiltenane@gmail.com

Or

Dr. Elaine Murtagh
Lecturer in Physical Education
Direct Tel: 061 204569
Email: elaine.murtagh@mic.ul.ie

If you have any concerns about this study and wish to speak to someone independent, you may contact:

MIREC Administrator,
Mary Immaculate College,
South Circular Road, Limerick
Tel: 061 204515; Email: mirec@mic.ul.ie

Appendix J: Participant information sheets and consent forms (cont'd)

Principal Consent Form

Active Classrooms: A classroom intervention to improve the physical activity levels of children.

Should you agree to your school's participation in the above study please sign the consent form below.

I consent to the involvement of this Primary School in this research project.

Name: (please print): (Principal) ______________________________

Signed: ______________________________

School: ______________________________

Date: ______________________________

Appendix J: Participant information sheets and consent forms (cont'd)

Teacher Information Leaflet

Teacher Information Sheet

Active Classrooms:

A classroom intervention to improve the physical activity levels of children.

Rosemarie Martin M.Ed, B.Ed.
Mary Immaculate College

COLÁISTE MHUIRE GAN SMÁL
OLLSCOIL LUIMNIGH
MARY IMMACULATE COLLEGE
UNIVERSITY OF LIMERICK

Who will carry out the research?
The study will be conducted by Rosemarie Martin a Ph.D. research student from Mary Immaculate College who is also a primary school teacher. The researcher is required to sign acceptance of the Mary Immaculate College Child Protection Guidelines and to be familiar with the Child Protection Guidelines/Policies of the school.

What are the risks?
There are no risks in this research greater than those involved in everyday practices.

What are the benefits?
This study may have health benefits for the children both now and into the future. You will receive information on the results of the study.

What happens to the information?
Information will be used to form the results section of a Ph.D. thesis. Summary data only will be used; individual teacher's data will not be shown. The study will be published as a research paper in a peer-reviewed journal and presented at a research conference.

Active Classrooms:
A classroom intervention to improve the physical activity levels of children.

How will confidentiality be kept?
Any personal identification will be omitted so that you will not be identifiable in the written analysis. Only the research team will have access to the data. The study has been approved by the Research Ethics Committee at Mary Immaculate College (MIREC).

What if I do not want to take part?
Participation is voluntary. You do not have to participate in this study if you do not want to. If you agree to be in this study, but later change your mind, you may withdraw at any time. There are no consequences of any kind if you decide you do not want to participate

If you have questions about the study or do not understand something, you may contact:
Rosemarie Martin,
Tel: 083 4188726
Email: rgiltenane@gmail.com

If you have any concerns about this study and wish to speak to someone independent, you may contact:
MIREC Administrator,
Mary Immaculate College,
South Circular Road, Limerick.
Tel: 061 204515
Email: mirec@mic.ul.ie

Appendix J: Participant information sheets and consent forms (cont'd)

Teacher Information Leaflet (cont'd)

Information for teachers

Invitation to Participate
Rosemarie Martin a Structured Ph.D. in Education student from Mary Immaculate College is conducting a study to explore the impact of a physical activity intervention in primary school classrooms. You are being asked to participate.

What is the study about?
The Researcher is interested in finding out how a programme that involves integrating physical activity into Literacy and Numeracy lessons affects the physical activity levels of children. Teachers are being asked to implement an 8-week classroom based physical activity programme, which integrates the aims of the primary school curriculum, during usual class time. The programme is designed to improve the physical activity levels of children in the classroom and reduce sedentary behaviour.

Why is the study being undertaken?
In order to maintain good health, children are advised to accumulate at least 60 minutes of moderate-vigorous intensity physical activity each day. Recent studies have indicated that many Irish children are not meeting these guidelines. Schools play a key role in promoting physical activity for children. The results of the study will help develop other classroom-based programmes to improve children's physical activity levels.

What will I have to do?
Your school will be randomly assigned to either 1. Intervention or 2. Delayed- treatment control groups. If you agree to participate in this study, what you have to do will depend on which group your school is assigned to. Both options are outlined here:

1. Intervention group:

If you agree to participate in this study, you will be given brief training and asked to teach Literacy and Numeracy lessons using active methodologies. Sample lessons will be provided. You will also be asked to complete a questionnaire regarding your views on the effectiveness and sustainability of the intervention. This will take 10 minutes post intervention. Some teachers may also be asked to share their experiences in a brief interview with the researcher.

2. Delayed- Treatment control group:

If you agree to participate in this study, you will be given a brief explanation on how the children should wear the accelerometers and how to keep an accelerometer wear time log. You will carry on teaching as normal and distribute and collect the accelerometers each day during the measurement weeks. You will also record when and why the children are not wearing the accelerometers during this time period (eg. swimming). (**Please note:** participating teachers in Delayed- Treatment control schools will also receive training and the intervention resource materials once the control data has been collected.)

What do I do now?
When you have read this leaflet decide if you would like to participate.
Enclosed with this information you will find a copy of a form marked 'Teacher's Consent Form'. Please read and sign the form if you wish to participate and return it to the researcher.

Research measures:
1. Children in your class will be asked to wear an accelerometer each day during measurement weeks (baseline, Week 8 and 4 months follow-up).
An accelerometer (as shown in the photograph above) is a lightweight, unobtrusive device that is worn on an elastic belt around the waist. It is approximately the size of a box of matches. The children will wear it during the school day. The device will record the amount of activity that the child does each day. You are asked to give the children the accelerometers at the start of the school day, collect them before the children leave at the end of the day, and record when and why the children are not wearing the accelerometers (eg. swimming).
2. All consenting children will have weight and height measures taken individually by the researcher in the presence of another adult. Privacy of results will be maintained.

Additional Measures for the Intervention group:
1. As well as recording your student's accelerometer wear time you will be asked to log the physically active lessons you carry out in the classroom.
2. You will also be asked to complete a questionnaire regarding your views on the effectiveness and sustainability of the intervention programme and offer ideas for its improvement. Some teachers may be invited to be interviewed by the researcher.

Appendix J: Participant information sheets and consent forms (cont'd)

Teacher Consent Form

Active Classrooms: A classroom intervention to improve the physical activity levels of children.

Please read the following statements:

- I have read and understood the participant information sheet and have had due time to consider it.
- I understand what the project is about, and what the results will be used for.
- I am fully aware of all of the procedures involving myself, and of any risks and benefits associated with the study.
- I know that my participation is voluntary and that I can withdraw from the project at any stage without giving any reason.
- I am aware that my results will be kept confidential.

By signing below you are agreeing to the above statements and giving informed consent for you to participate in the above study.

Name: (please print): ______________________________

Signed: ______________________________

School: ______________________________

Date: ______________________________

Appendix J: Participant information sheets and consent forms (cont'd)

Parent Information Leaflet

Who will carry out the research?
The study will be conducted by Rosemarie Martin a Ph.D. research student from Mary Immaculate who is also a primary school teacher. The researcher is required to sign acceptance of the Mary Immaculate College Child Protection Guidelines and to be familiar with the Child Protection Guidelines/Policies of the school. The research will be conducted in an open environment and the researcher will never be alone with a child.

What are the risks?
There are no risks in this research greater than those involved in everyday practices.

What are the benefits?
This study may have health benefits for your child both now and into the future. All parents will receive information on the results of the study.

What happens to the information?
Information will be used to form the results section of a Ph.D. thesis. Summary data only will be used; individual children's data will not be shown. The study will be published as a research paper in a peer-reviewed journal and presented at a research conference.

Active Classrooms:
A classroom intervention to improve the physical activity levels of children.

How will confidentiality be kept?
Any personal identification will be omitted so that your child will not be identifiable in the written analysis. Only the research team will have access to the data. The study has been approved by the Research Ethics Committee at Mary Immaculate College (MIREC).

What if I do not want my child to take part?
Participation is voluntary. Your child does not have to participate in this study if you or your child does not want to. If you agree for your child to be in this study, but later change your mind, you may withdraw your child at any time. There are no consequences of any kind if you decide you do not want your child to participate

If you have questions about the study or do not understand something, you may contact:
Rosemarie Martin,
Tel: 083 4188726
Email: rgiltenane@gmail.com

If you have any concerns about this study and wish to speak to someone independent, you may contact:
MIREC Administrator,
Mary Immaculate College,
South Circular Road, Limerick.
Tel: 061 204515
Email: mirec@mic.ul.ie

Parent/Carer Information Sheet

Active Classrooms:
A classroom intervention to improve the physical activity levels of children.

Rosemarie Martin M.Ed, B.Ed.
Mary Immaculate College

COLÁISTE MHUIRE GAN SMÁL
OLLSCOIL LUIMNIGH
MARY IMMACULATE COLLEGE
UNIVERSITY OF LIMERICK

Appendix J: Participant information sheets and consent forms (cont'd)

Parent Information Leaflet (cont'd)

Information for parents/guardians

Invitation to Participate
Rosemarie Martin a Structured Ph.D. in Education student from Mary Immaculate College is conducting a study to explore the impact of a physical activity intervention in primary school classrooms. Your child is being asked to participate.

What is the study about?
I am interested in finding out how a programme that involves integrating physical activity into Literacy and Numeracy lessons affects the physical activity levels of children. If assigned to the intervention group, your child's school has agreed to implement an 8-week classroom based physical activity programme, which integrates the aims of the primary school curriculum, during usual class time. The programme is designed to improve the physical activity levels of children in the classroom and reduce sedentary behaviour.

Why is the study being undertaken?
Children are advised to accumulate at least 60 minutes of moderate-vigorous intensity physical activity each day. Recent studies have indicated that many Irish children are not meeting these guidelines. Schools play a key role in promoting physical activity for children. The results of the study will help develop other classroom-based programmes to improve children's physical activity levels.

What will my child have to do?
Your child's school will be randomly assigned to either 1. Intervention or 2. Delayed- treatment control groups. If you and your child agree to participate in this study, what he/she will have to do depends on which group his/her school is assigned to. Children in both groups will wear an accelerometer and have their weight and height taken (details outlined under Research Measures). If his/her school is assigned to the Intervention group, your child will also be asked to participate in additional research measures as outlined on this page. (**Please note:** participating classes in Delayed- Treatment control schools will also receive the intervention resource materials once the control data has been collected.)

Research measures:

Intervention and Delayed- Treatment Control Schools:

1. Your child will be asked to wear an **accelerometer** each school day during the study measurement weeks (baseline, week 8 and at 4 months follow-up). An accelerometer (as shown in the photograph above) is a lightweight, unobtrusive device that is worn on an elastic belt around the waist. It is approximately the size of a box of matches. The device will record the amount of activity that your child does each day. The class teacher will give your child the accelerometer at the start of the school day and collect it before your child leaves at the end of the day.

2. All consenting children will have once off **weight and height** measures taken (in socks and normal clothes) by the researcher using a scales and stadiometer in the school during the the study. Your child will be asked to stand on the scales whilst his/her weight is taken. Similarly your child will be asked to stand against the stadiometer in order to measure height. The results will be recorded privately by the researcher and not shared with children or school personnel.

Additional Measures for Intervention Schools:

1. Your child will be asked to **write and draw** about their experiences of English and Maths lessons.
2. Some children will be randomly selected to participate in audio taped **focus group discussions** with the researcher & other children in the class about their experiences of English and Maths lessons.

What do I do now?

1. When you have read this leaflet decide if you would like your child to take part and discuss the same with him/her.

2. Enclosed with this information you will find a copy of a form marked 'Parent's/Carer's Consent Form'. Please read and sign the form if you wish to participate and return it to the school. Please also return the 'Child's Assent Form' signed by your child.

Appendix J: Participant information sheets and consent forms (cont'd)

Parent/ Guardian/ Carer Consent Form

Active Classrooms: A classroom intervention to improve the physical activity levels of children.

Please read the following statements:

- I have read and understood the parent/guardian/carer information sheet and have had due time to consider it.
- I understand what the project is about, and what the results will be used for.
- I am fully aware of all of the procedures involving my child, and of any risks and benefits associated with the study.
- I know that my child's participation is voluntary and that I can withdraw him/her from the project at any stage without giving any reason.
- I know that my child can withdraw from the project him/herself from the project at any time without giving any reason.
- I am aware that results will be kept confidential.

By signing below you are agreeing to the above statements and giving informed consent for ______________________________ to participate in the above study.

Signed: ______________________________

Print Name: ______________________________

Relationship to the participant: ______________________________

Date: ______________________________

Information Script for Children

Active Classrooms: Classroom Intervention to Improve Physical Activity Levels of Children

Hello everyone,

I am here today because your school has been asked to take part in a project. You all will be asked if you would like to take part.

I want to find out if a new programme of English and Maths lessons taught using active methods helps children to be more active during the school day. This means that you may be physically active while learning English and Maths.

You do not have to take part if you do not want to. You can talk about it with your parents and then decide. We have given your parents some information about the project in a letter, and they have agreed to let you take part if you wish to do so.

If you do want to take part you will be asked to wear this little device [*show accelerometer*]. You wear it on the elastic belt [*show elastic belt*] around your waist, over your uniform or school tracksuit and it measures how active you are each day. Your teacher will give you the accelerometer at the start of the school day and collect it before you leave at the end of the day. You can use this poster to keep count of the days you wear the accelerometer.

Your weight and height measures will be taken individually in the classroom at the beginning of the study. Nobody else will see your measures and they will be kept private in my study. You may also be asked to draw a picture and write about your experiences of English and Maths lessons now and again during the last week of the programme. Some of you may be randomly selected (like being pulled out of a hat) to tell me about your pictures in a group discussion. Again you do not have to do this if you do not wish to.

Does anyone have any questions?

Appendix J: Participant information sheets and consent forms (cont'd)

Child Information Leaflet

Child Information Sheet

Active Classrooms:
A classroom intervention to improve the physical activity levels of children.

Rosemarie Martin M.Ed, B.Ed.
Mary Immaculate College

COLÁISTE MHUIRE GAN SMÁL
OLLSCOIL LUIMNIGH
MARY IMMACULATE COLLEGE
UNIVERSITY OF LIMERICK

If you have questions about the study or do not understand something, you may contact:
Rosemarie Martin,
Tel: 083 4188726
Email: rgiltenane@gmail.com

If you have any concerns about this study and wish to speak to someone independent, you may contact:
MIREC Administrator,
Mary Immaculate College,
South Circular Road, Limerick.
Tel: 061 204515
Email: mirec@mic.ul.ie

Active Classrooms
A classroom intervention to improve the physical activity levels of children.

Child Information Leaflet (cont'd)

Information for children

Hello!

You and your school have been chosen to take part in a new and exciting project called Active Classrooms. This leaflet will tell you all about the project. When you have read it, you and your parents can decide if you would like to take part.

What is the study about?

We want to find out if a programme that integrates physical activity into English and Maths lessons helps children to be more active throughout the school day.

What happens if I take part?

- A person called a researcher will visit your school.
- You will be asked to wear an accelerometer (like in the picture on this page) in school, each day during the first and last weeks of the programme and in four months' time. This measures the amount of activity that you do.
- Your teacher will give you the accelerometer at the start of the school day and collect it before you leave at the end of the day.
- Your weight and height measures will be taken individually, by the researcher, in your classroom. Your results will be kept private.
- If you are in an intervention school you will also need to do other things which are explained under 'Intervention Schools' on this page.

Intervention Schools:

Some schools will be selected to have active lessons. If you are in one of these schools as well as wearing the accelerometer, you will also be asked to do the following:

- Write and draw about your experiences of English and Maths lessons.
- You may also be selected to talk about your drawings to the researcher in a small group with other children from your class.

Other things you should know.

You do not have to take part in the project if you do not want to. If you decide to take part and then change your mind that is ok with me.

I will share the findings with other people who are interested in the project but won't use your name so people won't know who you are.

If you have any worries about taking part you can talk to me or to your teacher or parents.

What do I do now?

When you have read this leaflet talk to a parent or carer about taking part. We have also given them a leaflet to tell them all about the study so you can decide together.

Enclosed with this information you will find a form marked 'Child's Consent Form'. We would like you to read and sign the form and return it to your school.

Appendix J: Participant information sheets and consent forms (cont'd)

Child Assent Form

Active Classrooms: A classroom intervention to improve the physical activity levels of children.

My name is ________________________________. I agree to take part in the study. I know that I don't have to participate if I don't want to. I know that whenever I feel like stopping that's okay, I won't get in trouble and I don't have to say why I feel like stopping. I know that I will have to wear an accelerometer and I know that I don't have to if I don't want to, or I can stop wearing it at any time without getting into trouble or giving a reason. I know my weight and height will be measured once. I know I may be asked to draw pictures and write a few lines about my experiences of English and Maths lessons now and in the last week of the study.

I know this isn't a test or an exam and by participating I am just helping out the teacher from Mary Immaculate College.

Please tick the box below if you would like to be in with a chance of being selected to chat to the teacher from Mary Immaculate College about your experiences of English and Maths lessons.

Yes, I would like to share my experiences with the teacher from Mary Immaculate College in a group, with others from my class, if I am selected. ☐

Appendix J: Participant information sheets and consent forms (cont'd)

Focus Group: Parental Information and Consent Form

Active Classrooms: Classroom Intervention to Improve Physical Activity Levels of Children

Dear Parent/ Guardian/Carer,

Your child and 3 of his/her classmates have been randomly selected to participate in a group discussion with the researcher about their experiences of the above programme. The children's drawings and written passages about the active lessons will form a basis for the discussion to evaluate their enjoyment of the Active Classrooms programme. The discussion will be recorded for the researcher's use only and recordings will not be made publically available. All identifying information will be kept confidential. Participation in the focus groups is voluntary and your child can withdraw from the discussion at any time.

If your child agrees to participate and if you would like your child to take part in the focus group discussion please read, complete and return the consent sheet attached:

Appendix J: Participant information sheets and consent forms (cont'd)

Focus Group: Parental Information and Consent Form

Active Classrooms: Classroom Intervention to Improve Physical Activity Levels of Children

Please read the following statements:

- I have read and understood the parent/guardian/carer information sheet and have had due time to consider it.
- I understand what the project is about, and what the results will be used for.
- I am fully aware of all of the procedures involving my child, and of any risks and benefits associated with the study.
- I know that my child's participation is voluntary and that I can withdraw him/her from the project at any stage without giving any reason.
- I know that my child can withdraw from the project him/herself from the project at any time without giving any reason.
- I am aware that results will be kept confidential.

By signing below you are agreeing to the above statements and giving informed consent for ______________________________ to participate in the focus group discussion.

Signed: ____

Print Name: ____

Relationship to the participant: ____

Date: ____

Appendix K: Links between the components of the 'COM-B' model of behaviour and the intervention functions (Michie *et al.* 2008), replicated from Martin and Murtagh (2015a)

Model of Behaviour: Sources	Why are teachers not using physically active teaching methods?	What needs to change?	Education	Persuasion	Training	Environmental Restructuring	Modelling	Enablement
Capability-Psychological	• Teachers lacking skills to implement physically active methods (Darmody *et al.* 2010, McCoy *et al.* 2012)	• Professional development/ training needs to be provided to teachers • Development of action plans/goal setting	✓		✓			✓
Motivation-Reflective and Automatic	• Teachers preference for direct instruction (McCoy *et al.* 2012) as active methods require much more preparatory work (Niemi 2002) • Overloaded curriculum and a lack of time (Niemi 2002) • Teachers' negative beliefs, perceptions and attitudes towards physical activity in the classroom (Morgan and Hansen 2008)	• Teachers must plan to use physically active methods and develop a habit of using them. • Believe in the benefits of physically active methods by teachers (information sessions) • Teachers must want to increase physical activity levels. • Provision of integrated lesson plans and resources	✓	✓		✓	✓	✓
Opportunity-Physical	• Space constraints within the classroom and large class sizes pose logistical constraints (McCoy *et al.* 2012) • Poor teaching and learning resources (Niemi 2002)	• Use of physically active methods with large groups of children even in classrooms with space constraints • Provision of resources				✓		✓

Appendix L: Examples of trial intervention features mapped onto behaviour change taxonomy and techniques (BCT), replicated from Martin and Murtagh (2015a)

Taxonomy	Intervention Function	BCT	Definition	Example in Active Classrooms Intervention
Shaping Knowledge	Training	Instruction on how to perform a behaviour	Advise or agree on how to perform the behaviour (includes skills training)	Provide an individual information session and a sample of lesson plans to each participating teacher illustrating how to integrate physically active methods into English and Maths lessons
Associations	Education, Environment Restructuring	Prompts/ cues	Introduce social stimulus with the purpose of prompting the behaviour	Text message at the beginning of each week prompting the use of active methods. Poster to display in the classroom requiring daily ticks when active lessons have been taught.
Comparison of outcomes	Persuasion	Persuasive source	Present verbal or visual communication from a credible source in favour of the behaviour	Present results of PAAC programme (Donnelly *et al.* 2009) to show increase in PA levels of children in the classroom
Feedback and Monitoring	Enablement	Self- monitoring of behaviour	Establish a method for the person to monitor and record their behaviour as part of a behaviour change strategy	Teachers keep a log of lessons taught using PA methods to include date, time, lesson, and duration of PA
Repetition and Substitution	Training	Behaviour Substitution	Prompt substitution of the unwanted behaviour with the wanted behaviour	Replace inactive teaching methods with physical activities in teaching English and Maths
	Training	Habit reversal	Prompt repetition of the wanted behaviour to replace the unwanted habitual behaviour	Use active methodologies as often as possible to replace habitual inactive methods
	Training	Generalisation of a target behaviour	Advise to perform the wanted behaviour already performed in a particular situation, in another situation	Advise to use active methods across other topics in English and Maths and in other subject areas
Antecedents	Environment Restructuring	Restructuring the physical environment	Advise to change the physical environment in order to facilitate the performance of the wanted behaviour	Advise to arrange desks in the classroom to allow space for movement

Appendix L: Examples of trial intervention features mapped onto behaviour change taxonomy and techniques (BCT), replicated from Martin and Murtagh (2015a) (Cont'd)

Taxonomy	Intervention Function	BCT	Definition	Example in Active Classrooms Intervention
Comparison of behaviour	Education	Information about others' approval	Provide information about what other people think of the behaviour. The information clarifies whether others will like, approve or disapprove of what they are doing.	Share anonymous feedback from the teachers who implemented the pilot on what they thought of the programme
Goals and Planning	Enablement	Problem solving	Analyse factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators	Teachers complete a reflective exercise to analyse factors influencing the behaviour and engage in discussion with the researcher to generate strategies that include overcoming barriers and/or increasing facilitators
	Enablement	Goal setting (behaviour)	Set or agree a goal defined in terms of the behaviour to be achieved	Eg. Plan to teach using PA methods in at least two lessons each day (one English and one Maths)
	Enablement	Action planning	Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity)	Prompt to plan to teach a lesson using PA methods for at least 10 minutes twice a day during English and Maths lessons.

Appendix M: Teacher training workshop agenda: replicated from Martin and Murtagh (2015a)

Agenda Item	Description
Introduction to Active Classrooms	• Brief description of inactivity problem in primary school children • Role classroom teachers can play • Active Classrooms integrates physical activity into academic content with a focus on English and Mathematics • Physically active teaching methods • Does not reduce academic teaching time
Physically Active Methods	• Explanation of physical activity as any type of movement • Explanation of moderate and vigorous physical activity • Examples of physically active teaching methods for English and Mathematics • Preparation of the classroom environment
Reflective Exercise	• Teacher analyses his/her current teaching style, asks him/herself if they could implement this intervention? Why/why not? • Teacher engages in discussion with the researcher exploring ideas to overcome barriers
Lesson Planning	• Researcher shares sample lesson plans for physically active Mathematics and English lessons
Conclusion	• Intervention Timeline • Researcher contact details • Support available

Appendix N: Standard operating procedures for weight and height measures

Procedure for measuring weight:

1. Remove shoes, coats, jumpers, items in pockets and jewellery
2. Stand in the center of the scale with weight evenly distributed on both feet
3. With hands by sides, stand as still as possible
4. Weight is recorded in kg to the nearest 0.1kg on a Seca Corp digital scale, model #899 (Germany)

Procedure for measuring height:

1. Remove shoes and any head piece which may affect recording of height
2. Stand on 'footprints' with heels together and touching the backstop
3. Stand straight, arms by sides with shoulder blades and buttocks touching the scale
4. Look straight ahead so that the eye is in line with the flap of the ear
5. Headboard is placed firmly onto the head, compressing hair as much as possible
6. Height is recorded to the nearest centimetre on a Seca Corp stadiometer, model #214 Road Rod (Hanover, MD)

Appendix O: Sample of student write and draw worksheet

Name: ______________________________

Please **draw** yourself in an **English lesson** and in a **Maths lesson** and **write a few sentences to tell me about each one**:

<u>Week 8:</u>

English Lesson:
____
____
____
____
____
____

Maths Lesson:
____
____
____
____
____
____

Appendix P: Sample open ended questions from the teacher questionnaire adapted from the 'ToyBox' study (Androutsos et al. 2014)

---

1) Please outline any difficulties/ challenges you found while implementing the intervention programme:
2) Please outline any strengths/weaknesses of the intervention programme:
3) How likely are you to continue using the active lesson ideas after the study? Please state a reason for your answer.
4) Please state any changes you would make to improve the intervention to enhance teaching or learning while also encouraging physical activity in the classroom:

Appendix Q: Letters of Acceptance for Publication

Chapter 2 - Part B: Research Quarterly for Exercise and Sport

Decision Letter (15-09-PED-06.R1)

From: weimozhu@uiuc.edu

To: rgiltenane@gmail.com

CC:

Subject: Research Quarterly for Exercise and Sport - Decision on Manuscript ID 15-09-PED-06.R1

Body: 03-Feb-2017

Dear Ms. Martin:

PLEASE READ THIS ENTIRE LETTER. IT CONTAINS IMPORTANT INSTRUCTIONS ABOUT YOUR PAPER.

I am pleased to inform you that your revised paper 'Systematic Review of the Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes' is accepted for publication in Research Quarterly for Exercise and Sport. Your next step is to prepare the final manuscript that will be published. At the bottom of this letter, I have enclosed the Associate Editor’s, reviewers', and my comments on the manuscript. As you prepare the final manuscript, please incorporate these comments. I will check the manuscript to make certain all comments have been addressed. PLEASE UPLOAD A SEPARATE WORD DOCUMENT FILE INDICATING HOW YOU ADDRESSED THE COMMENTS. DO NOT INCLUDE THIS FILE AS PART OF YOUR MAIN DOCUMENT FILE.

Please check to make sure that all aspects of the manuscript conform to APA/RQES format and style requirements including indenting each paragraph, and ADDING YOUR AUTHOR INFORMATION ON THE TITLE PAGE.

To assist you with this process, I have enclosed a checklist of these requirements. As a part of the final check, please make sure that all your references are correctly presented and that there is a 100% correspondence between what you cite in the body of your paper and what appears in the reference list. In addition, please remove any colored font or other highlighting, and delete any responses to the reviewers that may have appeared in the previous version of the manuscript.

It is very important that you prepare everything—in particular tables and figures—according to the checklist. Doing so will eliminate additional requests for revisions either from our office or during the publishing process.

Please complete and sign the attached release form. Please attach it with the final manuscript. ATTACH THE FORM AT THE END OF THE MANUSCRIPT AS A SEPARATE FILE. Please upload the form as a copyright Form file.

To revise your manuscript, log into http://mc.manuscriptcentral.com/rqes and enter your Author Center, where you will find your manuscript title listed under "Manuscripts Accepted for First Look." Under "Actions," click on "Submit Updated Manuscript." Please follow the instructions and complete each step carefully.

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer.

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Please be aware that your accepted manuscript will be subject to editing at the page proof stage by the managing editor and copy editor. Approximately 2 - 6 weeks after your manuscript clears First Look, you will receive page proofs from the managing editor for the online publication of your article on iFirst. If you have any questions about when your paper will appear, please contact me at RQESjournal@illinois.edu.

Thank you for your fine contribution. On behalf of the Associate Editors and the Editorial Board of the Research Quarterly for Exercise and Sport, we look forward to your continued contributions to the Journal.

Sincerely,
Dr. Weimo Zhu
Editor-in-Chief, Research Quarterly for Exercise and Sport
weimozhu@uiuc.edu

Associate Editor
Comments to the Author:
(There are no comments.)

Reviewers' Comments to Author:

Reviewer: 1

Comments to the Author
This is a very timely paper that addresses a very important topic related to physical activity, academic achievement, and health. The authors have greatly improved the manuscript with their edits and responses to the reviewers' comments.

Date Sent: 03-Feb-2017

File 1: * URQE-Copyright-Form.pdf

File 2: * APA-RQES-style-checklist-First-Look-2015.pdf

Appendix Q: Letters of Acceptance for Publication (Cont'd)

Chapter 5: Journal of Physical Activity and Health

Decision Letter (JPAH.2016-0358.R1)

From: eic_jpah@hkusa.com, eic-jpah@hkusa.com

To: rgiltenane@gmail.com

CC:

Subject: Journal of Physical Activity & Health - Decision on Manuscript ID JPAH.2016-0358.R1

Body: 22-Nov-2016

Dear Ms. Martin:

Congratulations. It is a pleasure to accept your manuscript entitled "Active Classrooms: A Cluster Randomized Controlled Trial Evaluating the Effects of a Movement Integration Intervention on the Physical Activity Levels of Primary School Children" JPAH.2016-0358.R1 in its current form for publication in the Journal of Physical Activity & Health.

Upon receipt of this letter, please complete a title page (e.g., list all author names in the desired order, provide detailed affiliations for each author, and supply the contact information for the corresponding author), then log-in to Manuscript Central and upload the title page. Please be certain that the information provided is correct.

JPAH is now participating in Human Kinetics' In Press program, which allows for early online publication of all articles, submission to PubMed, and assignment of a DOI. However, the journal cannot process your manuscript for In Press publication until you have submitted the title page. An e-mail will be sent to you, including notice of your publication date, when your article is posted in the In Press section.

When it is appropriate, you will receive galleys to review and any other pertinent information from our Managing Editor. When the galley proofs from your manuscript are available, please review them very carefully and respond to Human Kinetics, following their instructions, within 48 hours. To avoid production delays, please respond with your changes in an expeditious manner.

Please be aware that substantive changes to text CANNOT be made after a manuscript has been submitted for publication. In addition, NO changes can be made to figures after a manuscript has been submitted to the publisher. If an error is found in a figure, please contact Avinash Chandran immediately at jpah@hkusa.com. Any request for changes may result in removal of your paper from its assigned issue and placement in a later issue, as space permits.

Should you have a change of address during the publication phase, please notify Avinash Chandran and he will notify the publisher. If you have any questions, please contact him at jpah@hkusa.com.

Again, congratulations on the acceptance of your manuscript and thank you for your support of JPAH.

Sincerely,
Catrine Tudor-Locke, PhD, FACSM, FNAK
SENIOR associate Editor
Journal of Physical Activity & Health

Date Sent: 22-Nov-2016

Appendix Q: Letters of Acceptance for Publication (Cont'd)

Chapter 6: Teaching and Teacher Education

Ms. Ref. No.: TATE-D-16-00677R2
Title: Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme
Teaching and Teacher Education

Dear Rosemarie,

I am pleased to confirm that your revised paper "Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme" has been accepted for publication in Teaching and Teacher Education. We have read your revised manuscript and see that you have attended to the concerns raised by the reviewers. We appreciate the ways that you incorporated the recommendations into your revisions.

Thank you for submitting your paper to Teaching and Teacher Education and we look forward to seeing it in print.
If you are not already registered as a reviewer, we ask that you please go to the TATE site and do so. Reviewing manuscripts for TATE is something we ask of our authors.
Your accepted manuscript will now be transferred to our production department and work will begin on creation of the proof. If we need any additional information to create the proof, we will let you know. If not, you will be contacted again in the next few days with a request to approve the proof and to complete a number of online forms that are required for publication.

When your paper is published on ScienceDirect, you want to make sure it gets the attention it deserves. To help you get your message across, Elsevier has developed a new, free service called AudioSlides: brief, webcast-style presentations that are shown (publicly available) next to your published article. This format gives you the opportunity to explain your research in your own words and attract interest. You will receive an invitation email to create an AudioSlides presentation shortly. For more information and examples, please visit http://www.elsevier.com/audioslides.

Yours sincerely,

Robert C. Kleinsasser, PhD
Associate Editor
Teaching and Teacher Education

Appendix R: Statements of Authorship

Chapter 2: Part B:

> **Article Title**: Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review, (In Press), *Research Quarterly for Exercise and Sport,* (impact factor 1.702).

Statement of authorship:

We hereby declare that Rosemarie Martin (Ph.D. candidate) is the principal author of this article. The following statements outline her contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

Signed: ______________________________

(Ph.D. candidate)

Signed: ______________________________

(Supervisor & Co-author)

Appendix R: Statements of Authorship (cont'd)

Chapter 3

Article Title: 'Preliminary Findings of Active Classrooms: An Intervention to Increase Physical Activity Levels of Primary School Children During Class Time', *Teaching and Teacher Education*, 52, 113-127 (impact factor 1.82).

Statement of authorship:

We hereby declare that Rosemarie Martin (Ph.D. candidate) is the principal author of this article. The following statements outline her contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

Signed: ______________________________

(Ph.D. candidate)

Signed: ______________________________

(Supervisor & Co-author)

Appendix R: Statements of Authorship (cont'd)

Chapter 4

Article Title: 'An Intervention to Improve the Physical Activity Levels of Children: Design and Rationale of the 'Active Classrooms' Cluster Randomised Controlled Trial', *Contemporary Clinical Trials*, 40, 180-191 (impact factor 2.05).

Statement of authorship:

We hereby declare that Rosemarie Martin (Ph.D. candidate) is the principal author of this article. The following statements outline her contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

Signed: ______________________________

(Ph.D. candidate)

Signed: ______________________________

(Supervisor & Co-author)

Appendix R: Statements of Authorship (cont'd)

Chapter 5

Article Title: 'Active Classrooms': A Cluster Randomised Controlled Trial Evaluating the Effects of a Movement Integration Intervention on the Physical Activity Levels of Primary School Children', (2017 in press), *Journal of Physical Activity and Health*, (impact factor 1.88).

Statement of authorship:

We hereby declare that Rosemarie Martin (Ph.D. candidate) is the principal author of this article. The following statements outline her contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

Signed: ______________________________

(Ph.D. candidate)

Signed: ______________________________

(Supervisor & Co-author)

Appendix R: Statements of Authorship (cont'd)

Chapter 6

Article Title: 'Teachers' and Students' Perspectives of Participating in the 'Active Classrooms' Movement Integration Programme', *Teaching and Teacher Education*, 63, 218-230, (impact factor 1.82).

Statement of authorship:

We hereby declare that Rosemarie Martin (Ph.D. candidate) is the principal author of this article. The following statements outline her contributions to the work:

- Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; AND
- Drafting the work and revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (ICMJE 2014).

Signed: ______________________________

(Ph.D. candidate)

Signed: ______________________________

(Supervisor & Co-author)

Appendix S: Copyright Permissions

The following information outlines the publishing companies copyright permission policies regarding using the content of my published articles in this thesis:

Elsevier

Personal use

Authors can use their articles, in full or in part, for a wide range of scholarly, non-commercial purposes as outlined below:

- Use by an author in the author's classroom teaching (including distribution of copies, paper or electronic)
- Distribution of copies (including through e-mail) to known research colleagues for their personal use (but not for Commercial Use)
- Inclusion in a thesis or dissertation (provided that this is not to be published commercially)
- Use in a subsequent compilation of the author's works
- Extending the Article to book-length form
- Preparation of other derivative works (but not for Commercial Use)
- Otherwise using or re-using portions or excerpts in other works

These rights apply for all Elsevier authors who publish their article as either a subscription article or an open access article. In all cases we require that all Elsevier authors always include a full acknowledgement and, if appropriate, a link to the final published version hosted on Science Direct.

Accessed from: https://www.elsevier.com/about/our-business/policies/copyright/personal-use, date accessed 17.05.17.

Human Kinetics

The authors explicitly reserve the following rights:

- All proprietary rights other than copyright, such as patent rights.
- The right to use all or part of this article in future works of their own, such as dissertations, lectures, reviews, or textbooks.
- The right to make copies for their own teaching use.
- The right to use original figures and tables in future publications, provided explicit acknowledgment is made of their initial appearance in this journal.
- The right to post an electronic version of the final manuscript, as accepted for publication, on the authors' own Web site or Web site(s) or other electronic repositories controlled by the authors' institution, provided that the electronic version is in PDF or other image-capturing format. The posted version must contain the words "As accepted for publication in *Journal of Physical Activity and Health*, ©Human Kinetics" and include the DOI link to the article or, if no DOI is available, a URL link to the article's abstract page.

From: *Transfer of Copyright: Journal of Physical Activity and Health* (2015)

Taylor and Francis

Dear Ms. Martin,

We are in receipt of your request to reproduce your article for use in your dissertation

Rosemarie Martin & Elaine M. Murtagh (2017)
Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review
Research Quarterly for Exercise and Sport 88 (2):149 -168.
DOI: http://dx.doi.org/10.1080/02701367.2017.1294244

You retain the right as author to post your Accepted Manuscript on your departmental or personal website with the following acknowledgment: "This is an Accepted Manuscript of an article published in *Research Quarterly for Exercise and Sport* online [March 22, 2017], available online: http://www.tandfonline.com/doi/full/10.1080/02701367.2017.1294244

An embargo period of eighteen months until September 22, 2018 applies for this Accepted Manuscript to be posted to an institutional or subject repository.

This permission is all for print and electronic editions.

This permission is for non-exclusive English world rights. This permission does not cover any third party copyrighted work which may appear in the material requested.

Full acknowledgment must be included showing author, year published, article title, and full Journal title, reprinted by permission of the Society of Health and Physical Educators, (http://www.shapeamerica.org).

Thank you very much for your interest in Taylor & Francis publications. Should you have any questions or require further assistance, please feel free to contact me directly.

Appendix T: Differences between thesis content and published articles

- Abbreviations PA, PE and MVPA have been used for consistency throughout the thesis.

Chapter 3:

Section 3.4.1

- The primary outcome is minutes ~~per day~~ and percentage time in MVPA during the intervention lessons

Section 3.8.1

- Table 5 in the published article has been replaced with Table 3.5 as shown below:

-	~~Sedentary~~	~~Light~~	~~Moderate~~	~~Vigorous~~	~~MVPA~~	~~Lesson Duration~~
~~Intervention English lessons~~	~~6.1~~	~~10.1~~	~~1.6~~	~~2.4~~	~~4.0~~	~~20.2~~
~~Intervention Maths lesson~~	~~5.3~~	~~7.4~~	~~1.8~~	~~2.2~~	~~3.9~~	~~16.6~~
~~Mean daily intervention lessons~~	~~11.4~~	~~17.6~~	~~3.4~~	~~4.6~~	~~8.0~~	~~36.8~~
~~Comparison lessons~~	~~25.8~~	~~7.1~~	~~0.3~~	~~0.0~~	~~0.3~~	~~33.3~~

Table 3.5:

n = 20	Comparison lessons mins per day (SD)	Intervention lessons mins per day (SD)	P Value
Sedentary	25.8 (2.7)	11.4 (2.2)	<.001
LPA	7.1 (2.1)	17.6 (1.9)	<.001
MPA	0.3 (0.2)	3.4 (0.8)	<.001
VPA	0.0 (0.1)	4.6 (1.2)	<.001
MVPA	0.3 (0.2)	8.0 (1.6)	<.001
MVPA boys (*n* = 7)	0.4 (0.3)	7.5 (1.7)	<.001
MVPA girls (*n* = 13)	0.2 (0.2)	8.3 (1.6)	<.001
Lesson duration (mins)	33.3	36.8	

Note: P values refer to differences between intervention lessons and comparison lessons

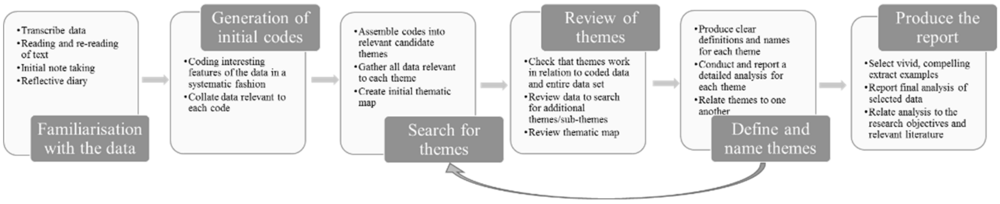
Chapter 4:

Section 4.3.1

- The primary outcome will be change in class time (inserted) minutes of moderate-to vigorous-intensity physical activity (MVPA) measured using accelerometers at baseline, post intervention and four months follow-up

Appendix T: Differences between thesis content and published articles (cont'd)

<u>Chapter 6:</u>



- Figure 4 (above) in the published article has been updated to the following:

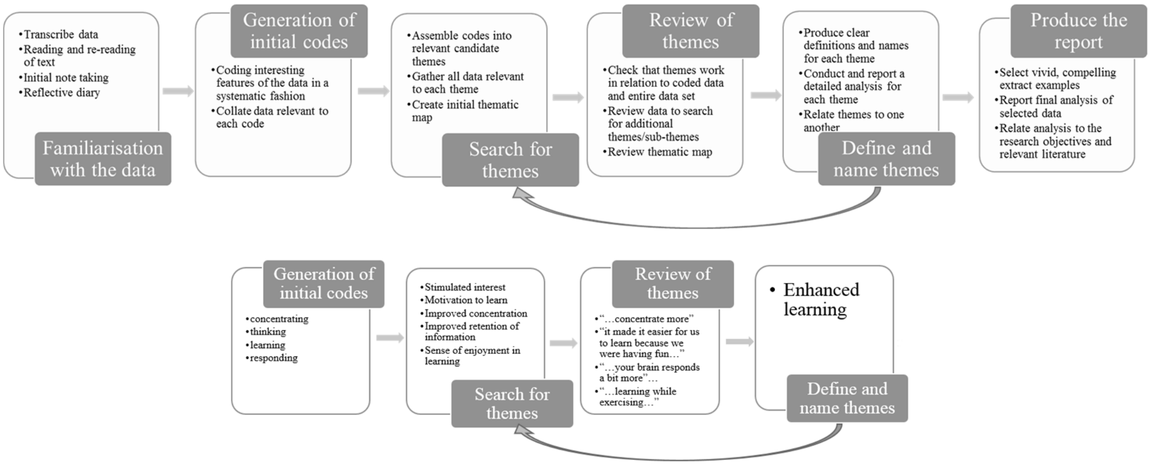


Figure 6.4 Thematic Analysis Flow Chart based on Braun and Clarke (2006) and its application in the development of the 'enhanced learning' theme