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

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

1.1 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

1.2 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.

1.3 Methods

1.3.1 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.

1.3.1.1 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.

1.4 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.

1.5 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.

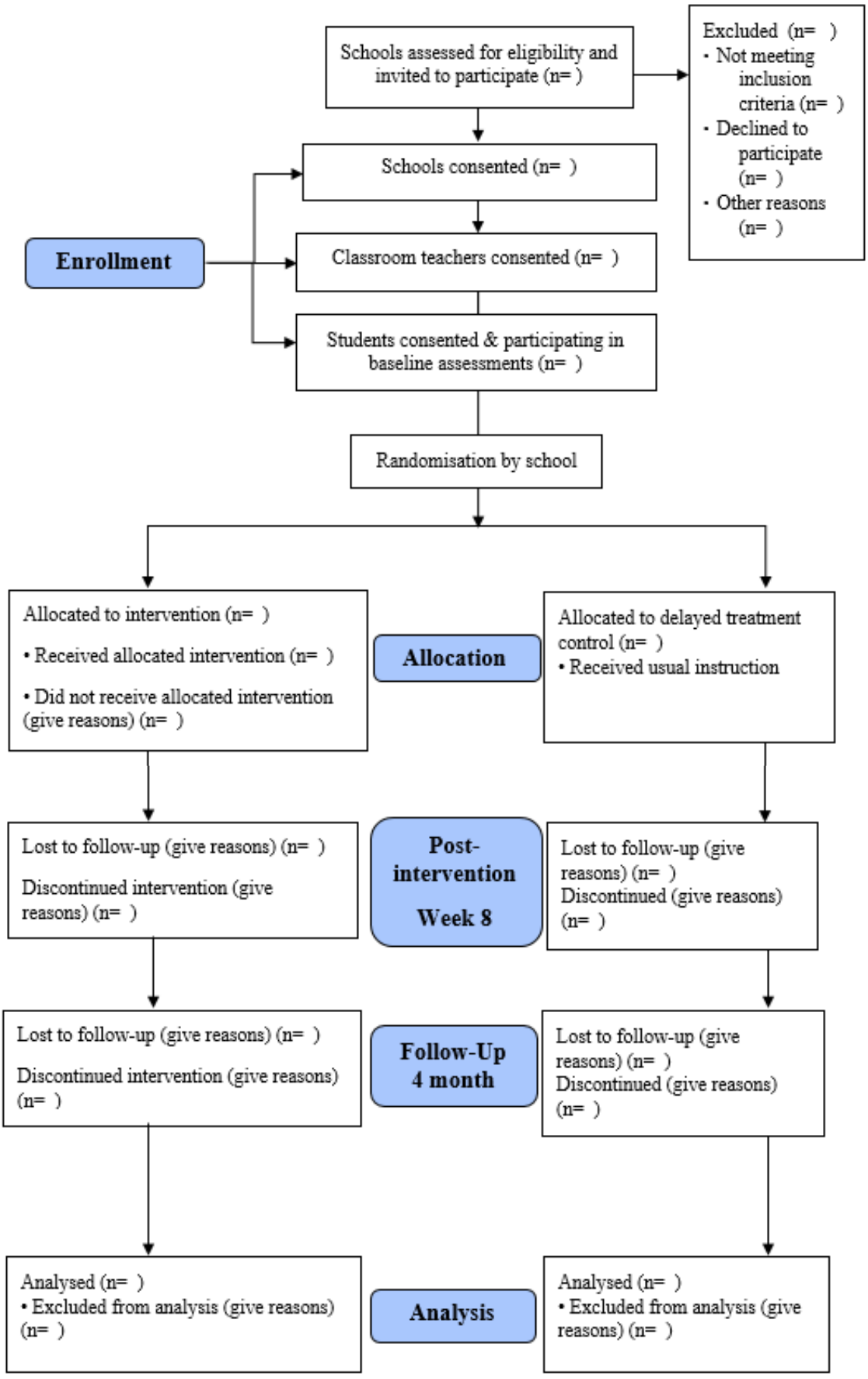

Figure 4.1 Flow of participants through Active Classrooms

1.6 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.

1.7 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.

1.8 Physical Activity Intervention

1.8.1 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.

1.8.1.1 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.

1.8.1.2 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.

1.9 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).

1.10 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.

1.11 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.

1.12 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.

1.12.1 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.

1.13 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.

1.14 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.

1.15 References

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