School Day Intervention Opportunities for Increasing 7-11 Year Old Children's Moderate To Vigorous Physical Activity.

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A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy

April 2011

Acknowledgements

This work was completed in the Faculty of Education, Community and Leisure, of Liverpool John Moores University and was supported by the award of a studentship from Liverpool John Moores University.

First and foremost, I would like to thank my Director of Studies Dr Stuart Fairclough for his guidance and patience through the process of the thesis. I know it's taken a long time to get to this point, but thank you for the opportunity and all your help and support Stu! I would also like to thank Professor Gareth Stratton for all his advice over the course of the thesis.

Secondly, I would like to take the opportunity to thank the schools, staff and children involved in the studies contained within the thesis, as without them it would not have been possible. In particular, I would like to thank Julie Wiseman and Sarah Linton for all their hard work in delivering the Blackpool Intervention.

Finally, I would like to thank my friends and family for all their love and support over the past 7 years. I know it's taken a long time, but I hope that you can be proud. Charlotte, I couldn't have got through the past couple of years without you. Skippy & Ange, thank you for always being there, no matter what. Most importantly, thank you to my beautiful husband Myles, who has been there through the good times and picked me up through the bad times - I love you.

"Everything is of its own time." (Christopher Luke, 2011)

LIVERPOOL JOHN MOORES UNIVERSITY

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Abstract

The development and maintenance of healthy physical activity behaviours from an early age is a priority for public health in the UK. Schools provide a number of different opportunities (time inside and outside of the curriculum) and resources in the form of space, equipment and staff for children to learn and develop healthy behaviours, at a time when they are most receptive to behaviour change. The overall aim of the thesis was to identify the different opportunities within the school context whereby children could be physically active and use theoretically driven, whole school interventions to optimise and subsequently increase healthful physical activity. Study 1 demonstrated that primary schools wishing to use pedometers within their curricula can be confident that the EZ-V model is sufficiently accurate to measure physical activity in the form of steps taken (r=0.897). Using the EZ-V pedometer, Study 2 demonstrated that feedback from pedometers along with information on how children can be physically active during the school day, can significantly increase children's mean daily steps·min^{-1} compared to feedback alone or control groups over the course of a school week. Furthermore, boys were significantly more active than girls across each treatment group.

Study 3 explored the affect of the primary school travel plan (TP) on the moderate to vigorous physical activity (MVPA) of 7-11 year olds during the winter and summer season. In order to examine the impact of the TP, schools were separated into schools deemed to have an Established TP (implemented for at least 2 years) or 'New' schools (i.e., had just drafted their TP and were in the first year of its implementation). Children in the New TP schools accumulated 7.24 (winter) and 24.11 (summer) more minutes of MVPA (5.2% and 15.66% respectively) throughout the day compared with those in the

Established TP school children ($F_{(1,35)} = 0.955$, $p=0.207$, $d=0.33$). Overall, children were more active during the summer by 7.81 minutes ($F_{(1,35)} = 0.089$, $p=0.768$, d=0.1).

The final study examined the affect of a 12 week, multi-component, whole school intervention which aimed to increase children's school day MVPA. Following baseline physical activity measures via accelerometry, intervention components consisting of a Health Week, Playtime Pals and a Pedometer Challenge were delivered sequentially over the first 6 weeks. Subsequent accelerometer data were collected after each intervention was delivered at 2, 4, 6 and 12 weeks. Results showed that from baseline to follow-up, children increased their MVPA by 6.57 minutes during the school day, which according to the Q statistic was likely to be beneficial. Results from the Pedometer Challenge found that boy s' mean pedometer steps·day^{-1} were significantly higher than girls' ($F_{(1,95)}= 9.987$, $p=0.002$, $d=0.65$) and overall, mean pedometer steps·day^{-1} significantly increased from week one to week five ($F_{(1,93)}= 5.845$, $p=0.018$, $d=0.24$). When the lowest and highest active 50% groups were compared, children in the lowest active 50% group significantly increased their steps from week one to week five ($F_{(1,47)}= 20.847$, $p=0.000$, $d=0.93$), while the highest active 50% did not ($F_{(1,47)}= 0.000$, $p=0.990$, $d=0$). Furthermore, boys in the highest active 50% group were found to accumulate significantly more steps than the girls, in the highest active 50% group ($F_{(1,46)}= 14.701$, $p=0.000$, $d=0.81$), while there was no significant difference between the boys' and girls' pedometer steps in the lowest 50% group ($F_{(1,46)}= 0.456$, $p=0.503$, $d=0.14$).

The overall findings of the thesis suggest that schools can successfully optimise the different opportunities during the school day in order to increase children's physical activity, but that larger, controlled and longitudinally designed studies are needed to confirm cause and effect. Most importantly, these changes may have most impact in the least active boys and girls. Interventions such as this should therefore be targeted at the least active children to ensure that they benefit as much as possible from the opportunity to increase their daily physical activity.

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Associated Publications and Presentations

The findings in this thesis have been presented, in part, in the following:

Publications

Butcher, Z.H., Fairclough, S.J., & Stratton, G. (2007). The effect of feedback and information on children's pedometer step counts at school. *Pediatric Exercise Science*, 19: 29-38.

Fairclough, S.J., **Butcher, Z.H.,** & Stratton, G. (2007). Whole day and segmented day physical activity variability in Northwest England school children. *Preventive Medicine*, 44: 421-425.

Fairclough, S.J., Stratton, G. & **Butcher, Z.H.** (2008). 'Primary school children's health-enhancing physical activity patterns: The school as a significant environment?' *Education 3-13*, 36: 371-381.

Peer Reviewed Conference Presentations

Butcher, ZH., Fairclough, SJ., & Stratton, G. (2007). Can a 12 week 'whole school' intervention increase primary school children's physical activity? In the 24th Pediatric Work Physiology Meeting, 5-9 September Tallin, Estonia.

Butcher, ZH., Fairclough, SJ., & Stratton, G. (2006). 'The effect of feedback and information on children's pedometer step counts at school'. In British Association of Sport and Exercise Sciences, University of Wolverhampton.

Butcher, ZH., Fairclough, SJ., & Stratton, G. (2005). 'Accelerometer measured physical activity of children who walk and are driven to school'. In the XXIII Symposium Pediatric Work Physiology, Gwatt, Switzerland, 22-25 September.

List of Abbreviations

ACSM	American College of Sports Medicine
BASH	Be active, stay healthy
CON	Control
DCSF	Department for children, Schools and Families
DfES	Department for Education and Skills
DH	Department of Health
EYHS	European Youth Heart Study
FB	Feedback
FB+I	Feedback and information
FU	Follow up week
HW	Health week
IOTF	International Obesity Task Force
MCID	Minimal clinically important difference
MVPA	Moderate to vigorous physical activity
NICE	National Institute for Health and Clinical Excellence
OFSTED	Office for standards in education
PE	Physical education
PED	Pedometer week
POL	Policy week
PPW	Playtime pals week
SPW	Self-paced walking test
TP	Travel Plan
TWT	Treadmill walking test
WHO	World Health Organisation

Chapter 1 Introduction

1.1 Background

Physical activity is defined as 'any bodily movement produced by the skeletal muscles that results in energy expenditure' (Caspersen *et al.*, 1985, p 126). In contrast, physical inactivity is described as the non-engagement of physical activity 'beyond daily functioning' (CDC, 1996). There is mounting global evidence to suggest that physical inactivity has a substantial negative impact on individual and public, current and future health (Department of Health [DH], 2004). This is because physical inactivity is the main modifiable risk factor contributing to the development of many chronic diseases, such as; obesity, cardiovascular disease, type II diabetes, hypertension, breast and colon cancer, osteoporosis, osteoarthritis, and depression (DH, 2004; Bauman, 2004; Warburton *et al.*, 2006). While these lifestyle-related diseases are primarily associated with adulthood, the numbers of children suffering from diseases such as type II diabetes, hypertension and metabolic syndrome are on the increase (Burke, 2006; Lottenberg *et al.*, 2007; Must & Strauss, 1999; CDC, 1996).

The importance of physical activity in children is from both a physical and a psychological perspective (Parfitt & Eston, 2005; Twisk, 2001). Maintaining a healthy level of physical activity during childhood is essential for healthy growth and development and in maintaining energy balance (DH, 2004). Moreover, despite clinical symptoms not presenting until later life, the origin of many chronic diseases begins in early childhood (Twisk, 2001). From a psychological perspective, moderate intensity physical activity is associated with low levels of anxiety and depression and increased self-esteem in children and adolescents (Mutrie & Parfitt, 1998; Annesi, 2005; Floriani & Kennedy, 2008; Fox & Farrow, 2009). In order to achieve healthy levels of physical activity, current recommendations state that children should participate in a minimum of 60 minutes of at least moderate intensity physical activity each day, and at least twice each week they should take part in activities that improve bone health, muscle strength and flexibility (NICE, 2009). During the pre-pubertal years, insufficient participation in load bearing and high intensity physical activities that promote the development of bone mineral density (BMD) and content (BMC), increase the risk of developing osteoporosis later in life (Biddle *et al.*, 2004), particularly among females (Ondrak & Morgan, 2007). Similar activities are also important for the healthy development of muscle and connective tissues, which are required for strength, balance, co-ordination, functional capacity and metabolism (DH, 2004; NICE, 2009).

Lifestyle and health behaviours relating to physical activity and chronic diseases are learned early at school, when individuals are most receptive (Rogers *et al.*, 1998; McKenna & Riddoch, 2005). It is therefore important that children develop the tools with which to make healthy lifestyle choices by gaining the correct information relating to physical activity and health, as well as the opportunity to gain positive physical activity experiences. Despite the weak to moderate tracking of physical activity from childhood to adulthood (Talema *et al.*, 2005; Azevedo *et al.*, 2007: Kristensen *et al.*, 2008), many adults who do not participate in current physical activity attribute this to negative experiences they had as children, and in particular while they were at school (Stevens, 1996).

In summary, the promotion of children's physical activity has the potential to impact on their current and future physical and mental health (Twisk, 2001; Licence, 2004). It is for this reason that physical activity promotion in children is a public health priority in the UK (Biddle *et al*, 1998; NICE, 2009).

1.2 Approaches to increasing children's physical activity

Schools have been have been used as a vehicle for health promotion in the UK since the 1980's (Denman *et al.*, 2001), and more recently have been identified as key settings for implementing health-enhancing physical activity and healthy eating interventions in the government's battle to prevent and manage overweight and obesity in the UK (NICE, 2009). Traditionally, physical education (PE) has been viewed as the main opportunity for increasing physical activity and sport participation. However, schools also provide a unique context and a number of different opportunities for children to learn and develop healthy behaviours, at a time when they are most receptive to behaviour change (Fox et al., 2004). Children from a full range of socioeconomic backgrounds attend school (in the majority) for approximately 6 hours a day (i.e., 40-45% of waking time) (Fox *et al.*, 2004), five times a week, for approximately 40 weeks of the year. Furthermore, school environments are such that they have, on the whole, the resources (in the form of space, equipment and staff) and opportunity (time in and outside of the curriculum) to deliver and reinforce health promotion strategies. Indeed, research supports the school environment as an opportunity to promote physical activity as it has been found that the majority of children's daily physical activity takes place during the school day (Mota *et al.*, 2008; Fairclough, Butcher & Stratton, 2009; Olds *et al.*, 2009). The opportunities for the promotion of physical activity within the school day are typically separated into discrete periods; the journey to and from school, curriculum time, physical education, 'playtime' or 'recess' and extra-curricular activities. Each of these opportunities will be discussed in more detail in Chapter 2

1.3 Conceptual model for physical activity

Youth physical activity is a complex behaviour which is determined by a number of factors (Welk, 1999; Sallis *et al.*, 2000). In order to design the most appropriate interventions that increase the likelihood of children and adolescents participating in physical activity, they must be based on conceptual models that best explain the exercise behaviour of the population (Welk, 1999; Sallis *et al.*, 2000; Wallace *et al.*, 2000). The limitation in much of the research conducted in physical activity promotion and especially in smaller evaluative studies conducted by local authorities is their lack of theoretical foundation (Dishman, 1994).

Previous studies have applied models to children and adolescents that were developed in adults, however, the ways in which children and adolescents are motivated and influenced differ from that of adults and so these models may not be appropriate in explaining children's behaviours (Welk, 1999). In order to develop more specific behaviour models, authors have identified a number of variables that determine physical activity behaviour in youth. A review of 102 published papers published between 1970-1998, examining the correlates of physical activity of children (*n*=54) and adolescents (*n*=54) conducted by Sallis et al. (2000), evaluated 40 different factors believed to influence physical activity behaviour in children. As a result of their meta-analysis, the authors were able to identify only nine of the forty factors that were consistently associated with the physical activity behaviour of children and adolescents: perceived physical competence, intention, barriers, parental support, direct help from parents, support from significant others, programme/facility access, opportunity to be active, and time outdoors. In 2007, Van der Horst and colleagues developed the work of Sallis et al. (2000) and conducted a more contemporary review (1999-2005) of the correlates of children's and adolescent's physical activity, including low level physical activity and sedentary behaviour. The results of their analyses demonstrated that in children, physical activity was only associated with gender, self-efficacy, parental support and in boys, parental physical activity. These results differ to that of Sallis et al. (2000) as they did not find a correlation between physical activity and environmental factors, access to facilities or opportunity. This difference may have been due to the inconsistency of the studies included in the Van der Horst et al. (2007) review and the different ways that physical activity was measured, supporting the need for consistency and accuracy of measurement when conducting physical activity research with children. In order to help in the development of more effective interventions aimed at increasing physical activity and reducing sedentary behaviours in children and adolescents, Van der Horst et al. (2007) call for more prospective data regarding their determinants of change. In the interim, the results of these reviews do however provide support to social-ecological models and psychological theories (e.g., social cognitive theory (SCT)) which propose that in children and adolescents' physical activity behaviour is influenced by the personal, social and physical environment (Bandura, 1986).

1.3.1 The Social-Ecological Model

The socio-ecological model is a framework through which the inter-related effects of an individual on their environment can be examined (Inman, van Bakergem, Larosa & Garr, 2011). By using a social-ecological framework to design and evaluate intervention programmes that aim to increase children's physical activity in primary schools, it is possible to address the complex reciprocal relationships between the child and the family, school, community and society (Figure 1.1). By designing interventions that address the multiple levels of this model, it is more likely that any change in physical activity behaviour will be maintained (Inman, van Bakergem, Larosa & Garr, 2011). To this end, the World Health Organisation (WHO) has outlined their Health Promoting Schools Framework (WHO, 1996), based on the social-ecological model, through which schools should base their health promotion strategies on. The framework defines a health-promoting school as one that organises its policies, procedures, infrastructure and activities to protect and promote the health and wellbeing of its students, teachers, staff, parents and community. Through the guidance of organisations such as the WHO, social-ecological models are becoming more widely used in health promotion research (Elder *et al.*, 2007).

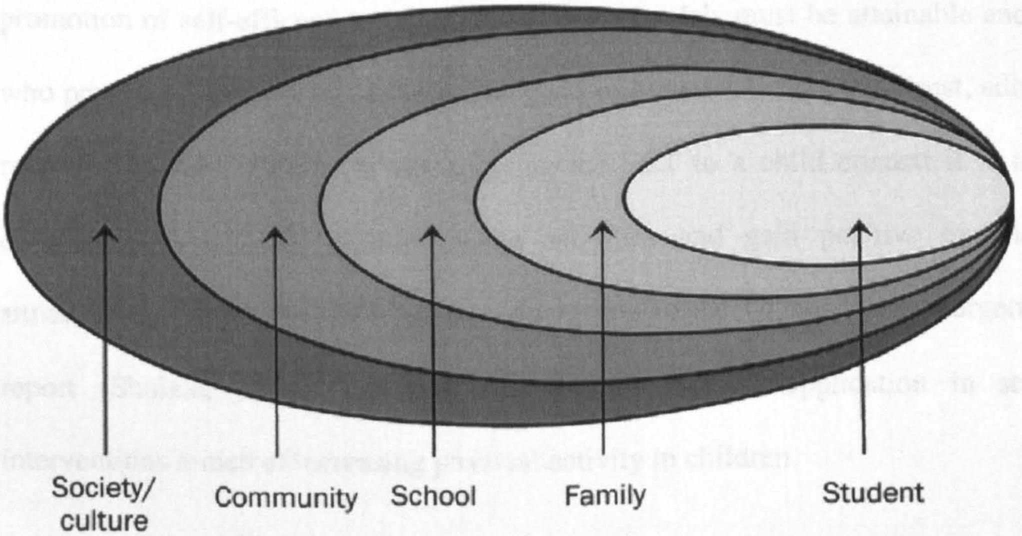

Figure 1.1 The social-ecological model for school based physical activity promotion (taken from Inman, Baergem, LaRosa and Garr, 2011)

1.3.2 Social Cognitive Theory

Bandura's SCT (1986) provides an interactive model in terms of behaviour determinants and suggests that behaviour change is influenced by the reciprocal interaction between an individual and their social and physical environment (Sallis & Hovell, 1990; Wallace *et al.*, 2000), as well as by the attributes of the behaviour itself (Bandura, 1977). Each of the determinants can affect and can be affected by either of the others (Shalala, 1999). Central to the SCT is the concept of self-efficacy, with self-efficacy being a person's belief in his or her ability to succeed in a particular situation (Bandura, 1986). Put simply, in a physical activity context; individuals will only take part in physical activity if they value the activity and believe that they are able to be successful. Furthermore, it is important that individuals gain positive experiences and interact favourably with others and/or the place/situations they encounter while taking part. Bandura (1986) states that self-efficacy can be increased in a number of ways; such as through skill development or training, providing clear instructions and by modelling of the desired behaviour. However, in order for the promotion of self-efficacy to be effective, these models must be attainable and the people who promote them should be viewed as good role models who evoke trust, admiration and respect (Bandura, 1986). When applying the SCT to a child context it is important to consider the way that children value activities and gain positive experiences from situations that promote self-efficacy. According to the United States Surgeon General's report (Shalala, 1999), the SCT has had the widest application in school based interventions aimed at increasing physical activity in children.

1.3.3 Youth Physical Activity Promotion Model (Welk, 1999)

Welk's Youth Physical Activity Promotion (YPAP) model (1999) is a validated (Nahas, Goldfine & Collins, 2003), heuristic model, which aims to bridge the gap between theory and practice to provide a guide for developing physical activity interventions in children and youth (Spence & Lee, 2003). The YPAP model applies some of the SCT principles, taking a broader perspective of the factors that influence physical activity behaviour in children and encompasses the socio-ecological model, which states that environmental factors can have a direct and indirect influence on physical activity behaviour. Furthermore, the YPAP model utilises the Precede-Proceed health promotion planning model in which the specific needs and characteristics of a population are identified before the intervention is established (Green & Kreuter, 1991). Welk (1999) proposes that in each study/intervention aiming to change physical activity behaviour, the first step of its design is to diagnose and identify the primary determinants of the physical activity behaviour in the examined group. These determinants are then organised into factors that predispose, enable or reinforce children to be physically active, depending on the factors' importance and potential for change (Welk, 1999). Finally, interventions are designed and planned according to the available resources and potential barriers.

In light of the present thesis, Figure 1.1 represents the conceptual model of Welk (1999)'s YPAP model, applied to promoting physical activity through the primary school. This model is the theoretical foundation on which the whole-school approach taken in the design and implementation of each of the studies reported in the proceeding chapters is based. By identifying the factors that enable, predispose and reinforce the physical activity of the children in the different schools examined, each intervention study aims to utilise the whole of the school to increase the amount of health enhancing physical activity that children engage in.

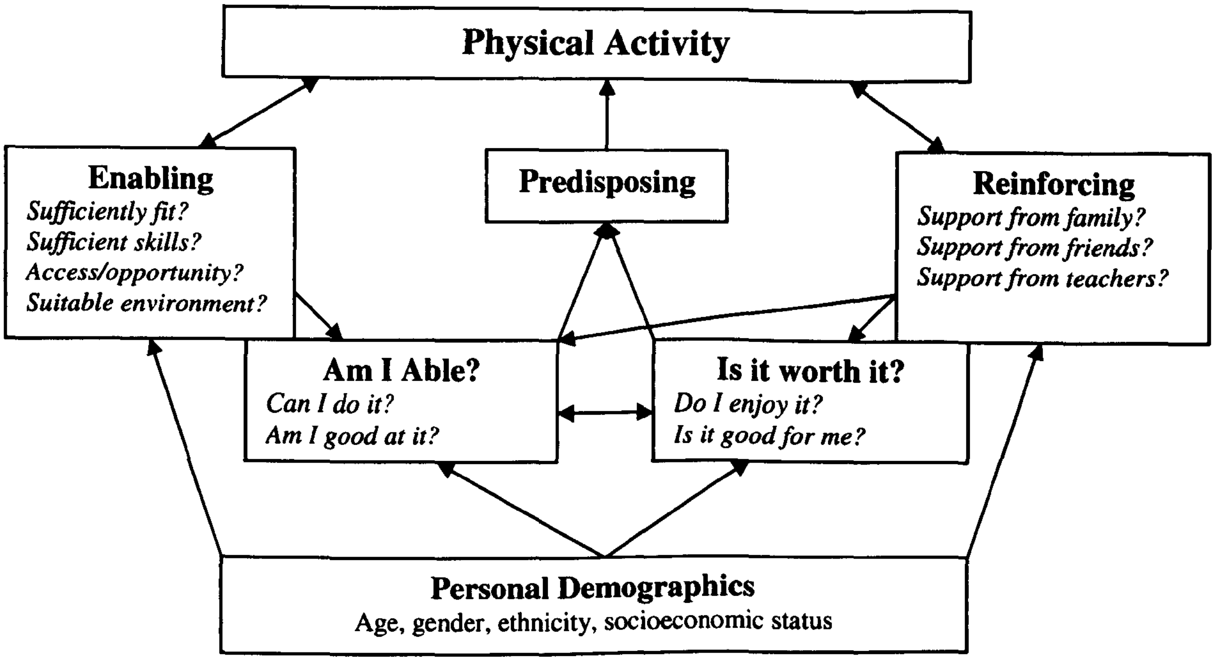

Figure 1.2 Conceptual diagram of Welk's (1999) Youth Physical Activity Promotion Model applied to school-day physical activity.

1.3.4 The Whole School Approach

In its guidance for the prevention and treatment of obesity and the promotion of physical activity in children, NICE (2004, 2009) suggests that schools employ a 'whole school approach'. This is based on the premise that health promotion and education will be most successful if the principles that underpin all that happens within the school actively involve all those connected within the school (Denman *et al.*, 2001). Subsequently, the whole school approach has been promoted by organisations such as NICE (2004, 2009), Healthy Schools (Denman *et al.*, 2001), British Heart Foundation (2004). In the context of the present thesis, the 'whole-school' refers to all of the people (teachers, pupils, staff and parents) and all of the resources (to include the physical buildings; classrooms, playground, gymnasium; as well as equipment e.g. playground games), all of the time (on the way to and from school, during and outside curriculum time, 'play time').

While it is recognised that achieving a whole school approach in its complete sense can be difficult (Denman *et al.*, 2001), by combining the approach with Welk's YPAP model (1999), each of the intervention studies within the present thesis aims to provide children with positive reinforcement regarding physical activity from their peers, teachers, staff, and indirectly (by providing consent for the interventions) from their parents. Through the use of direct feedback via pedometers, the studies aim to enable children to be physically active, through developing feelings of perceived self-competence (Welk, 1999) and in turn, it is hoped that children will enjoy physical activity, predisposing the likelihood of them repeating and maintaining the behaviour. By providing the children with information about the health benefits of physical activity, it is hoped that children will value the behaviour, again increasing the likelihood that they will repeat and maintain the behaviour. Finally, in order to enable the children to take part in physical activity, the intervention studies aim to improve the environment, access and opportunities within the schools (Figure 1.1). This is achieved by providing training to lunchtime supervisors and older peers and by providing supplementary equipment to optimise the lunchtime opportunities. Furthermore, by providing supplementary health related physical education (PE) and additional information on how to increase physical activity, it is hoped that the children will develop sufficient skills to be able to take part in and enjoy the opportunities provided.

1.4 Thesis Organisation

The central theme of the thesis is to examine the affect of interventions aimed at increasing physical activity in primary school children. **Chapter 2** provides a review and critique of the current literature surrounding this theme. The particular focus of the literature review is children's physical activity during the school day; the relative contribution of the school day and the different opportunities within that time to meet children's current physical activity recommendations; and the affects of different interventions aimed to increase physical activity in the school setting. By conducting a critique of the current literature and identifying gaps in the research, Chapter 2 provides the direction and rationale for the research within this thesis. Study 1 is presented in **Chapter 3**, which is the validation of the pedometer used in Chapter 4. **Chapter 4** reports an intervention study which is the first to use pedometers and information as a motivational tool to increase children's physical activity in primary schools. An evaluation of the impact of the school Travel Plan on the physical activity of primary school children in Liverpool during the winter and summer followed and is described and reported in **Chapter 5**. The culmination of the research carried out in the preceding chapters was the evaluation of a 12-week, multi-component, whole-school physical activity promotion intervention, which took place in a Blackpool primary school. These data are reported in **Chapter 6**. **Chapter 7** provides a synthesis of the results from all four studies, with **Chapter 8** providing a summary of the conclusions of the research presented in the thesis. Finally, **Chapter 9** provides suggestions for future research and recommendations for practice in primary schools.

Chapter 2 Review of Literature

2.1 Introduction to the Literature Review

The aim of the first section of the present chapter is to provide a background and rationale for the theme of promoting moderate to vigorous intensity physical activity in primary school children. This is achieved by firstly providing an overview of the importance of physical activity for the healthy growth and development of children and the prevention of disease. Secondly, the literature examining children's current levels of physical activity in relation to guidelines for health is examined, along with a review of the different methods of measuring children's physical activity.

The latter sections of this chapter provide a rationale for the use of the primary school as a setting for the promotion of physical activity, through examination of current government recommendations as well as the literature. The final section of the Review of Literature examines the different methods by which researchers have already used the primary school environment to promote physical activity.

2.2 Physical Activity and Health

Physical activity has number of benefits across the lifespan. These include healthy growth and development, maintenance of energy balance, maintenance of healthy lipid and glucose profiles, maintenance of psychological well-being (i.e., mood, stress management, and self-esteem), and providing opportunities for social interaction (Corbin & Pangrazi, 1999; Biddle *et al.*, 2000; Fuentes et al., 2003; Kohl et al., 2000; Steinbeck, 2001; DH, 2004). Conversely, the population attributable risk (PAR) of physical inactivity for chronic diseases is very high, with data suggesting that 35% of deaths from heart disease and type II diabetes could be prevented through sufficient physical activity (Powel & Blair, 1994; Twisk, 2001).

Opinion is mixed as to the direct health benefits of physical activity in children as many chronic diseases manifest themselves over time (Biddle *et al.*, 2004). However, the benefits of childhood activity have been found to have a bearing on adult health status, with evidence now accumulating to suggest that the onset of many chronic, hypokinetic diseases that manifest in adulthood lies in children (Fuentes *et al.*, 2003; Kohl *et al.*, 2000; Steinbeck, 2001; Saakslahti *et al.*, 2004; Power *et al.*, 1997). These diseases include obesity, type II diabetes mellitus, cardiovascular disease (CVD), cancer, osteoporosis, osteoarthritis and depression (Warburton *et al.*, 2006).

Overweight and obesity, classified as a body mass index (BMI) of ≥ 25 kg.m^2 (overweight) and ≥ 30 kg.m^2 (obese) in adults, is a major unresolved problem currently facing world health (IOTF, 2000). The classification of BMI in children however, has for some time now proved difficult, as a result of changes to children's BMI as a result of their normal growth and development, but also due to the use of a number of differently derived cut points (Cole *et al.*, 2000; Chinn & Rona, 2004; McCarthy *et al.*, 2006). In England, the National Child Measurement Programme, designed to monitor the height and weight of children in Reception (4-5 years old) and Year 6 (aged 10-11 years old), use age and sex specific centiles (UK90) to determine whether children's BMI is classified as underweight, healthy weight, overweight or obese (NHS Information Centre [NHSIC], 2010). The UK90 growth charts classify overweight as a BMI greater than or equal to the 85th centile but less than the 95th centile; and obese as a BMI greater than or equal to the 95th centile (NHSIC, 2010). Despite the problem with differing classification methods, an increasing trend in overweight and obesity has also been highlighted in children and adolescents, with 21% of UK youths classified as overweight in 2003 (Lobstein & Frelut, 2003). The proportion of the under 20 age group classified as overweight in the Fore*sight* Report of 2007 had risen to 25%, with an additional 10% of 6-10 year old boys and girls classified as obese (Butland *et al.*, 2007). Most recent data from the NCMP in 2009-10, show that in 35% of boys and 31.6% of girls in Year 6 were deemed to be overweight or obese, which is a small increase on the figures reported in 2008-2009 (NHSIC, 2010). Encouraging data from the Sportslinx project in Liverpool (England), reported by Boddy et al. (2010) suggest that incidences of overweight and obesity have reached a plateau in the city, with boys' BMI remaining the same across 4 cohorts and girls' BMI declining over the same period. It is acknowledged by the authors however, that BMI does not give an indication of fat or lean mass and so any changes cannot be attributed to a reduction in adiposity (Boddy *et al.*, 2010)

Obesity has been found to track from childhood into adolescence and further into adulthood, with studies showing that individuals are most likely to be obese adults if they were so between the ages of 8-16 years (Butland *et al.*, 2007). Overweight and obesity are independent risk factors for increased morbidity and mortality throughout the lifespan (Deckelbaum & Williams, 2001). An increase in body fatness and in particular, intra-abdominal visceral obesity, has an association with a number of serious medical complications in adults such as type II diabetes, hypertension, dyslipidaemia, coronary artery disease and stroke, and respiratory complications (Kopelman, 2007). Due to this association, the number of adults who suffer from these medical complications is increasing in line with the numbers classified as obese (Butland *et al.*, 2007). With these increases also come an augmented burden on the National Health Service (NHS) (NICE, 2006; Butland *et al.*, 2007; Kopelman, 2007). In their guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children, NICE reported in 2006 that the estimated overall cost of obesity and overweight (including days off sick etc.) in England was £6.6 – 7.4 billion per year. Furthermore, the Fore*sight* report predicts that at current rates and without action, obesity-related diseases will cost the NHS alone £6.5 billion per year by 2050 (Butland *et al.*, 2007).

As with adults, children have been found to express co-morbidities associated with overweight and obesity (Deckelbaum & Williams, 2001). This suggests that children who are overweight and obese who experience symptoms of their co-morbidities, will increase the duration of their suffering by some 20 years (Deckelbaum & Williams, 2001). Unfortunately, childhood obesity appears to substantially increase the risk of subsequent morbidity whether or not obesity persists into adulthood (Keiss *et al.*, 2001; Steinbeck, 2001; Fuentes *et al.*, 2003; Swinburn & Egger, 2002; Power *et al.*, 1997), suggesting that the damage is done irrespective of weight loss. It is therefore important the focus of efforts in tackling overweight and obesity should be directed towards prevention rather than cure.

As previously explained, the development of obesity is attributed to a prolonged period of energy imbalance; however, there are multiple aetiologies of this energy imbalance which means that the increase in the prevalence of obesity and its co-morbidities cannot be attributed to one factor (Butland *et al.*, 2007; Dehgham *et al.*, 2005). It is likely that the prevalence of obesity is supported by a complex, obesogenic environment, which is made up of environmental factors, lifestyle preferences, cultural environments and behavioural and social factors (Butland *et al.*, 2007; Dehgham *et al.*, 2005). The relatively recent rise in childhood obesity may therefore be attributed to the development of technologies and the preferences to pursue more sedentary behaviours such as TV viewing and playing video games (Ekelund, *et al.*, 2006; Swinburn & Egger, 2002; Tremblay & Williams, 2003; Hesketh *et al.*, 2007), with young people watching on average 1.8 – 2.8 hours of TV per day, and playing screen based games 11 - 12 hours per week (Marshall *et al.*, 2006; Parker *et al.*, 2006; Patriarca *et al.*, 2009). Existing evidence suggests children who spend time engaging in these highly sedentary pursuits, have an increased likelihood of gaining excess body fat and being less physically active (DuRant *et al.*, 1994; Ball *et al.*, 2001; Faith *et al.*, 2001; Dennison *et al.*, 2002). In contrast however, another body of research argues that it is time spent in MVPA (or lack thereof) that is more closely associated with the overweight and obesity (Marshall *et al.*, 2004; Ekelund, *et al.*, 2006: Mitchell *et al.*, 2009). A meta-analysis of the relationships between media use, body fatness and physical activity in children and youth conducted by Marshall et al. (2004) determined that despite there being a statistically significant relationship between TV viewing and body fatness, only 1% of the variance in body fatness was explained by TV viewing. Moreover, the authors found a significant negative relationship between physical activity and TV viewing, but again this was small and unlikely to be clinically meaningful. An observational study by Ekelund et al. (2006) as part of the EYHS, data demonstrated that of a sample of 2,000 children between 9-15 years old, the fattest children watched the most TV. However, TV viewing was not associated with MVPA, with the most active children not always watching the least TV. However, of the studies reviewed, the majority of the data came from cross-sectional or observational research, with no studies demonstrating a control group, which means that it is difficult to draw conclusions.

Despite the multifaceted problem of obesity, many researchers believe that the main modifiable risk factors for childhood obesity is physical inactivity (Deckelbaum &

Williams, 2001; Stensel, Gorely & Biddle, 2008); and it is generally agreed within the literature that obese children are less likely to participate in moderate and vigorous intensity physical activity compared to their normal weight counterparts (Steinback, 2001). For example, Mitchell et al. (2009) conducted a cross sectional study examining the association between sedentary behaviour and obesity among 5,434 twelve year old children from Southwest England. Physical activity and sedentary behaviour were measured using accelerometry for one week, with cut-points for MVPA and sedentary behaviour derived by a separate calibration study. In order to examine the impact of a number of confounding factors on sedentary behaviour and obesity, a series of adjusted logistic regression models was performed. From these analyses, the authors were able to calculate odds of being obese for each of these factors. Results found that for each hour spent sedentary per day, children were 1.18 times more likely to be obese. This relationship was strengthened when the effects of social factors, early life factors, and maturation were controlled (OR=1.32). However, when the models were adjusted for 15 minutes of MVPA per day (criterion for low level activity), the association between sedentary behaviour and obesity was negated.

As previously stated, NICE (2006) advocate the promotion of MVPA in their guidance on the prevention and treatment of childhood obesity. Interventions that have aimed to increase physical activity in children for the purpose of reducing obesity have had mixed results. Dobbins et al. (2009) produced a recent review of the literature surrounding school-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18 years. The aim of the review was to examine two broad outcome variables; lifestyle variables and physical health status. Of the 104 relevant studies reviewed, 14 reported results for BMI, across both childhood and adolescence. Of these studies, only four reported statistically significant reductions in BMI post-intervention, with control groups in each of the studies reporting increases in BMI over the intervention period. On average, the intervention groups experienced an increase of one or less in their BMI ratings, versus an increase of almost two for those in the control groups. The remaining ten studies reported no difference in BMI over the intervention period. The authors proposed that the most logical explanations for the different findings in these studies, relates to the amount of physical activity that participants actually engaged in. Although the evidence suggests that school-based physical activity interventions were effective in increasing duration of physical activity, it is unclear whether all studies found an increase in moderate or vigorous intensity physical activity. That is, if study participants did not significantly increase their frequency of at least moderate intensity physical activity, then significant changes in BMI would not be expected nor are they realistic. Also, the duration of a number of studies may be insufficient to elicit a reduction in body fatness, as 12 weeks is the minimum time suggested by NICE (2006) for an obesity intervention to be effective. Variations in results may also be related to the varying participant numbers in each study, which ranged from 55-5000 (Dobbins *et al.*, 2009). The limitations identified in this review highlight the need for more longitudinal research into obesity prevention which uses objective measurements of physical activity intensity and duration in order to be clearer about how such interventions have been successful. By gaining more detailed and accurate data about changes in frequency and duration of physical activity over time and its impact on BMI during school based studies, more effective intervention strategies can be developed.

While for many years, diseases such as type II diabetes and other risk factors associated with CVD (hypertension, abnormal lipid profile, obesity) were seen primarily in adults, a greater prevalence of these risk factors has been observed in children in recent times (Biddle *et al.*, 2004; Butland *et al.*, 2007; Kopelman, 2007; McGavock *et al.*, 2007; WHO, 2003). Indeed, type II diabetes was not previously described in UK children before 2000 (Ehtisham *et al.*, 2000), however countries such as the United States, Canada, Japan, Hong Kong, Australia, New Zealand, Lybia and Bangladesh have reported an increase in cases affecting their children prior to this time (Fagot-Campagna *et al.*, 2001). One study in the United States reported a 10-fold increase in the number of children being diagnosed with type 2 diabetes and insulin resistance between 1982 and 1994 (Pinhas-Hamiel *et al.*, 1996). Type II diabetes mellitus is a complex disease, but put simply, is characterised by the resistance of cells to insulin (the hormone responsible for the regulation of blood glucose), which in turn leads to hyperglycaemia (high blood sugar). The reason why this disease is public health problem is because chronic hyperglycaemia results in ketosis, which damages tissues such as nerves and blood vessels. Such damage can lead to long term complications such as diabetic neuropathy (nerve damage in the extremities), diabetic retinopathy (damage to the blood vessels in the eye, leading to blindness) and renal disease (damage to the kidneys) (Dishman, Washburn & Heath, 2004).

The emergence of type II diabetes in youth has been linked to the increased prevalence of obesity (Biddle *et al.*, 2004). This is because obesity is recognised as the most important risk factor of type II diabetes in children (Chang *et al.*, 2006; Goran *et al.*, 2003). In 2002, Sinha et al. conducted a study examining the prevalence of impaired glucose tolerance (a type II diabetes risk factor) in obese children and adolescents. Of the 55 obese children tested, 25% were found to have impaired glucose tolerance. With the increases in obesity seen in recent years, it is expected that the numbers of cases of type II diabetes will also continue to increase in a similar fashion (Biddle *et al.*, 2004).

There is also accumulating evidence that obesity, insulin resistance, abnormal lipid profile and elevated blood pressure (all modifiable CVD risk factors) cluster together in children (DH, 2004; Crespo *et al.*, 2007; Morrison *et al.*, 2007). This phenomenon is referred to as the metabolic syndrome (Brage *et al.*, 2003). In adults, the presence of these health risk factors increases the risk of CVD and type II diabetes (Department of Health & Human Services, 2001; DH, 2004; Crespo *et al.*, 2007). Cardiovascular disease manifests itself over time and so few incidences of CVD are observed in children. While there is a body of evidence to indicate that physical activity helps to protect adults against metabolic syndrome and CVD (Hardman & Stensel, 2009) and preliminary findings from the literature suggest that there may be an inverse association between CVD risk factors and childhood inactivity (Biddle *et al.*, 2004), the same relationship in children is less clear (Eisenmann, 2007; Steinberg *et al.*, 2007; Stensel, Gorley & Biddle, 2004).

In a review of the limited literature surrounding physical activity, obesity and the risk of type II diabetes and cardiovascular risk in children and adolescents, Goran and colleagues (2003) reported that physical activity is positively related to healthier metabolic profiles in children. However, in Dobbins et al. (2009)'s review, authors are less convinced. Of the 104 school based physical activity studies reviewed, data suggest that overall, such interventions are effective in reducing mean blood cholesterol and improving cardiorespiratory fitness levels among children and adolescents, but not for reducing mean systolic and diastolic blood pressure, BMI, and pulse rate. It is difficult to generalise such studies that aim to decrease cardiovascular risk factors when it is unclear in what context physical activity has been improved. Again, in order for changes to occur, research suggests there needs to be an increase in the duration and intensity of physical activity to at least moderate and in some cases vigorous intensity. The duration of exposure to MVPA required for a change in these risk factors to occur is also in question. Furthermore, it may be that only children with adverse lipid profiles and blood pressure can improve their risk status. Further research is required to further explore the impact of increasing MVPA on health risk factors in children. At present there are no interventions reported in the literature that have assessed the effectiveness of physical activity in preventing type II diabetes, although there is some suggestion that physical activity is inversely related to insulin resistance and positively associated with insulin sensitivity (Stensel, Gorely & Biddle, 2008).

The childhood and adolescent years are a time of much growth and development and are a crucial period for bone development (Stensel, Gorely & Biddle, 2008). Osteoporosis is a debilitating disease commonly found in adults, whereby bones become weak due to a loss of bone mass, density (BMD) and mineral content (BMD) that occurs as one becomes older (Ondrak & Morgan, 2007). This increases the risk of falls and subsequent fractures in later life, which can have a negative impact on quality of life. Bone loss occurs naturally in adults, typically by 1% per year after the age of 40 in men and by 2-3% in post-menopausal women (Giangregorio & Blimkie, 2002). By attaining a high BMD and BMC that peaks post puberty, individuals are able to delay the onset of osteoporosis (Ondrak & Morgan, 2007). Physical activity is an important factor in the development of BMD and BMC in pre-pubertal children. This is because the skeleton is sensitive to mechanical stimulation such as load bearing and repetitive physical activities and in order to attain sufficient peak bone mass, children should be physically active before puberty. Therefore, during the pre-pubertal years insufficient participation in physical activities that promote the growth of BMD and BMC (load bearing and repetitive activities), increase the risk of osteoporosis later in life (Biddle *et al.*, 2004), particularly in females (Ondrak & Morgan, 2007). Similar activities are also important for the healthy development of muscle and connective tissues, which are required for strength, balance, co-ordination, functional capacity and metabolism (DH, 2004; NICE, 2009).

There have been some research published in the literature which examines the effect of exercise on the bone health of children. In a cluster, randomised control trial conducted in Canada, Macdonald and colleagues (2007) examined the implementation of a school-based programme, based on the principles of bone adaptation, on the bone strength of 281 primary school children. The intervention was part of a bigger socio-ecological approach to increase physical activity in the schools, but focused on a daily jumping programme called 'Bounce the Bell', and an additional 15 minutes of classroom based physical activity. Teachers were given instruction by the research group as to the implementation of both elements of the intervention and the effect of the 16 month intervention on bone strength was measured via peripheral quantitative computed tomography (pQCT; a scan of the distal tibia; Binkley & Specker, 2000). Results of the analyses found that the adjusted difference for change in primary and secondary pQCT measures for boys were greater in the intervention group compared to the control group. This difference was not significant however. The only significant difference was found when the change was analysed by Tanner stage, whereby boys in the pre-pubertal group increased their bone strength the most. Results of the girls' data found that there was very little difference between the bone strength of either condition. The authors concluded that such daily physical activity can have a positive effect on the bone strength of pre-pubertal boys, although the approach may need to be changed in order to elicit similar results in girls and older boys. Larger studies are needed to examine the effects of similar interventions aiming to increase bone strength in children and young people.

There is growing evidence to suggest that the link between physical activity and positive mental health found in adults is also true in children (Floriani & Kennedy, 2008; Parfitt & Eston, 2005). Research has shown that physical activity is negatively correlated with depression and anxiety (Jorm, Morgan & Wright, 2008; Parfitt & Eston, 2005) as well as with bullying (Fox & Farrow, 2009; Griffiths *et al.*, 2006) and low self-esteem (Wang & Veugelers, 2008). These are all psychological factors that may be related to obesity (Floriani & Kennedy, 2008; Fox & Farrow, 2009) and further research is required to more clearly establish the links between physical activity, obesity and mental health. The benefits of physical activity in children have also been found to have a positive impact on academic attainment (Ahmed *et al.*, 2007; Dowda *et al.*, 2005; Strong *et al.*, 2005) as well as on concentration, memory and classroom behaviour (Strong *et al.*, 2005).

Physical activity is therefore an evidence based intervention that offers benefits to both the physical and mental health of children (Floriani & Kennedy, 2008; Jorm, Morgan & Wright, 2008; Wiles *et al.*, 2008). Such benefits may include the prevention and treatment of a number of diseases, as well as the promotion and maintenance of good mental health throughout the lifespan; and it is for this reason that the promotion of physical activity in children has become a public health priority for the UK government (Centres for Disease Control, 2001; DH, 2004; NICE, 2006, 2009).

2.3 Children's Physical Activity

2.3.1 Current Guidelines

In response to the growing consensus of the benefits of a physically active lifestyle in children, guidelines have been drafted to determine the amount of physical activity required for health. By determining thresholds whereby physical activity becomes beneficial for health, it allows those involved in physical activity research and promotion to evaluate whether children are sufficiently active to benefit their health. In addition, it enables researchers and promoters to focus their attention on those in the population who are not sufficiently active to benefit their health (Cavill *et al.*, 2001).

The guidelines outlined by NICE (2009) were first proposed in 1998 (Biddle *et al.* 1998) and state that children should accumulate at least 60 minutes of moderate-to-vigorous physical activity every day, in bouts of at least 10 minutes in duration. Moderate-intensity is described by NICE (2009) as activity that increases breathing and heart rates to a level where the pulse can be felt and the person feels warmer; while vigorous activity results in being out of breath or sweating. Moderate intensity physical activity has been compared to the same intensity as a brisk walk (Bar-Or & Rowland, 2004). Furthermore, the guidelines recommend that on at least two occasions during the week, activities should be performed that are weight bearing and sufficiently physically stressful to enhance and maintain muscular strength, flexibility and bone health.

In addition to the guidance provided by NICE (2009), Tudor-Locke et al. (2004) have provided standards for recommended pedometer determined steps per day. The recommendations are based on a large sample of children aged 6-12 years old and are associated with maintaining normal weight in boys and girls. Authors recommend that according to a normal weight BMI reference, boys should accumulate 15000 steps per day and girls' 12000 steps (Tudor-Locke *et al.*, 2004). These standards provide a simpler means of determining children's levels of healthful physical activity, as quantifying intensity and duration of physical activity can be complicated, especially non-research users, such as a teacher, parent or coaches.

2.3.2 Measurement of Children's Physical Activity

The measurement of physical activity in children has inherently posed a problem for researchers over the years. This is due to the intermittent and sporadic nature of the way children engage in unstructured activities (Baquet *et al.*, 2007), as well as the different problems associated with the different instruments designed to measure physical activity (Table 2.1) (Khol *et al.*, 2000). In order to quantify children's levels of physical activity for comparison against current recommendations and to assess any interventions aimed at increasing physical activity, it is vital to use accurate assessment techniques (Sirard & Pate, 2001). There have been a number of different instruments and methods that have been used to measure children's physical activity, all with varying levels of accuracy. These include self-report (questionnaires, diaries), motion sensors (pedometers, accelerometers) doubly labelled water, heart rate monitors, indirect calorimetry and direct observation (Welk *et al.*, 2000; Macfarline *et al.*, 2006; Marshall & Welk, 2008). Each technique has its own advantages and disadvantages (Table 2.1), which includes their validity and reliability relative to criterion measures and these must be considered when selecting a suitable instrument (Khol *et al.*, 2000).

The decision as to which method of physical activity measurement to use with children largely depends on the design of the study and the age of the participants (Khol *et al.*, 2000). Because the different measures provide different units of measurement, such as energy expenditure (doubly labelled water, indirect calorimetry); duration, intensity and pattern (accelerometers); step counts/volume (pedometers); time spent in types of activity etc (direct observation, diaries and questionnaires); the measurement of choice will depend on the outcome variable desired as well as the resources available and sample size etc. (Welk, 2005). Table 2.1 provides an overview of the different methods used by researchers for measuring children's physical activity. They are separated into direct (doubly labelled water, indirect calorimetry, direct observation and monitors) and indirect measures (diaries, questionnaires, heart rate monitors).

Table 2.1 Table showing the advantages and disadvantages of different direct and indirect physical activity measurements used in children (information *collated* from: Dishman *et al.*, 2004; Khol *et al.*, 2000)

METHOD	DESCRIPTION	MEASUREMENT OUTCOME	ADVANTAGES	DISADVANTAGES
Doubly Labelled Water	Measure of total daily energy expenditure	Energy expenditure	• Gold standard of measuring total daily energy expenditure in adults • Primarily used as a validation measure to compare other measures of physical activity against • Energy expenditure information can be collected over a long time period in a relatively unobtrusive manner	• Expensive • Requires specialist equipment (mass spectrometer) and training • Participants must be controlled as disruption to normal metabolism can exaggerate the variability • Does not provide direct information on energy expenditure from physical activity • Does not provide information about the pattern, intensity or duration of physical activity over time • Uncertainty as to the accuracy in children
Indirect Calorimetry	An estimate of energy expenditure is derived from applying a calorific equivalent to the consumption of oxygen and production of carbon dioxide during a given time period. Requires the collection of expired air and measurement of oxygen and carbon dioxide.	Energy expenditure – RER – Kcal		• Requires specialist equipment and training • Generally laboratory based • Requires an element of participant familiarisation • Requires child specific equipment (mouthpieces/face masks)
Direct Observation	Individuals or a team or observers witness physical activity (generally in a given situation such as a playground or gymnasium) and record it using a coding system. This can be done in real time or via video taping for a given period of time or on a number of occasions.	Activity rating – Type – Intensity – Duration	• Able to quantify type of activity • Able to monitor actual behaviour • Valuable for use in very young children • Very informative when used in conjunction with other methods (e.g. accelerometers)	• Requires trained observers • Inter tester reliability can be limited • Time and resource consuming-costly • Only individuals or small groups can be measured at any given time • Problems with reactivity to the observer

Heart Rate Monitors	Units that measure the electrical activity of the heart are strapped to the chest and heart beats are recorded over a given time period. This method uses the linear relationship between HR and oxygen uptake to estimate energy expenditure.	Heart beats·minute^{-1} – Energy Expenditure – can be used to calculate frequency, duration and intensity – can be used to form a pattern of daily activity –	• Easily used • Able to record data over time • Can assess the pattern of physical activity over the course of a day • Used to validate accelerometers in the past	• Delay in HR response to intermittent exercise may mask information • Physical fitness of children may be a limiting factor • The production of a person specific regression equation for energy expenditure is required for accuracy of the measurement
Accelerometers	Accelerometers are small, lightweight motion sensors, worn around the waist, that measure bodily movement in different planes (anterior-posterior, lateral and vertical). Digital acceleration signals are recorded during user-specified time intervals (epochs) and data are stored in the unit's memory as a volume of activity. Measurement and calculations of physical activity are based on the association between the integral of vertical acceleration with respect to time and energy expenditure	Acceleration counts – can be used to calculate frequency, duration and intensity – can be used to form a pattern of daily activity – estimate of EE Step counts – Units can be set to collect steps taken as a pedometer would	• Method of choice for measurement of habitual physical activity • Valid and reliable • Can be used to compare against physical activity recommendations • Able to record and store data for weeks at a time	• Expensive (e.g. each Actigraph unit alone costs approximately £165 (Model GT1M, ActiGraph, LLC, Fort Walton Beach, FL)) • Requires specific operational software • Data cleaning and missing data imputation labour intensive • Cannot be worn in water or during contact sports • Inaccurate during cycling activities • Compliance-non wearers • Requires a number of days monitoring for data to be representative of the population • Lack of agreement in the literature with regards to the appropriate cut-points for exercise intensity
Pedometers	Pedometers are motion sensors that use a horizontal spring-suspended mechanical lever arm to measure movement in the vertical. Pedometer units are small and are typically worn on the waistband above the right hip.	Step counts – can be used to calculate steps·minute^{-1} – some models can calculate distance walked and calories	• Relatively inexpensive (range from £5-£30 each approx.) • Models such as Yamax Digi-Walker have shown high agreement with criterion measures • Easy to administer	• Compliance- non wearers/shakers • Participant tampering (accidental zeroing) • Cannot be worn in water or during contact sports • Inaccurate during cycling activities

	Each time the mechanical arm inside the pedometer unit is triggered by a vertical movement, it is recorded numerically on a digital display. The number of movements displayed is referred to as the number of 'steps' and this provides a simple, immediate and continuous measure of physical activity volume.	*consumed*	• *Immediate and continuous* feedback is given to the wearer • Piezoelectric models can collect data and store for a number of days • Relatively easy to clean and reduce data	• *Requires a number of days* monitoring for data to be representative of the population • Less expensive models appear to be less accurate than models such as the Yamax Digi-Walker
Diary	Diaries require participants to record their daily participation in physical activity on a frequent basis. The information required can vary depending on the requirements of the research.	Duration of physical activity – Time segments (typically 10, 15, 30 minute segments)	• Cheap to administer • Ability to measure large numbers in a relatively short period	• Problem with interpretation • Problems with recall • Problems with compliance • Infrequently used with children • May not provide specific information about duration and intensity of physical activity
Questionnaire	Questionnaires can be self-administered, interviewer administered or completed by proxy. Participants are required to recall information regarding their physical activity participation over a given recent time period (e.g. 1day, 7 days or longer). Questions can be tailored to the needs of the research.	Duration of physical activity – Time segments (typically 10, 15, 30 minute segments)	• Cheap to administer • Versatile so that questions may be included/excluded depending on the needs of the researcher • Ability to measure large numbers in a relatively short period	• Parent proxy not always accurate • Problem with interpretation • Problems with recall • Problems with compliance • Retrospective • May not provide specific information about duration and intensity of physical activity

The doubly labelled water technique for measuring energy expenditure is the most valid and reliable criterion (Dishman *et al.*, 2004; Khol *et al.*, 2000: Marshall & Welk, 2008), as proposed by Schoeller et al. (1986). Despite its high level of accuracy and simple, non-invasive approach (Marshall & Welk, 2008), the doubly labelled water technique is not suitable for measuring large subject numbers, due to its large cost and the burden placed on participants for collection of urine samples and visits to the laboratory (Khol *et al.*, 2000). Indirect calorimetry, as described in Table 2.1, is a proxy method for measuring energy expenditure. Due to the requirement for measuring O_2 consumption and CO_2 production with this method, it usually requires participants to attend a laboratory setting, which can be invasive and does not allow for much freedom of movement. This is obviously a problem if researchers are concerned with the measurement of children's 'natural', activity patterns (Marshall & Welk, 2008). While there are portable versions of this technique, the methods remain somewhat cumbersome and 'unnatural', as well as being very expensive. For these reasons, when considering the methodologies associated with assessing habitual physical activity and time spent in MVPA in particular (as in the present thesis), the doubly labelled water and indirect calorimetry techniques are not be suitable.

As previously stated, it is paramount to use the most accurate measure of physical activity, but in reality, this decision may also be influenced by factors such as the equipment availability or the cost of equipment. The factor of equipment cost is a realistic problem facing researchers and it may be that in some instances, a trade-off may have to be made between the accuracy of the measurement used and the number of subject numbers measured in order to gain statistical power. Indeed, Welk (2005) suggests that it is important to consider the balance between the accuracy of the physical activity measurement tool being used and it's feasibility in terms of the study. To this end, the most common methods used to measure physical activity in school based interventions is that of accelerometry and pedometry.

2.3.2.1 Accelerometry

Accelerometers are small, lightweight motion sensors, worn around the waist, that measure bodily movement (or accelerations) in one (uniaxial) to three (triaxial) different planes (anterior-posterior, lateral and vertical) (Freedson & Miller, 2000; Schutz *et al.*, 2001; Welk, 2002). While some authors have found that triaxial accelerometers provide a more valid estimate of children's physical activity (Eston *et al.*, 1999; Welk, 2005), no direct evidence exists in the literature to suggest that the triaxial accelerometer is superior to the uniaxial in measuring children's physical activity (Freedson *et al.*, 2005). Digital acceleration signals are recorded during user-specified time intervals (epochs) and data are stored in the unit's memory as a volume of activity (Trost *et al.*, 2005). Data can be continuously recorded for periods of days, weeks and even months (Schutz *et al.*, 2001).

From the raw data provided by accelerometers, investigators can obtain a real-time estimate of frequency, intensity and duration of free-living physical activity as well as energy expenditure (Freedson & Miller, 2000; Schutz *et al.*, 2001). From a health research perspective, this is useful as accelerometer counts can be converted into estimated time spent in different intensity categories (Strath *et al.*, 2003). In particular, accelerometer counts can be converted into time spent in MVPA (Dishman *et al.*, 2001) through the use of age-specific cut-points (Freedson *et al.*, 2005) which enables researchers to compare their data against current guidelines for health (Welk *et al.*, 2000). A limitation to this approach however, is the relative lack of agreement between the different accelerometer cut-points proposed by authors. In the literature there are a number of different existing sets of activity cut-points proposed by authors that define intensity thresholds of light

(≤2.99 METS), moderate (≥3 and ≤5.99 METS) and vigorous (≥6 METS) physical activity in children and adolescents (Eston *et al.*, 1998; Freedson *et al.*, 1997; Trost *et al.*, 1998; Puyau *et al.*, 2002; Treuth *et al.*, 2004; Schmitz *et al.*, 2005; Mattocks *et al.*, 2007). These cut-points were derived as a result of Actigraph calibration studies which developed energy expenditure prediction equations as a result of the relationship between the energy expenditure and accelerometer counts at a given intensity (Mattocks *et al.*, 2007). The different studies have varied in their design, while some studies were conducted in free-living situations, using habitual activities such as playing computer games etc. (Eston *et al.*, 1998; Schmitz *et al.*, 2005; Treuth *et al.*, 2004); others have taken place in a laboratory situation, conducted on a treadmill at different speeds (Trost *et al.*, 1998; Freedson *et al.*, 1997); and some studies have used both methods (Puyau *et al.*, 2002; Treuth *et al.*, 2004; Mattocks *et al.*, 2007). It is important to note that accelerometers are limited by their capacity to assess static, non-weight-bearing activities that require little body movement in the vertical plane like cycling. Furthermore, they do not accurately capture changes in gradient which, in turn, influence physical activity intensity (Corbin *et al.*, 2004; Trost *et al.*, 2002) and so using free-living activities to calibrate cut-points that are dominated by upper body movements may mean that the accelerometers worn at the hip underestimate physical activity (Welk, 2005). However, despite this limitation, accelerometers continue to provide a reliable (Brage *et al.*, 2003, Metcalf *et al.*, 2002, Welk *et al.*, 2004) and valid (Eston *et al.*, 1998; Nichols *et al.*, 1999; Trost *et al.*, 1998), objective field measure of physical activity in children (Welk, 2005).

With the number of different cut-points proposed, comes a difficult decision as to which to use in order to quantify volumes of time spent in different intensity activities, as different cut-points provide different volumes of activity for a given set of data. In fact, five different studies using accelerometer measured data reported moderate intensity cut-points that ranged from 574-3200 counts per minute (Jago *et al.*, 2007). Mattocks et al. (2007) suggest that this lack of agreement between studies may be due to the small sample sizes used by some authors to derive their cut-points (e.g. n=32; Puyau *et al.*, 2002), or because studies were confined to one gender (Schmitz *et al.*, 2005) or age group (Mattocks *et al.*, 2007). Reilly et al. (2006) therefore suggest that the age of participants may be important when choosing the most appropriate cut-points to use. Freedson et al. (2005) further suggest that in order for cut-points to reflect the variety of habitual activities that children take part in, calibration studies should take place in a setting that closely represents the activities that children typically perform. With this in mind, the cut-points derived from calibration equations based on primary aged children (male and female) are those of Freedson et al. (1997) and Puyau et al. (2002). However, only those proposed by Puyau et al. (2002) were derived from varied activities.

Mota et al. (2007) examined the effects of these two cut-points on the estimated prevalence of meeting health-related guidelines of physical activity in 8-16 year olds. Sixty two children successfully wore the MTI Actigraph for three consecutive school weekdays (12 hours per day) and the amount of time spent in MVPA was calculated using both Freedson et al. (1997) and Puyau et al. (2002) cut-points. Analyses comparing the amount of time spent in MVPA derived as a result of the two cut-points found that irrespective of gender, the cut-points of Freedson et al. (1997) elicited significantly more time spent in MVPA (p<0.01). This meant that when using the Freedson et al. (1997) cut points, 70.4% more boys and 57.7% more girls achieved 60 minutes of MVPA per day. This is a problem for researchers wanting to examine physical activity in this context (i.e., comparing time spent in MVPA to recommendations for health). However, this lack of agreement may not be a problem when researchers wish to examine the % difference in physical activity between time points. Mota et al. (2007) recognise that the small sample size of children used in this study may not accurately reflect the difference between the two cut-points and suggest further examinations should be conducted using larger sample sizes.

In order to avoid this problem of lack of agreement with cut point criterion, some authors have now reported raw accelerometer counts per minute (Kelly *et al.*, 2005, Treuth *et al.*, 2005, Cooper *et al.*, 2005); while other authors have determined their own, population specific cut-points using individual calibration (Mitchell *et al.*, 2008). Calibration studies are however extremely time consuming as they involve the measurement of criterion physical activity (e.g. indirect calorimetry, direct observation; Welk 2005) in a large number of participants during a number of different activities (free living or treadmill based, or both)a task that is beyond the means of many other researchers, especially those with small subject numbers and limited resources. An alternative approach to calculating accelerometer cut points has been presented in the form of receiver operated characteristic (ROC) curves (Welk, 2005). ROC curves have traditionally been used in clinical research to determine the effectiveness of diagnostic tests and are based on the trade-off between sensitivity [true positives/ (true positives + false negatives)] and specificity [true negatives/ (true negatives + false positives)] of the measurement used (Welk, 2005). The ROC curves allow researchers to examine which accelerometer cut points most sensitively and specifically correspond to criterion measured physical activity intensity. The use of ROC curves to calculate cut points is still in its infancy, but this approach may provide a good alternative to regression equations.

It is clear from the literature that there is a lack of agreement as to the best method of quantifying accelerometer data and more work in this area is required to strengthen the evidence for use of any of the methods or cut-points presented (Welk, 2005). Determining the most accurate equation or cut-point for this population remains a priority for future research.

2.3.2.1.1 *Model of Accelerometer*

A number of studies have been carried out comparing different models of accelerometer under varying conditions in children and young people. An initial study carried out by Welk and Corbin (1995), used heart rate telemetry to validate the TriTrac-R3D and the uni-axial CSA accelerometers (now known as ActiGraph) with thirty one children aged 9-11 years. The authors found similar moderate correlations between the accelerometers and heart rate monitors ($r = 0.58$ and 0.52 respectively) and a high correlation between the two accelerometers ($r = 0.88$). In 1998, Eston et al. used treadmill walking and running exercises as well as free play activities to examine the relationship between oxygen consumption and the physical activity output of the ActiGraph and TriTrac-R3D accelerometers in thirty children (mean age 9.2 years). Across all activities, the authors found that the TriTrac-R3D demonstrated the strongest correlation with oxygen consumption ($r = 0.90$ compared to 0.78 with ActiGraph). On closer examination, authors found that during free play, the TriTrac-R3D recorded most movements in the horizontal plane. In conclusion, the authors suggest that the TriTrac-R3D was therefore more suited to measure children's free play than the ActiGraph. Ott et al. (2000) followed this study by looking at the ability of the ActiGraph and the TriTrac-R3D to measure children's free play at different intensities, across eight different activities. The accelerometers were compared to heart rate telemetry and observation based intensity scores. Both monitors produced significant correlations with heart rate and observation based intensity across all of the activities. As with the study by Eston et al. (1998) the TriTrac-R3D was found to correlate best with the criterion measures ($r = 0.66$-0.73) compared to the ActiGraph ($r =$ 0.53-0.64). However, in agreement with Welk and Corbin (1995), Ott et al. (2000) found that between accelerometer correlation was relatively strong (*r*= 0.86), suggesting that both the ActiGraph and TriTrac-R3D provided similar information in relation to children's physical activity during free-play. Having reviewed these studies, Trost et al. (2005) concluded that there was insufficient evidence to single out one brand of accelerometer over the other. For this reason, a number of additional factors come need to be considered when choosing which model to use; such as the cost of unit and operating apparatus, unit size, sturdiness, potential for subject tampering, quality and user-friendliness of software for downloading and manipulating raw data, and comparability of findings with other studies (Trost *et al.*, 2005). The model of accelerometer that is most commonly used in the literature (Gavarry *et al.*, 2003; Pate *et al.*, 2002; Pate *et al.*, 2004; Riddoch *et al.*, 2004; Ridgers *et al.*, 2006; Ridgers *et al.*, 2005; Trost *et al.*, 2003a) is the ActiGraph uni-dimensional accelerometer (ActiGraph, LLC, Pensacola, FL) as it is small, robust, is easy to interface with the operating software..

2.3.2.1.2 Epoch Length

As previously stated, an epoch is the time sampling interval used when measuring physical activity with accelerometers. When choosing a suitable epoch length in order to address a research question, it is important to identify the population being measured and how the study intends to use the raw physical activity data. If a volume of physical activity is required then the duration of the epoch selected does not matter (typically 60 seconds is used), as the total amount of physical activity will be presented for the measurement period. However if the investigator wishes to determine the amount of time spent at a certain intensity of physical activity, then the length of epoch may affect the study results, as the amount of activity is averaged over the measurement period (Trost *et al.*, 2005; Nilsson *et al.*, 2002). For example, if during a thirty second epoch an individual performs a bout of vigorous intensity physical activity followed by a period of rest, then the time spent in vigorous physical activity may be masked due to the average activity reflected by the cut-points applied (Trost *et al.*, 2005). This example is especially true for children as their physical activity is distinctively sporadic and intermittent in nature (Bailey *et al.*, 1995).

In a study examining the effect of different time sampling intervals (5, 10, 20, 40 and 60 second epochs) on different intensity levels when measuring physical activity in children, Nilsson et al. (2002) found that as the epoch length decreased, the time spent at high and very high intensities increased significantly (p<0.01). Furthermore, no significant difference was found between epoch length and time spent in moderate intensity physical activity. This may be because children are more likely to spend extended periods of time in moderate intensity physical activities than at high and very high intensity activities, which are typically 2-6 seconds in duration (Baquet *et al.*, 2007). The authors concluded that in order to achieve a more detailed picture of physical activity patterning a shorter epoch setting should be used. One of the potential problems with using shorter epochs however, is the amount of data that a number of days monitoring yield. By recording data in 5 second epochs, twelve times more data must be stored and analysed compared to when 60 second epochs are used. If the ActiGraph used cannot store the number of days data required, then this may impact on the design of a study. In order to overcome this problem, most recent versions of the ActiGraph (Model GT1M; ActiGraph, LLC, Pensacola, FL) have sufficient capacity to record 5 second epoch data for 21 days.

2.3.2.1.3 ***Positioning of the Accelerometer***

In order for the ActiGraph to be secure to collect data, the unit is worn on an elastic belt provided by the manufacturer, as close to the person's centre of gravity as possible (typically on the lower back) (Trost *et al.*, 2005). Wearing the ActiGraph in this position is not always feasible, especially in children and so Nilsson et al. (2002) also examined whether placement of an accelerometer on the hip or back would affect the assessment of physical activity in 7 year old children over 4 days monitoring. Overall, no significant difference was found between the two monitoring placement sites

2.3.2.1.4 Number of days Monitoring

The number of days monitoring required in order to obtain a reflective measure of physical activity has important implications for compliance and study costs (Trost *et al.*, 2005). Researchers need to obtain as many days monitoring as possible in order to gather a representative measure of physical activity, without over burdening the person being monitored. In children this can be especially challenging. In order to determine the minimum number of monitoring days required for reliable representation of children's moderate to vigorous physical activity, Trost et al. (2000) found that single-day intra-class correlation reliability of MVPA ranged from 0.46-0.49 and that in order to obtain an acceptable reliability of 0.8, between 4 and 5 whole days monitoring would be required. Despite these findings, researchers have felt that three days (inclusive of one weekend day) (Sirard *et al.*, 2005; Mota *et al.*, 2003; Pate *et al.*, 2004) and even two weekdays of monitoring (Cooper *et al.*, 2005; Trayers *et al.*, 2006; Ridgers *et al.*, 2005; Pate *et al.*, 2004) gave an adequately reliable representation of physical activity. However, in 2008, Mattocks et al. presented the results of a study on a large cohort from the Avon Longitudinal Study of Parents and children (ALSPAC), which tested the number of days and the number of minutes per day of measurement required to obtain sufficient reliability. The authors proposed that in order to maximise power, a reliability coefficient of 0.7 is acceptable and justified. To this end, they were satisfied that 3 days of accelerometer data were sufficient and that the specification of a weekend day to fulfil the inclusion criteria was not necessary. In addition, Mattocks et al. (2008) suggest that a full day of activity monitoring may not be necessary, as 3.1 days on which 420 minutes of monitoring were collected elicited a reliability coefficient of 0.7 and 92.3% power, which was similar to days where at least 600 minutes of activity were measured. Despite this finding, the authors explain that in order to compare the results of their physical activity data to that of a comparable cohort study (the EYHS), their inclusion criteria would require children to have accumulated at least 600 minutes on three days of the week.

In a study by Fairclough et al. (2007), authors assessed the variability of children's weekday physical activity in relation to discrete parts of the day. They found that physical activity variability was sex-specific and that the greatest reliability occurred during early morning and the time spent at school (7am-3pm, *r*= 077-0.757). In conclusion, the authors suggested that when using a reliability coefficient of 0.8, 5.1 days of monitoring were required to obtain a representative measure of physical activity during school hours. More specifically, Ridgers et al. (2006) examined the variability of children's physical activity during recess and found that two days of monitoring was sufficient to elicit reliability co-efficient of 0.8. Fairclough et al. (2007) did not report reliability data for recess, however, the data from these two studies were collected from very similar populations and so it may be that while a school day may warrant 5.1 days of monitoring to provide a representative measure of physical activity, even more discrete periods within that timeframe (such as recess/playtime) may require fewer days of monitoring.

2.3.2.2 Pedometry

Pedometers have been shown to be valid and reliable measures of physical activity in children (Beets *et al.*, 2005; Rowlands *et al.*, 1997; Tudor-Locke *et al.*, 2002; Tudor-Locke *et al.*, 2004; Kilanowski *et al.*, 1999; McKee *et al.*, 2005; Barfield *et al.*, 2004). Laboratory and field validations of pedometers have yielded relatively high correlations with criterion measures of oxygen consumption (r= 0.62 to 0.93) and direct observation (r= 0.80 to 0.97) (Sirard & Pate, 2001). Pedometers are motion sensors that use a horizontal spring-suspended mechanical lever arm to measure movement in the vertical plane (Bassett *et al.*, 1996; Scruggs *et al.*, 2003). Pedometer units are small, lightweight (e.g., Yamax Corporation, Tokyo, Japan is 19mm x 29mm x 52mm) and unobtrusive to the wearer (Scruggs *et al.*, 2003). Each time the mechanical arm inside the pedometer unit is triggered by a vertical movement, it is recorded numerically on a digital display. The number of movements displayed is referred to as the number of 'steps' and this provides a simple, immediate and continuous measure of physical activity volume (Tudor-Locke *et al.*, 2002). With advancing technology, pedometers have been developed in order to allow the user to input their stride length and body mass to gain information on the number of miles walked and calories expended. In addition, a number of pedometer units are now available which have a digital clock facility, enabling the user to calculate the number of steps accumulated during a given time frame ($\text{steps}\cdot\text{min}^{-1}$). Steps per minute are determined by dividing the absolute steps value by the duration of the time observed (Scruggs *et al.*, 2003).

The number of pedometer steps recommended for health for adults proposed by (Tudor-Locke & Bassett, 2004) is 10,000 per day, while the number of steps per day recommended for children has been proposed as 12,000 for girls and 15,000 for boys (Tudor-Locke *et al.*, 2004). In a study, Duncan et al. (2007) recommended that this figure be increased to 13,000 steps per day for girls and 16,000 steps per day for boys, as the authors felt that the criterion reference (BMI) used by Tudor-Locke et al. (2004) to obtain their figures was less accurate than using the present body fat criterion. While pedometers can only provide a volume of physical activity and not intensity, when data are expressed as $\text{steps}\cdot\text{min}^{-1}$ they have correlated highly with present MVPA (Eston *et al.*, 1998, Kilanowski *et al.*, 1999).

In a study conducted by Jago et al. (2006) with boys aged 10-15 years, the authors aimed to set pedometer based physical activity targets based upon current physical activity guidelines. Participants completed three types of activity (walking, fast walking and running) while wearing a pedometer and a CSA accelerometer. Authors found that the average pedometer counts during the fast walk was 127 counts·min^{-1} in normal weight boys and 125 counts·min^{-1} in overweight boys. In terms of current British physical activity guidelines that children should engage in 60 minutes of MVPA per day (NICE, 2009), the authors suggest that children should be advised to take 8000 steps in a 60 minute period (Jago *et al.*, 2006). If these same figures are applied to the accumulation of recommended activity in bouts of ten minutes, which can be applied to playtime for example, children should aim to take 1300 steps during these smaller time intervals. In a study conducted by Scruggs et al. (2003), authors used observation analyses to quantify that ten minutes of MVPA taken during a typical 30 minute PE lesson in 7-8 year old children was equivalent to 60-63 steps per minute. During the same time frame, authors found that fewer steps were required by 9-10 year olds (Scruggs *et al.*, 2005).

Quantifying pedometer steps in terms of physical activity guidelines (number of steps per day and time spent in MVPA) is a great advantage from a public health research perspective. By displaying a continuous measurement of physical activity, pedometers can act as an environmental cue to encourage people to achieve recommendations for health (Tudor-Locke & Corbin, 2002). For example, if an individual sets themselves a goal for the number of steps they aim to take during the day (or any given time period), they can examine their counts at any time and depending on the value, increase their activity to ensure they achieve their goal. In addition, individuals may wish to use a pedometer to measure the contribution of an activity or a given journey to their daily total. This can be done by recording step totals before and after an activity, or during a given time period and then comparing the discrete total by the daily total.

2.3.2.2.1 Positioning of the Pedometer

Pedometer manufacturers advise that the pedometer should be worn on a belt or waistband as close to the centre of gravity as possible and in line with the mid line of the thigh (Bassett *et al.*, 1996). Bassett et al. (1996)'s protocol for the positioning of a pedometer states that the unit should be positioned on the waistband, 5-7 cm from the umbilicus. A number of studies have looked into the effect of different positioning of the pedometer (left and right hips) on its measurement accuracy (Jago *et al.*, 2006). In agreement with Bassett et al. (1996) many of these studies found that there was little or no difference between the two sides (Bassett *et al.*, 1996, Jago *et al.*, 2006, Beets *et al.*, 2005). When using pedometers for research in children, it is easier for individuals to remember that the unit should sit on their hip. In the present studies to ensure that the children could easily remember where to position their pedometer, they were instructed to keep them situated next to their right hip.

2.3.2.2.2 Model of Pedometer

The most commonly used pedometers for research with children are the Yamax Digi-Walkers (Yamax Corporation, Tokyo, Japan) as these have been shown to be the most consistently accurate while measuring physical activity under free-living conditions (Le Masurier *et al.*, 2004). Pedometers are relatively inexpensive (e.g., SW200 Yamax Digi-Walker, Yamax Corporation, Tokyo, Japan is £10.99) compared to the more sophisticated accelerometer motion sensor (Scruggs *et al.*, 2003) which makes them a practical, alternate option for assessing physical activity in large samples.

2.3.2.2.3 Number of days Monitoring

In a paper discussing the methodological considerations for the use of pedometers in research, Tudor-Locke and Myers (2000) suggested that the number of days monitoring required for an accurate representation of physical activity would depend on the population being examined. This is due to the lack of agreement between studies examining the physical activity in different populations. For example, Tudor-Locke et al. (2005) found that at least three days of pedometer monitoring would provide a sufficient estimate of physical activity in adults, while Rowe et al. (2004) proposed that as many as six days may be required to provide a sufficient estimate of children's physical activity. This difference may be because adult's physical activity behaviour is more stable than that of children. More recent research carried out by Craig et al. (2010) as part of the Canadian Physical Activity Levels in Youth study examined how many days of monitoring were sufficient to gain an accurate representation of pedometer measured physical activity. This large study of 11669 5-18 year old children and adolescents revealed that two days of monitoring elicited an ICC of >0.85 which they deemed to be a sufficient number of days to determine daily pedometer steps (Craig *et al.*, 2010). In fact, authors argue that their results provide some support that one day of monitoring could be justifiable in order to maximise participant numbers. By using fewer days monitoring, the burden on the children is reduced and so more children are likely to comply with the requirements of the protocol.

2.3.3 Children's Physical Activity Levels

In order to examine whether children are sufficiently active to benefit their health, there have been a number of studies that have aimed to establish children's levels of daily physical activity (Epstein *et al.*, 2001; Gavarry *et al.*, 2003; Riddoch *et al.*, 2004). However little data has been obtained from representative samples and few studies have significantly more active than the adolescents (27% more active in boys, 32% in girls). The authors concluded from their results that virtually all 9 year olds achieved current activity guidelines while fewer did so at age 15 years. A UK representative study of accelerometer measured physical activity from the Health Survey for England (HSE) recently reported fewer children in this population meeting UK recommendations, with 51% of boys aged 4-10 and only 34% of girls accumulating at least 60 minutes of MVPA on all days (Aresu *et al.*, 2010). By comparison, another UK, based study examining the levels and patterns of accelerometer measured physical activity of 11 year old children from the Avon Longitudinal Study on Physical Activity in Children (ALSPAC) found much lower levels of MVPA (Riddoch *et al.*, 2007). The median time spent in MVPA in this study was 20 $\text{min}\cdot\text{day}^{-1}$, with boys accumulating 25 $\text{min}\cdot\text{day}^{-1}$ and girls only 16 $\text{min}\cdot\text{day}^{-1}$. The reasons for the large differences in accelerometer measured MVPA between studies may largely be due to the criterion for which moderate intensity physical activity was defined (≥3 METS in Riddoch *et al.*, 2004; Aresu *et al.*, 2010; and ≥4 in Riddoch *et al.*, 2007) and the accelerometer cut-points used. As previously discuss in section 2.3.2.1, these results further highlight the need for methodological agreement when measuring physical activity via accelerometry so that comparisons can be made across studies and populations.

In 2007, Duncan et al. conducted a study with 208 British primary school children, examining their daily pedometer determined physical activity over the winter, spring and summer terms. Children wore sealed piezoelectric pedometers, able to store the four days' step counts (2 weekdays and 2 weekend days) in the internal memory of the during each data collection phase. Results of the study revealed that 28.7% of boys and 46.7% of girls met or exceeded the BMI referenced step recommendations for health as proposed by Tudor-Locke et al. (2004c). The authors also reported data relative to weigh status, with

41.2% of normal weight, 36.4% of overweight and only 12.5% of obese children meeting the same recommendations. As with previous studies, Duncan et al. (2007) observed that boys were significantly more active than girls, despite more girls meeting the recommendations. No difference was observed over the seasons, although children were significantly more active during weekdays compared to weekend days.

The differing results observed in the literature as to whether children meet current physical activity guidelines for health may be due to the different methods used by researchers to measure or quantify physical activity (both methodologies and instruments) in their studies. As previously discussed in section 2.3.2., the different measurement techniques used by researchers to measure and quantify physical activity in children offer varying degrees of validity and reliability. Issues regarding the different methodologies used to measure physical activity in children via accelerometry and pedometry will be discussed further in section 3.2. However, one example of where different methodologies may influence the results obtained are clearly demonstrated by Gidlow et al. (2008). In their recent study examining the in-school and out-of-school physical activity of 505 primary school and secondary school children in England, Gidlow et al. (2008) analysed the accelerometer data they collected using two different algorithms to determine moderate physical activity thresholds. When the authors calculated time spent in MVPA using the thresholds proposed by Trost et al. (2002), they found that all primary school children accumulated the recommended 60 minutes of MVPA each day. However, when the algorithm proposed by Puyau et al. (2002) was used, less than 4% of primary and secondary school children achieved 60 minutes of MVPA each day. Such a vast difference between the two outcomes of the same data is of concern, as it is difficult to determine which method to use in order to interpret volumes of moderate intensity physical activity. This discrepancy demonstrates that there is need for further investigation as to the levels of physical activity in children, with consensus reached over the most appropriate and accurate method to measure and quantify physical activity (Welk, 2005). While there are conflicting data regarding whether or not children meet current physical activity guidelines, there is consistent data, across populations to suggest that boys are more active compared to their female counterparts (Mota *et al.*, 2003; Riddoch *et al.*, 2004; Butcher *et al.*, 2007; Aresu *et al.*, 2010) and that these differences in activity occur during discrete periods of the day (Mota *et al.*, 2003; Tudor-Locke, 2006, Fairclough *et al.*, 2007). Most concerning is the consensus that children's physical activity declines as they age into adolescence (Guvarry *et al.*, 2003; Riddoch *et al.*, 2004; Aresu *et al.*, 2010).

In 2006, Tudor-Locke et al. examined pedometer-determined physical activity during different segments of the school day, to investigate physical activity patterns during PE, playtime, lunchtime and the times before and after school. Pedometers were worn by 81 children from morning until bedtime on Monday-Wednesdays during two weeks of data collection. Students were instructed to record the amount of steps taken at specific times of the day that represented the segments of the day being observed, as well as the total daily pedometer step count. Overall, boys (*n*=28) took significantly more steps per day than girls (*n*=53). When the day was segmented, the significant difference remained during play time, lunch time and after school, but no difference was observed in the pedometer steps of girls and boys before school and during PE. The reason for this may be because during break times and after school, children are free to choose the activities that they take part in and therefore boys choose to take part in physically active pursuits. During playtimes, Ridgers et al. (2005) found that when given the choice, boys tend to take part in more vigorous activities such as ball games, while girls generally participate on the periphery of the playground in lighter, less dynamic activities (Ridgers *et al.*, 2005). Physical education however is prescribed by the teacher and in primary schools, lessons are typically taught in mixed classes. This means that boys and girls are expected to take part equally in the activities being lead.

It is important to gain more detailed information regarding children's daily physical activity patterns as it may be helpful to health promoters to focus their attention on specific populations and opportunities/times of the day where children are less active. One such phenomenon that is of importance to health promoters is the consistent decline in physical activity that is observed as children move into adolescence (Ekelund *et al.*, 2004; Olds *et al.*, 2009; Riddoch *et al.*, 2004; Pate *et al.*, 2002; Stevens *et al.*, 2005; Thompson *et al.*, 2005; Trost *et al.*, 2002). In Gidlow and colleagues' (2008) study examining the in and out-of-school physical activity of primary school and secondary school children in England (outlined previously), the authors experienced results typical of that observed in the literature, in that physical activity decreased with advancing age. It is therefore important that healthy behaviours surrounding physical activity are adopted from an early age and maintained, so that the decline in physical activity from the transition into adolescence and into adults is reduced.

Despite an increase in the numbers of children becoming overweight and obese across the developed world, some research suggests that young children are achieving the current recommended levels of physical activity to benefit their health. To this end, some authors suggest that the current physical activity recommendations are insufficient and the recommended time spent by children in MVPA should be increased beyond 60 minutes per day (Andersen *et al.*, 2006; Marshall & Welk, 2008). Andersen et al. (2006) suggested that as much as 90 minutes of MVPA is needed to prevent diseases such as type II diabetes. With this in mind, countries such as Canada recommend that children should increase their physical activity in an incremental fashion, depending on their current levels and up to a target of 90 minutes of MVPA a day (Marshall & Welk, 2008).

2.4 Physical Activity Promotion in Children

As the previous sections have outlined, the promotion of physical activity in children is a public health priority in the UK. This is because physical inactivity is the main modifiable risk factor for diseases such as obesity, type II diabetes, and the metabolic syndrome (Goran *et al.*, 2003; Koppleman, 2007; Powel & Blair, 1994; Mitchell *et al.*, 2009; Steinbeck, 2001). It is unclear from the literature whether children do achieve recommended levels of physical activity, however, it is important that health promotion strategies are in place that promote and maintain physical activity from childhood and through to adolescence and adulthood. In 2009, NICE published their guidelines on the promotion of physical activity in children and young people (NICE, 2009). Recommendation 9 identifies multi-component school and community programmes as a key opportunity for physical activity promotion. It highlights the need for school head teachers, with the support of the board of Governors, to deliver multi-component physical activity programmes involving the school, family and community-based activities. These should include education on the benefits of a physically active lifestyle, to motivate children to engage in physical activity; and provide opportunities for the development of children's perceived self-confidence. Furthermore, schools should consider policy and environmental changes in order to provide a supportive environment for physical activity, such as the inclusion of additional opportunities for physical activity during playtimes and out of hours. These recommendations are in line with Welk (1999)'s YPAP model and through the inclusion of children, staff, families and community, the social ecological framework proposed by the WHO (1996). While these recommendations provide schools with the appropriate suggestions, they do not provide information and support with how these recommendations can be delivered and what additional resources may be involved.

2.4.1 The Primary School as a Health Promotion Context

In recent years, schools have been identified as the most logical environments for the promotion of public health strategies (Fox *et al.*, 2004). This is because children spend the vast majority of their time; five days a week for approximately 40 weeks of the year at school. Schools are also environments where the full socioeconomic range of the population can be targeted equally (Fox *et al.*, 2004). This vehicle for health promotion is also important because lifestyle and risk behaviours relating to physical activity and chronic diseases are learned early at school, when individuals are most receptive (Rogers et al., 1998; McKenna & Riddoch, 2004). It is for these reasons that a number of attempts have been made to promote health and physical activity of youth through the curriculum (Fox *et al.*, 2004; McKenzie *et al.*, 2000; Oliver *et al.*, 2006; Fox *et al.*, 2004; McKenzie *et al.*, 2000; Michaud-Tomson & Davidson, 2003; Salmon *et al.*, 2005; Naylor *et al.*, 2006).

2.4.2 Primary School-Based Physical Activity

Despite formal curricula and government driven incentives for schools, there remains a need to improve the primary school environment for the promotion of physical activity. This is because primary schools rarely have staff with the expertise of effectively delivering health promotion strategies or physical activity interventions. As previously stated, there are a number of different opportunities within the school day where children can be active. Research has focused on discrete times of the day, on curricula and also on the whole school. The remaining sections will discuss this research in more detail in order to provide a rationale for the present thesis.

2.4.2.1 Physical Education

In 1992, the British Government drafted its first National Curriculum for Physical Education (PE), in order to address the issue of promoting physical activity for health in schools (Fox *et al.*, 2004). In recent years however, the National Curriculum for PE has been criticised. This is because the health focus on physical activity was believed to have been lost, as the curriculum was used more as a theme to be embedded in the delivery of sport (Fox *et al.*, 2004). It was felt that the promotion of physical activity was to enhance fitness for performance, rather than fitness for health (Harris, 1997). Since these criticisms were raised, the curriculum has been revised several times (Fox *et* al., 2004).

In 1997, the Centres for Disease Control produced guidelines for school and community programmes to promote lifelong physical activity in children and young people. In these guidelines it was stated that PE can provide children with a substantial proportion of recommended healthful physical activity, but in order to achieve this, children should be engaged in MVPA for at least 50% of the lesson time. This can only be achieved if teachers are able to instruct children and manage the lesson time effectively, which may be a challenge for primary school teachers, who are generally non-specialists (Stratton, Fairclough & Ridgers, 2008). It is for this reason that a number of PE based interventions have focused on the primary school setting and have used modified curricula and teacher training to increase physical activity.

The most notable examples of randomised control trials using modified curricular in primary schools to increase physical activity are that of the Child and Adolescent Trial for

Cardiovascular Health (CATCH) project (McKenzie *et al.*, 1996); and the Sports, Play and Active Recreation (SPARK) project (McKenzie *et al.*, 1997). These trials were conducted in the USA and it is important to note that there are no examples of similar interventions carried out in the UK. Project CATCH (McKenzie *et al.*, 1996) was designed to improve existing PE classes in 40 different schools across America, by increasing the opportunity for physical activity (target of 90 minutes per week) and optimising that opportunity by providing equipment and improving teaching delivery and management. Teachers were provided with resources such as the CATCH PE guidebook as well as an activity box, containing appropriate activities to engage children in physical activity. Training was also provided to teachers in terms of professional development sessions, along with peer observation and feedback. Physical activities during PE lessons were measured using the Systematic Observation of Fitness Instruction Time (SOFIT) instrument, during each of the six semesters over the two years. The aim of the analyses was to determine the effect of the intervention on children's physical activity by PE lesson context (teacher type and lesson location). Results found that when children in the intervention schools were taught by PE specialists their MVPA increased by 1 minute per session, while MVPA increased by 4 minutes when they were taught by classroom teachers. Overall, children in the intervention schools increased their MVPA and VPA significantly more than the children in the control schools. Results of further research on this project have found that the changes made to the school environment in order to support healthy behaviours during the intervention can be maintained over time (Hoelscher *et al.*, 2004).

Project SPARK was a grant funded PE programme that ran in 277 schools across America between 1989 and 1996 (McKenzie *et al.*, 1997). It was designed by a multidisciplinary team to encourage health related PE by maximising physical activity participation during lessons in order to improve fitness, skills and enjoyment (Dowda *et al.*, 2005). The

SPARK PE curriculum included only activities that could be realistically delivered in a school setting and each activity aimed to be active in order to promote health related fitness. As well as a new curriculum and similar to the CATCH programme, staff were provided with a development programme that included 32 days of training as well as peer observation and feedback. Physical activity data were collected via accelerometry and a 1 day recall questionnaire; and anthropometric and fitness data were also collected. Results of the analyses revealed that children in the control schools were given less PE than children in the intervention schools. This was reflected in a significant difference in MVPA between the two conditions, with children in the intervention schools achieving significantly more MVPA than those in the control schools. More holistic observations have been made of the SPARK PE programme, with positive effects found on the quality and quantity of teacher delivery of PE, sports related skills and importantly, academic attainment (Dowda *et al.*, 2005). This was maintained during an 18 month follow-up (Dowda *et al.*, 2005). As a result of the favourable findings of a number of studies evaluating the programme, SPARK PE was disseminated across schools in the USA. This project is a good example of using quality research (randomised control trial, with large subject numbers and measurement techniques with strong validity) in order to examine the efficacy of an intervention, and as a result of a positive evaluation the project was disseminated on a large scale. The success of the intervention and its evaluation is largely down to the funding available, which is one of the reasons why such research is few and far between.

One example of a PE intervention to increase PE MVPA in middle school children is the M-SPAN project (McKenzie *et al.*, 2000). The project was aimed at middle school children in the USA and focused on improving the conduct of PE lessons by using purpose written curricular materials, staff development and on-site consultants to facilitate its delivery (McKenzie *et al.*, 2004). The main aim of project was to increase pupils' MVPA during PE by enhancing the efficiency and delivery of lessons. Results of this two-year study showed modest increases in the MVPA of pupils in the intervention school compared to the control school. Overall, children in the intervention schools increased their MVPA significantly by approximately 3 minutes per lesson. Differences in MVPA were observed between boys' and girls' MVPA and the effect of the intervention increased boys' MVPA more than girls'. With regards to the Healthy People 2010 objective, children in the intervention group surpassed the 50% target (52%) while children in the control schools fell short (48%). Although such interventions can be successful in increasing physical activity in children and adolescents, even the best school PE programs do not provide enough physical activity to meet health related recommendations (McKenzie *et al.*, 2000). This suggests that people should not rely solely on PE to provide children with healthy levels of physical activity, and that other opportunities in the day should be maximised in order to achieve recommendations.

2.4.2.2 Playtime

Playtime or 'recess' as it is known in the USA, is a compulsory opportunity that children are provided during the school day away from the curriculum. This time is a valuable opportunity for children to participate in physical activity, to socialise and develop social skills (Blatchford & Baines, 2006). The time is generally spent outdoors (weather dependent) 'playing', and due to its vigorous nature, is an excellent opportunity for children to accumulate up to 30-40% (girls and boys respectively) of their daily recommended MVPA (Ridgers *et al*, 2006). In most schools in the UK, the opportunities for playtime occur mid-morning for a relatively short period of time (approximately 10-20 minutes) and again at lunch time for approximately 55-75 minutes (Blatchford & Baines, 2006). In some schools an additional mid-afternoon opportunity of approximately 10-15 minutes is provided. With pressure for schools to compete for league table places, along with staff concerns regarding child behaviour (i.e. bullying), these additional opportunities are becoming less, and more time is allocated to the curriculum (Blatchford & Baines, 2006).

In 2006, Blatchford and Baines reported the results of a nationally representative postal 'Pupil Break-time Questionnaire Survey', gathering information about break and lunchtimes in primary and secondary schools in England and Wales. The information they gathered examined the main features of break and lunchtimes, which included duration, supervision and facilities, views on its value and problems arising from poor behaviour. Some of the key findings of this survey surrounded the apparent decline in break and lunchtime allocated in schools. The authors found that as children get older, the time allocated for play is inversely proportional with age, with children in KS2 (7-11 year olds) only getting 77 minutes of playtime per day (21% of the school day, 14 minutes less than children aged 4-7 years old). This is in contrast to guidelines expressed in the government's report 'Time for Play', which states that school playtime should take a 25% proportion of the total school day (DCM, 2006). Furthermore, with the reduction in physical activity observed as children age (Ekelund *et al.*, 2004; Olds *et al.*, 2009; Riddoch *et al.*, 2004; Pate *et al.*, 2002; Stevens *et al.*, 2005; Thompson *et al.*, 2005; Trost *et* al., 2002), the reduction in playtime opportunity may be a contributing factor. Data also suggests that time allocated at lunch break had reduced since the 1995 survey. In conflict with this finding is that children reported to value the free time they were given during break and lunchtime to socialise and be physically active. With the potential for the accumulation of a large amount of healthful physical activity during this period, and the psycho-social benefits that the opportunity brings (Pellegrini & Bohn, 2005), it is important that the opportunity which is available is optimised (Blatchford & Baines, 2006; Beighle *et al.*, 2006).

Despite the reduction in time allocated to school playtime, researchers aiming to promote physical activity in children have identified this as a valuable opportunity for intervention. This is mostly due to the time and resources available (space, equipment and staff). A number of studies have been conducted into optimising the playtime opportunity through manipulating the space, equipment and staff available to children in order to increase their physical activity, with physical activity measured using a range of objective measures (Loucaides *et al.*, 2009; Stratton, 2000; Ridgers *et al.*, 2006; Verstraete *et al.*, 2006; Ridgers *et al.*, 2007). In 2000, Stratton introduced painted playground markings to encourage primary school children to be more active during playtimes. The study involved an intervention and a control school; whereby children in the intervention school designed a series of markings (ten in total were used) that were painted onto the tarmac playground surface. No markings were given to the control school, but children were allowed to play with equipment during play time. Children's physical activity was measured using heart rate telemetry during three different playtimes, before and after the implementation of the markings in the intervention and control schools. MVPA was calculated by determining heart rate thresholds from individual heart rate reserves of children. Results demonstrated that the addition of playground markings elicited a significant increase in MVPA of between 10 and 15% in children from the intervention school, whereas the activity of those who attended the control school remained constant. Most noticeable was the almost 50% increase in vigorous intensity physical activity demonstrated in the intervention group. Despite the small numbers observed in this study, it demonstrated that it was possible to increase children's playtime physical activity through introducing playground markings to the playground.

In response to the findings of Stratton (2000), Ridgers et al. (2006) conducted a large scale, funded study called 'The Liverpool Sporting Playgrounds Project', which examined the impact of colourful playground markings and equipment based on the Sporting Playground zonal design. Fifteen schools received £20,000 to re-design their playgrounds while eleven schools were used as matched controls. Physical activity data were measured via heart rate telemetry and accelerometry at baseline, 6 weeks, six months and twelve months follow up (Ridgers, Fairclough & Stratton, 2010). Results found that children in the intervention schools were engaged in 4-4.5% more MVPA and 2.3-2.4% more VPA than those in the control group. The positive interaction found between playtime duration and intervention meant that the effect was stronger as playtime increased. Results also suggested that the effect of the intervention on MVPA and VPA was strongest in children who were least active at baseline (Ridgers *et al.*, 2006). Furthermore, results suggested that the intervention effect was greatest at 6 months post-test (Ridgers, Fairclough & Stratton, 2010), with physical activity declining from six to twelve months post intervention. These results suggest that in order for any increase in physical activity to be sustainable, additional strategies may be required, such as peer-lead games or training of lunchtime supervisors. Furthermore, while interventions that incorporate playground re-design such as this can have a significant impact on children's MVPA and VPA, they may be too costly to implement on a large scale and if funding is not available, many schools are unable to afford them.

With this in mind, a small number of studies have examined the impact of providing games equipment during playtime on children's physical activity. One such study was that conducted in Belgian elementary school children by Verstraete and colleagues (2006). In their study, the authors provided 4 intervention schools (n=122) with games equipment for three months, during morning and lunchtime break and compared their accelerometer-measured physical activity with 113 children from 3 control schools. Results demonstrated that moderate intensity physical activity increased significantly from baseline by 12% during lunch break in the intervention group, while moderate physical activity decreased in the control group (5% and 6% respectively) over the three month period. These results were more modest during the morning break, where moderate intensity physical activity increased in the intervention group by 4%, but declined in the control group by 7%. The authors concluded that providing games equipment during break times was effective in increasing children's healthful physical activity. With results showing a decline in the moderate intensity physical activity in the control schools' children during the three month intervention period, authors suggest that providing games equipment may also help to prevent a decline in children's physical activity during break times (Verstraete *et al.*, 2006).

More recently, Loucaides and colleagues (2009) examined the effect of providing playground markings, equipment and allocating areas for play to different children on different days on pedometer measured physical activity. The study, conducted in three primary schools in Cyprus, all of similar size and playground facilities available, allocated the schools into two intervention groups and one control group. The first intervention school (*n*=89) was provided with playground markings, which included games such as hopscotch, snakes and ladders etc; equipment in the form of skipping ropes; and finally, some of the playground space was allocated for team games, with a rota given for allocated groups to play within them. The second intervention school (*n*=89) was allocated the same space and rotas for team games as the first school, but without the markings and equipment. Physical activity volume was measured by individuals using pedometers during the 20 minute morning playtime and during the time after school on the 4 days pre and post intervention (4 weeks). Loucaides et al. (2009) found that during the 20 minute break time, physical activity significantly increased in the two intervention schools (8.7% and 13.2% increase in pedometer steps respectively), whereas no difference was found in the control school. Further analysis demonstrated that there was no difference in the physical activity of the two intervention groups post intervention, suggesting that allocating basic space allocation to physical activity is sufficient to change behaviour. This is supported by the similar changes in physical activity in the Louciades et al. (2009)'s study to those of previous research (Ridgers *et al.*, 2007; Stratton & Mullan, 2003; Verstraete *et al.*, 2006). A school by gender interaction was observed, with boys in both the intervention schools observing significantly more steps than the control schools boys; whereas, only girls in the first intervention observed a significant difference in pedometer steps post intervention. This supports research by Ridgers et al. (2007) which observed that girls are physically active during break time in different ways to boys. However, the limitations of the Loucaides et al. (2009) study mean that generalisability of the intervention is difficult. Only one school was used per intervention group and so more schools would be required in future study. The difference in the structure of the school day in Cyprus may also mean that this approach may not transfer to other countries such as the UK.

2.4.2.3 Active Transport

In the last 15 years, the amount of children who walk and cycle to school has fallen dramatically. In a paper discussing the contribution of the journey to school on children's physical activity, Cooper (2003) stated that in Britain, travel to school by car has doubled in this time, while walking to school has fallen by 12%. There are many barriers that have elicited this change in travel to school which include travel distance, traffic danger, weather conditions, crime danger, bullying and opposing school policy (Centres for Disease Control, 1999).

Tudor-Locke and colleagues first broached the subject that active commuting to school may be an overlooked source of children's physical activity (Tudor-Locke *et al.*, 2001). In discussion of the subject, the authors stated that as children must travel to school in some manner, day after day, it should be viewed as a unique opportunity to experience the benefits of physical activity. They pointed out that in adults, intervention studies on walking to work demonstrated its efficacy and cost efficiency with regards to health and fitness outcomes. At this time however, no study had been carried out to determine whether walking to school is a healthful source of physical activity. In conclusion, the authors called for research into the possible health benefits of active commuting to school in children. In light of this paper, a number of studies have been conducted to examine whether children who actively commute to school are indeed more active than those who travelled passively. These studies used a number of methods to measure physical activity, including surveys (Tudor-Locke *et al.*, 2002), questionnaires (Tudor-Locke *et al.*, 2003), pedometers (Michaud-Tomson & Davidson, 2003) and accelerometers (Cooper *et al.*, 2003; Cooper *et al.*, 2005: Cooper *et al.*, 2006). Tudor-Locke et al. (2001) initially analysed physical activity data obtained by the Russian Longitudinal Monitoring Study, in which more than 6400 households from all regions of Russia were surveyed between 1992 and 1998. The data were parent-proxy measures of their children's physical activity and were examined in terms of how many children met health related physical activity guidelines. Analysis of the data initially included children who actively commuted to school. These children were then omitted out and the analysis was repeated. They found that by omitting those children who were active commuters from the analysis, there was a statistical decrease in the amount of children achieving physical activity guidelines for health from 20% to 12%. This study provided initial evidence that children who actively commuted were more active than those who travelled passively and provided a platform on which to base further research into this area.

In 2003, Tudor-Locke et al. conducted a study to compare the physical activity of Filipino adolescents who walked to school with those who travelled by car. They used questionnaires to collect detailed health, nutritional and demographic information as well as the frequency, duration and mode of travel to school. Caltrac accelerometers were also used as an objective measure of physical activity. Their results found that males and females who actively commuted to school expended 44.2 $kcal \cdot d^{-1}$ and 33.2 $kcal \cdot d^{-1}$ more than those who travelled by car. They also found that commuting mode was not significantly related to participation in sport or exercise except in females, where fewer girls participated in sport when they travelled to school by car. The authors concluded that active transport to school was responsible for an increase in daily energy expenditure in this population. A study conducted in Australia by Michaud-Tomson and Davidson (2003) used primary school children to examine the 'walk to school'. It aimed to identify whether children who attended an 'Active Australia' school had higher physical activity levels than those children who attended a non-Active Australia school. Here, the authors used pedometers and questionnaires to measure physical activity, with the measurements taken over a four day testing period. The results show that children who walked to school were significantly more active than those who travelled by other means. The effect size of this difference was 12.3. In terms of pedometer counts, children who walked to school produced around 3,500 more steps than other children. As with the Tudor-Locke study, Mauchaud-Tompson and Davidson found that significantly more active commuters participated in sport than those who travelled passively. They concluded that with an extra

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their younger peers. They also suggest that these findings need to be verified in larger studies. In the most recent study on the topic of active commuting to school, data obtained from the Danish arm of the EYHS was analysed to investigate the association between physical activity levels and travel mode to school (Cooper *et al.*, 2006). Grade 9 children wore MTI Actigraph accelerometers for four days (including two weekend days) to measure their habitual physical activity, while simple questions were asked regarding their mode of travel to school. Results demonstrated that children who walked to school recorded significantly higher accelerometer counts than those who travelled by car. They also found a gender difference in activity related to travel mode, where boys who walked to school were significantly more active than car travellers. Girls also demonstrated a 16% difference in physical activity between the two groups, but the difference was not significant. Weekend data were analysed separately and no significant difference was found in activity levels between week and weekend day, while no significant difference in weekend activity levels between travel groups was found. Numerically however, children who walked to school were approximately 18% more active at the weekend than the children who travelled by car. As with the study by Cooper et al. (2003), activity patterns of the children were plotted on graphs to investigate the difference in activity. These showed that in boys, the activity level of active commuters were higher than passive travellers throughout the day, with most marked differences occurring during the journey to and from school, during break times and during after school day care centre times. In girls however, there was no difference in activity levels between travel mode during the day other than the journeys to and from school. This study also examined physical activity intensity. Results showed that children who walked to school accumulated significantly more MVPA than those who travelled by car. The journey to school itself however did not contribute very much to the total amount of MVPA. In conclusion, the authors stated that walking and cycling to school may be associated with higher levels of physical activity in primary school children when compared to those who were driven. Furthermore, the authors called for more research into the social and environmental determinants of active commuting to school in order to identify why car users are less active than their peers.

In an attempt to gain consensus as to the contribution of active commuting to children's daily physical activity, Faulkner and colleagues (2009) conducted a review of the literature examining the question of whether children who actively commute to school are more active than those who travel by motorised transport and whether children who actively commute have a healthier body weight or lower BMI than non-active commuters. Of the thirteen studies that met the inclusion criteria of the review, the authors found that eleven studies demonstrated that children who were classified as active commuters were significantly more physically active than those who took motorised transport and that this difference was similar across populations. Of the three studies that did not find a difference, one study was conducted on children under 5 years old and it was suggested that younger children's walking behaviour is different to older children. Authors were unsure why the remaining two studies found no difference, but suggested that the different methodologies used and the way that active commuters were classified may have been a factor. Indeed, some children combine two or more modes of transport on their journey to school and this may result in miss-classification. In addition, only one study reported a difference in fitness between modes of transport to school, with cyclists found to be fitter than all other commuters (Cooper *et al.*, 2006). In conclusion Faulkner et al. (2009) highlight the importance of focusing on transport related physical activity research due to its health and environmental benefits, and state that the literature confirms that active commuters are more physically active than children who travel passively to school. As a result of reviews such as this, NICE strongly recommend active commuting and in particular the school travel plan in their guidance, as a means of increasing physical activity in children and young people (2009).

In the UK, a number of different initiatives have been employed to facilitate active commuting, such as walking school buses, designated 'walk to school weeks' and school travel plans (TP), but little research is available examining the different initiative's contribution to promoting physical activity. Indeed, of the fourteen studies reviewed by Chillon et al. (2011), only two were from the United Kingdom. One of these studies was a quasi-experimental trial conducted in Scotland, which aimed to increase the distance children travelled to school by walking and reduce the journey distance travelled by car (McKee *et al.*, 2007). The intervention, named the 'Travelling Green Project, took place over a 10 week school term and involved curriculum materials to support teachers to deliver active travel projects across the curriculum; and children and family resources, which aimed to encourage families to take part in project outside of the formal curriculum. Families were provided with a map of the school and the community, highlighting the core path networks that linked the wider community to the school. This included information on safe routes, with information about pedestrian crossings etc. Children and families were encouraged to set targets with regards their active travel and to increase the distance they walked to and from school. Results of the study found that children in the intervention school significantly increased the distance walked to school over the intervention period by 38.9%, however post-intervention the distance walked to school decreased by 57.5%. This suggests that curricular interventions combining goal setting can increase active commuting in children. It is still unknown however, whether such interventions can increase MVPA. The only study to date that has examined the effectiveness of the school travel plan on the incidence of active commuting in the UK was a randomised control trial conducted by Rowland et al. (2006). Rowland et al. (2006)

examined the effects of 16 hours of assistance from an expert travel plan officer on the proportion of children who walked or cycled to school, as well as the proportion of schools that actually implemented their TP. They found that having a TP coordinator led to increased numbers of schools who produced a TP; however, there was no evidence that these actually changed travel patterns. Rowland et al. (2006) suggested that a change in travel patterns resulting from TPs may take a number of years to occur due to the time it takes to implement the different activities associated with the TP, as recommended by the UK government (NICE, 2009). With the amount of resources that are being made available for school TPs in light of government recommendations, it is surprising that there is such a small evidence base supporting the work. Indeed, much more research of a high quality study design is needed to examine the effects of interventions currently aimed at increasing the number of children who walk to school and if this promotes an increase in children's physical activity (Chillon *et al.*, 2011).

2.4.2.4 Integrated Curriculum Approaches

Another approach that has been used by few researchers to increase physical activity in primary school children is through an integrated curriculum approach. Oliver et al. (2006, p78) stated that: 'the promotion of physical activity participation holistically through the school environment may enhance the likelihood of behaviour sustainability'. While the concept of curriculum integration is not new within the education sector (Oliver, Schofield & McEvoy, 2009), the use of integrating physical activity throughout the primary school curriculum is limited. The reason for the lack of research in this area may be due to the fact that using an integrated approach can be time consuming and problematic, requiring teachers with sufficient content knowledge and experience. This may be especially true in the UK primary school setting, as non-specialist teachers are required to deliver PE and few schools have access to a physical activity specialist. The integration of physical activity in primary school curriculum has been considered in different forms. Examples from the literature include the Take 10! programme, a resource for teachers that uses instruction cards for providing blocks of 10 minutes of physical activity through the curriculum (Stewart *et al.*, 2004); others include the use of pedometers to promote physical activity throughout the day (Oliver, Schofeild & McEvoy, 2009); the use of health related PE (Fairclough, Butcher & Stratton, 2008; Verstraete *et al.*, 2007), classroom based health education (Kipping, Payne & Lawler, 2010) and extracurricular PA promotion (Trost, Rosenkranz, & Dzewaltowski, 2008); and computer and media based resources in addition to signposting of local physical activity events (Gorley *et al.*, 2009).

In 2006, Oliver et al. conducted a feasibility study on an intervention that used an integrated curriculum approach to increase habitual physical activity in primary school aged children. Authors examined the use of pedometers to integrate physical activity across the curriculum by designing a four-week 'virtual walk' competition, whereby children would accumulate pedometer steps in order to move themselves along a 'virtual walk' around New Zealand. A thematic approach to the delivery of the intervention was used, whereby different subjects, such as English, maths, social studies, PE and statistics were linked to the 'virtual walk'. Lesson plans were designed in order to achieve this and were based on New Zealand's national curriculum. Physical activity data were collected via pedometry at baseline, and pedometer steps were recorded every day over the four week intervention period by the class teachers. Results of the study showed that at baseline, 80 % of children (n=61) were already achieving recommended daily step counts. Overall, when all children's data were analysed together, no significant difference was found between baseline steps per day and those during the intervention. However, when children were separated out into physical activity quartiles, the least active children (i.e., those accumulating less than 15,000 steps per day) significantly increased their daily physical activity. It is important to note that 15000 steps is arguably high to be labelled 'least active', but is likely to be a reflection of the high proportion of children exceeding recommended daily step counts. The results of this study advocate the use of pedometers as a means of integrating physical activity across the curriculum and that this method of physical activity promotion is a feasible way of targeting the least active children within a population without being singled out.

Verstraete et al. (2007) designed a comprehensive physical activity programme for use in 16 Belgian primary schools (8 condition and 8 control). The intervention was based on the SPARK programme (Sallis *et al.*, 1997) and aimed to increase children's physical activity during PE classes and outside of school by implementing a health related PE programme and a self-management programme. In addition, physical activity was also promoted during playtimes. Physical activity was measured via accelerometry and physical activity questionnaire; while additional data were collected using the Eurofit test battery. Measurements were taken at baseline and post-test, following 24 months of the intervention. Results revealed that children in the intervention schools engaged in significantly more MVPA than those in the control schools, which was magnified by a decrease in MVPA in the control schools over the 24 month period. The results of the test battery found no difference in fitness from baseline to follow-up in the intervention group. This suggests that although the increase in the volume of physical activity was significant, the intensity of physical activity was not increased sufficient to improve cardiovascular fitness. However, children's body fatness, measured by sum of skinfolds, was significantly higher in the control group post-test, suggesting that the intervention was successful in maintaining or reducing body fatness in the intervention schools. A randomised control trial in the UK was recently published by Gorely and colleagues (2009). The 'GreatFun2Run' intervention trial ran for ten months and was run by an events management company, whereby a holistic approach to children's health education was adopted. Teaching resources such as a CD-ROM were introduced to classroom teachers that contained lesson plans for including health and activity related issues across the curriculum (literacy, numeracy, history, design, science and geography) and included the importance of good food and nutrition as well as physical activity for health. Teachers, pupils and parents were given access to an interactive website which supported the content of the CD-ROM, while two different events were highlighted in order to provide children with physical activity goals and promote mass participation. Further support for the programme was provided by a local media campaign and children were supplied with a summer activity wall planner to record their activity out of school. Physical activity was measured during the intervention via pedometry and accelerometry and data were collected at baseline, midway and at the end of the intervention. Additional data such as aerobic fitness, fruit and vegetable intake, anthropometric information, knowledge of healthy lifestyles and psychological measures were also taken. The main findings of the study found that by the end of the intervention children in the intervention schools were taking part in 20 minutes of MVPA more than those in the control schools. This was as a result of increasing their own MVPA by up to a minute a month for the 10 month intervention, and the control group reducing their MVPA at the same level.

2.5 Summary

There is an evidence base suggesting that physical activity can have a positive impact on children's current and future heath and that healthy behaviours related to physical activity can and should be adopted and maintained from an early age. Currently, it is unclear whether children are sufficiently active to benefit their health due to inconsistencies in measurement techniques and a lack of representative data. Subsequently, further research is required and it may be possible that current guidelines may need revision in order to reflect this. Schools have been identified as environments in which healthy physical activity behaviours can be fostered and where children can accumulate healthful levels of physical activity. Within the school day, there are a number of opportunities that are available for children to be physically active and a number of studies have suggested that these opportunities can be maximised through intervention. However, there remains a lack of consistent evidence that such interventions can be successful in UK schools. Because physical activity behaviour is complex, current guidance on increasing physical activity in children and young people (NICE, 2009) state that for interventions to be successful and to be maintained, they need to be based on psychological theories and models. Guidance also states that school interventions need to be based on a whole school approach. These recommendations support the framework presented by the Medical Research Council (MRC) which outline the process of how researchers should develop and evaluate such complex interventions (Craig et al., 2008). The framework states that researchers designing a complex intervention should first examine existing evidence in order examine what is already known about similar interventions; researchers should then identify and develop a theory that underpins the likely mechanism of change; and finally, researchers should then go through a process of modelling process and outcomes, whereby a series of studies may be required in order to refine the design of a robust and full scale evaluation (Craig et al., 2008). To date, there has been no study that has based an integrated, whole school intervention on such a model and there is need to examine the effect of such an intervention on the healthful physical activity of primary school children.

2.6 Thesis Aims

The purpose of this thesis is to examine the effect of primary school based interventions aimed at increasing 7-11 year old children's MVPA. This aim was stratified as follows:

2.6.1 Study 1

- To validate the EZ-V model of pedometer for the use in primary school children.

2.6.2 Study 2

- To examine the effects of providing primary school children with feedback and information relating to the number of pedometer steps accumulated during a full school day.
- To examine whether there was a gender difference in step counts per day.

2.6.3 Study 3

- To assess the affect of the school travel plan on the MVPA of primary school children.
- To examine the difference in children's daily MVPA by season.

2.6.4 Study 4

- To evaluate the affect of a multi component, whole school intervention on the MVPA of primary school children.
- To examine whether feedback from pedometers as well as information on how and why children should be physically active could increase and maintain children's mean daily step count over 5 weeks.
- To identify whether the whole school intervention affected the most or least active children's pedometer measured physical activity.

2.6.5 Thesis Study Map

A thesis study map demonstrating the objectives and key findings of the studies will be presented at the beginning of each study chapter.

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Chapter 3 Study 1: Measurement accuracy of a modestly priced pedometer for measuring physical activity in a primary school setting

3.1 Thesis Study Map

Study	Aims
Study 1: Measurement accuracy of a pedometer for measuring physical activity in a primary school setting	• To validate the Ez-V model of pedometer for the use in primary school children.
Study 2: The effect of feedback and information on children's pedometer step counts at school.	
Study 3: Affect of school travel plans on children's physical activity during the winter and summer.	
Study 4: Can a 12-week, whole school intervention increase primary school children's moderate to vigorous intensity physical activity?	

3.2 Introduction

Accurate measurement of physical activity in children is critical in order to quantify levels of physical activity for comparison against current recommendations and in order to assess any interventions aimed at increasing physical activity (Sirard & Pate, 2001). Due to the intermittent and sporadic nature of the way children engage in unstructured activities (Bailey *et al*, 1995; Baquet *et al.*, 2007; Rowlands *et al.*, 1997), measuring physical activity in this population has posed a problem for researchers over the years (Beets *et al.*, 2005).

More recently, there has been an increase in the number and type of objective physical activity assessment instruments (pedometers and accelerometers) that have become commercially available to consumers, practitioners and researchers (McClain & Tudor-Locke, 2008). Due to the vast array of differing/similar instruments available, it can become confusing and difficult to select the most appropriate instrument to use. While researchers will always want to use the most valid and reliable tool for measuring physical activity, there may be other factors that influence which instrument is used.

Cost has been identified as a strong factor for consideration when choosing a physical activity measurement tool (Duncan *et al.*, 2007). 'Research standard' pedometers such as the Yamax Digi-Walkers (Yamax Corporation, Tokyo, Japan) are relatively inexpensive compared to accelerometers (Scruggs, 2003) and have been shown to be consistently accurate while measuring physical activity under free-living conditions (Le Masurier *et al.*, 2004). Despite being seen as a low-cost alternative to accelerometry, in order to obtain the number of pedometer units required for large scale studies, the cost incurred may beyond the fiscal means of the project (Duncan *et al.*, 2007). If cost is a problem at a research level, then the issue of cost would also be a barrier for schools or other schemes or organisations when considering using pedometers as teaching and learning resources. Assessing the measurement error in a more modestly priced pedometer therefore makes practical sense, not just for the research study, but also when applying theory into practice where it is intended, in the school setting. The purpose of this study therefore, was to determine the validity of the Ez-V model pedometer for use in primary school aged children..

3.3 Methods

3.3.1 Subjects and Settings

A sample of 20 Year 4 students (10 girls and 10 boys) with a mean age of 8.6 years were recruited from a primary school in the North West of England and asked to take part in a 'fun activity morning' of different activities at the University gymnasium. During this time, the self-paced walk (SPW) and treadmill walking test (TWT) protocols (Beets *et al.*, 2005) were performed in order to test the validity of the pedometers at different walking speeds. Ethical approval was obtained from the Liverpool John Moores University Ethics Committee prior to the test day, along with informed parental consent from each child.

3.3.2 Instruments and Procedures

The Ez-V digital pedometer (RYP Sports, USA) was the pedometer unit selected for piloting. This model of pedometer was chosen due to its mid-range price (£10.99) compared to the most expensive model (Yamax Digiwalker 70; £19.99). Though less expensive pedometers than the Ez-V were available anecdotal evidence suggested that such units were generally found to be extremely inaccurate and unreliable.

In order to test the viability of the chosen pedometer unit the shake test, as outlined by Vincent and Sidman, (2003), was performed on the full complement of 100 Ez-V digital pedometers. The pedometers were placed in the shake test box which held the units firmly in the vertical position (Figure 3.1).

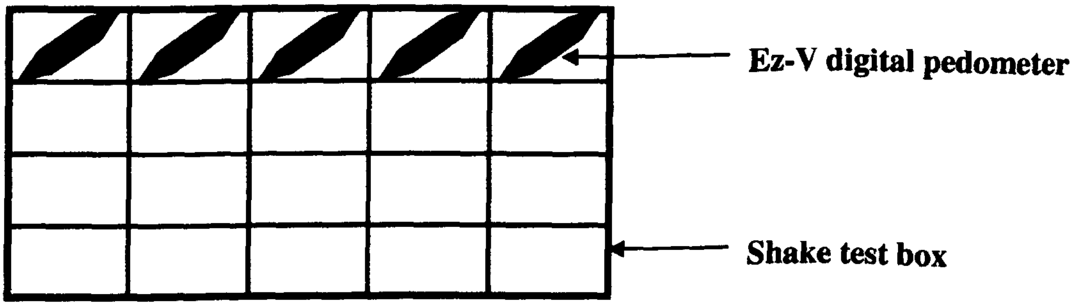

Figure 3.1 Diagram (Aerial view) illustrating the position of the pedometers in the shake test box during the procedure.

With one end of the box maintaining contact with a the table in order to minimise any extraneous movements, the other end was 'shaken' 100 times (Figure 3.2) (Vincent and Sidman, 2003). The number of 'steps' recorded on the display of each pedometer was recorded by the researcher. The box could accommodate ten pedometers during a single trial and so ten trials were required to test all 100 pedometers.

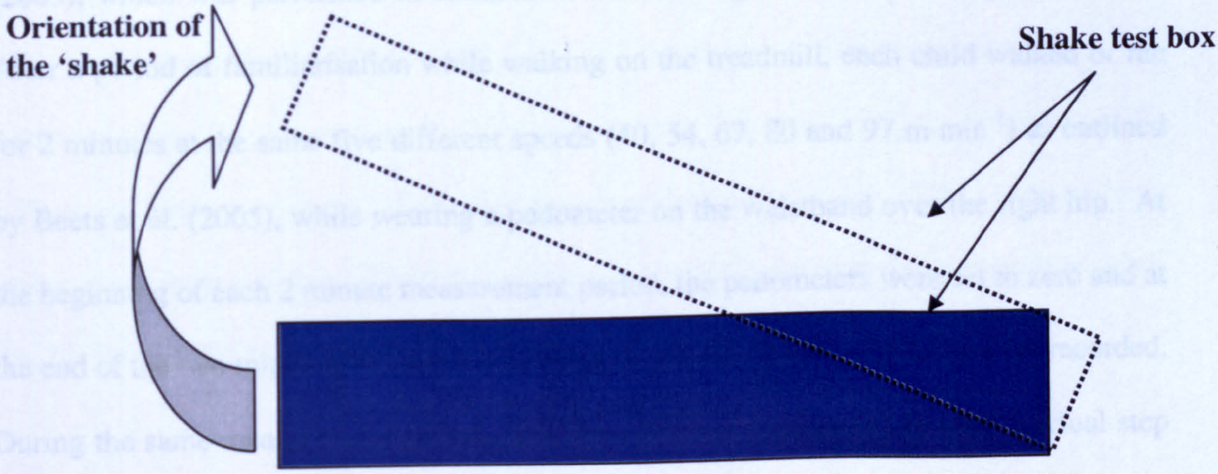

Figure 3.2 Diagram illustrating the orientation of the shake test box during the procedure (side view).

Measurement error was determined by calculating the mean and absolute deviation from 100 shakes. As with the results of Sidman and Vincent (2003), who tested the Digiwalker SW-200 Yamax pedometer using the same method, none of the Ez-V digital pedometers exceeded 5% error (i.e., ±5 steps out of 100). In their conclusion, Vincent and Sidman (2003) state with such little measurement error, researchers can be confident of the accuracy of the unit. For this reason, the decision was made that additional testing would be appropriate to further determine measurement accuracy in this model of pedometer when measuring steps taken in primary school children.

During the 'fun activity morning' the children were put into smaller groups (*n*=5) and within those groups, they rotated around a number of different activities. Stature was measured to the nearest 1 mm using a Leicester Height Measure (Birmingham, England) and body mass were calculated to the nearest 100g using Seca weighing scales (Birmingham, England; Lohman *et al.*, 1988). Body mass index was calculated as $kg{\cdot}m^{-2}$. One of the activities involved taking part in the TWT protocol, outlined by Beets et al. (2005), which was performed in children of a similar age as those in the present study. After a period of familiarisation while walking on the treadmill, each child walked or ran for 2 minutes at the same five different speeds (40, 54, 67, 80 and 97 $m{\cdot}min^{-1}$) as outlined by Beets et al. (2005), while wearing a pedometer on the waistband over the right hip. At the beginning of each 2 minute measurement period, the pedometers were set to zero and at the end of the two minutes, the number of steps displayed on the pedometer were recorded. During the same measurement periods, two investigators independently tallied actual step counts for each child using hand counters.

The second test performed by the twenty children was the SPW protocol, adapted from that outlined by Beets et al. (2005). Children were asked to walk at their normal walking speed for the length of an all-weather hockey pitch (100 metres) in order to become familiarized with the pace, before completing one lap of the pitch, which measured 294 metres. Children wore a pedometer on the right hip and the number of steps accumulated during the test lap was recorded. Each child took part in the test lap separately from their peer group, while a researcher walked behind each child at a distance of no less than 1.8 metres away, in order to count the number of observed steps. This was so that there was no influence on the walking pace of the child (Beets *et al.*, 2005). The time each child took to complete a lap was measured using a handheld stopwatch. Walking speed was also calculated using the time taken to walk the 294 metre pitch (speed= distance/time).

3.3.3 Statistical Analysis

Single-measure intraclass correlation coefficients (ICC) and 95% confidence intervals (95%CI) were calculated to assess the consistency between 1) pedometer counts and observed 1 (investigator 1) steps and, 2) observer 1 steps and observer 2 (investigator 2) steps during both the TWT and SPW. Levels of agreement between comparisons were evaluated using Baumgartner et al. (2003)'s standards (i.e., ≤0.79 is low agreement; 0.80-0.89 is moderate agreement; ≥0.90 is high agreement; Betts *et al.*, 2005). Percent error ((pedometer steps – observed steps)/observed steps) x 100) was calculated at each speed of the TWT and SPW test to determine any over or under-recording.

3.4 Results

Data were obtained from all twenty children. Table 3.1 demonstrates the mean anthropometric characteristics of the children in the sample.

3.4.1 Treadmill Walking Test

The mean (± SD) number of steps collected by the pedometer at 40, 54, 67, 80 and 97 $m \cdot min^{-1}$ were 259.33 (26.19), 296.22 (23.68), 346.56 (24.42), 377.67 (18.69) and 386.61 (19.55) respectively. The mean (± SD) number of steps observed at each speed were 266.00 (21.24, 295.06 (22.30), 322.06 (30.94), 371.44 (22.31) and 380.61 (23.60) steps, respectively. Statistical data from the TWT (n=20) are presented in Table 3.2. High inter-observer agreement (mean ICC=0.94, 95%CI=0.772-0.988) was established, and moderate to high agreement was exhibited between pedometer and observed steps (mean

ICC=0.897, 95%CI=0.724-0.961) (Butcher *et al.*, 2007). The greatest pedometer step agreement was exhibited at a speed of 54 m·min^{-1} (ICC=0.94, 95%CI=0.772-0.988), while the weakest pedometer step agreement was exhibited at a speed of 67 m·min^{-1} (ICC=0.696, 95%CI=0.187-0.886). The mean percent error (%) (± SD) of the pedometer at the five different walking speeds is presented in Figure 3.3. Walking at 67 m·min^{-1} provided the largest error (5% ± 9%), while walking at 54m·min^{-1} (1% ± 3%) produced the least error.

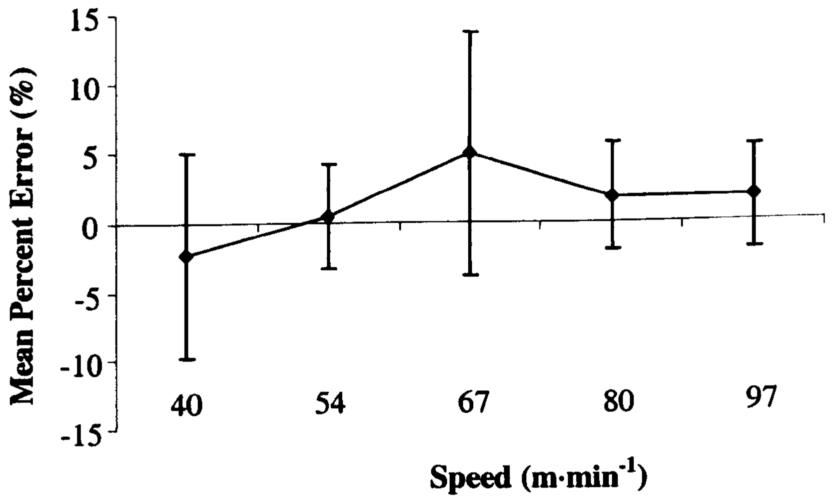

Figure 3.3 Mean percent error (±SD) of pedometer and observer 1 during the 5 treadmill walking speeds (m·min^{-1}).

Table 3.1. Mean (±SD) characteristics of males and females.

Gender	Age (years)†	Stature (cm)†	Mass (kg)†	BMI (kg·m^{-2})†	Stride Length (m)†	SPW speed (m·min^{-1})†
Male (*n*=10)	8.5 (0.53)	133.0 (0.07)	29.33 (5.0)	16.47 (1.24)	0.72 (0.05)	49 (3.0)
Female (*n*=10)	8.7 (0.48)	135.0 (0.05)	32.89 (6.62)	18.02 (2.77)	0.66 (0.07)	44 (4.0)

† All P values for the comparisons between genders at baseline were greater than 0.05

Table 3.2 Intraclass correlation coefficients (95% confidence interval) for pedometer.

	Pedometers Vs Observed 1			Observed 1 Vs Observed 2		
		95% Confidence Interval			95% Confidence Interval	
Speed	**ICC**	**Lower Bound**	**Upper Bound**	**ICC**	**Lower Bound**	**Upper Bound**
40	0.761	0.362	0.911	0.985	0.935	0.997
54	0.941	0.843	0.978	0.943	0.749	0.987
67	0.696	0.187	0.886	0.976	0.893	0.995
80	0.872	0.658	0.952	0.736	-0.172	0.940
97	0.854	0.610	0.945	0.941	0.737	0.987
Mean	0.897	0.724	0.961	0.940	0.772	0.988

3.4.2 Self-paced Walking Test

Data from the SPW test (*n*=10) are presented in Table 3.3. Fewer children completed the SPW test due to time constraints and poor weather (blustery winds and rain). The comparison of pedometer steps with actual steps observed resulted in a moderate agreement with ICC=0.856 (95%CI=0.640-0.934). All pedometers under-estimated actual steps, however the mean value of percent error did not vary more than 8.1%. Mean SPW speed calculated from the time taken to complete the 294 metre course was 47 $\text{m}\cdot\text{min}^{-1}$ (±4.0 SD).

3.5 Discussion

The purpose of the present study was to examine the measurement accuracy of a modestly priced pedometer for use in a subsequent research study in primary school children. Overall, pedometer steps exhibited moderate to high agreement with actual steps walked during the TWT conditions (ICC=0.897), while high inter-observer agreement (ICC=0.94) was exhibited between observer 1 and observer 2. The highest agreement with actual steps walked was exhibited at a speed of 54 $\text{m}\cdot\text{min}^{-1}$ (ICC=0.94), while the lowest agreement was exhibited at a speed of 67 $\text{m}\cdot\text{min}^{-1}$ (ICC=0.696). These results are further demonstrated in Figure 3.3, which presents the mean percentage error of the pedometer at each speed of the TWT. The figure shows that the mean percent error of the pedometer ranges from 5% (±9) at the speed of 67 $\text{m}\cdot\text{min}^{-1}$, to 1% (±3) at a speed of 54 $\text{m}\cdot\text{min}^{-1}$. Measurement error was also more accurate at speeds faster than 67 $\text{m}\cdot\text{min}^{-1}$, a result supported by previous authors (Ramirez- Merrero *et al.*, 2002; Beets *et al.*, 2005; Duncan *et al.*, 2007). A possible reason why the highest agreement with actual steps was exhibited at the speed of 54 $\text{m}\cdot\text{min}^{-1}$ may be because children were observed by the researcher to be most coordinated while walking at this speed, compared to any other speed during the test.

That is, they didn't under or over stride and their stride pattern was rhythmic. While walking at 40 m·min^{-1}, a number of children commented that they were 'not used to walking so slowly' and that it was uncomfortable to do so. When asked whether the speed of 54 m·min^{-1} was more comfortable to those children, they agreed that it was. Support for this anecdotal evidence may be taken from the walking speed calculated during the SPW. The average walking speed was calculated to be 47 m·min^{-1} which is within 7 m·min^{-1} of the more preferred and most accurate treadmill speed of 54 m·min^{-1}. With this in mind, Beets et al. (2005) suggest that when selecting a pedometer for the use with children, typical walking speed should be taken into consideration. Furthermore, Duncan et al. (2007) suggest that speed-related pedometer error may not be an issue during self-paced walking.

Observations made during the TWT may also help to explain the reason behind the lowest agreement found at the speed of 67 m·min^{-1}. While exercising at this speed, the majority of children struggled to maintain a consistent pattern of movement, as it was the speed was 'in between' walking and running. The children tended to shuffle and stumble at times between walking and running, while some children took longer (and therefore slower) steps which may mean that the pedometer units, as well as observers, were unable to detect the movement and hence the low agreement at this speed. Children who were able to either walk normally or run, found this speed less of a challenge. These observations are supported by the 95%CI values for the 3 speeds (40, 54 and 67m·min^{-1}) as the speeds where children reported difficulties demonstrate the greatest CI range (40 and 67 m·min^{-1}); while at 54 m·min^{-1} (the children's self-reported speed of preference) the CI range is at its lowest (Table 3.2). Further support for this supposition is provided by Duncan et al. (2007). In their study looking at the effects of age, walking speed and body composition on pedometer accuracy in children, Duncan et al. (2007) conducted a similar TWT to that conducted in the present study, using speeds of 42, 66 and 90 m·min^{-1}. They found that pedometers underestimated steps by approximately 20% at speeds of 40 and 66 m·min^{-1}, but that the degree of underestimation decreased as the number of steps taken increased (as observed in the present study). They suggested that children who take long, controlled steps during these speeds may generate less vertical acceleration forces than those who take short, jolting steps and therefore not register steps with the pedometer (Duncan *et al.*, 2007).

Results of the SPW test show a moderate agreement between pedometer recorded steps and those observed by the researcher (ICC=0.856). Mean percent error was calculated at 4.0% (±3.0%), with all pedometers under-estimating the number of steps observed by the researcher. One possible reason for the level of agreement being less than that of the TWT is that the weather on the day of testing was not favourable. A number of the children took part in this test while it was raining and blustery, which may have had an effect on the their gait (i.e., the steps taken by a child did not generate a vertical acceleration force above 0.35g required to register a step, or the tilt angle of the pedometer was greater than during the TWT, as the children tended to stoop a little when walking against the wind and rain) (Duncan *et al.*, 2007). This supposition is supported by the Duncan et al. (2007) who found that the Yamax Digi-Walker SW 200 underestimated treadmill walking at all speeds by 2.6 times when the tilt angle of the pedometer was ≥10°.

When comparing the results of the present TWT to the literature, the data are rather different to those reported by Beets et al. (2005) and Duncan et al. (2007). From all the different pedometers tested by Beets and colleagues (2005) and from the results of Duncan et al. (2007), the greatest agreement found with actual steps taken was exhibited at speeds of ≥67 $m \cdot min^{-1}$. Similar to the present study however, Beets et al. (2005) found that when examining the accuracy of steps from the SPW in relation to the TWT, the moderate to high degree of accuracy during SPW mirrored that from the TWT. This is because when measuring SPW speed, Beets et al. (2005) reported that no child walked at a speed lower than 67 $m \cdot min^{-1}$. The reason for this difference in SPW speeds between the children in the three studies is unclear. An intuitive suggestion would be that the two groups differed in their anthropometrical characteristics and so resulted in quite different walking speeds, however Beets et al., (2005) report their sample to have very similar characteristics to the children within this study (mean height (years) males/ females= 8.3±1.47/8.9±1.72; mean height (cm) males/females= 130.8±8.92/131.1±14.00; BMI ($kg \cdot m^{-2}$) males/females= 16.1±0.99/16.9±2.98). When explaining the small difference in their results between boys and girls, Duncan et al. (2007) suggest that the mere walking style of the children may be sufficient to elicit a difference. It may therefore be that the walking style of the children from the two studies differed sufficiently to observe this difference in walking speed.

Despite the differences between the these studies, by adopting the suggestions put forward by Beets et al. (2005) that pedometers with an agreement of ICC= 0.857 or above would be recommended for use with primary school aged children, the Ez-V digital pedometer (RYP Sports, USA) would qualify.

3.6 Conclusions

In conclusion, moderate to strong agreement was demonstrated in the SPW test and TWT. Furthermore, strong agreement was observed at a speed approximating typical walking speed of the population being studied. On this basis, the modestly priced Ez-V pedometer was deemed an accurate device with which to monitor primary school children's daily activity levels.

Chapter 5 Study 3: Affect of school travel plans on physical activity during winter and summer.

5.1 Thesis Study Map

Study	Aims
Study 1: Measurement accuracy of a pedometer for measuring physical activity in a primary school setting	• To validate the Ez-V model of pedometer for the use in primary school children.
Study 2: The effect of feedback and information on children's pedometer step counts at school.	• To examine the effects of providing primary school children with feedback and information relating to the number of pedometer steps accumulated during a full school day. • To examine whether there was a gender difference in step counts per day.
Study 3: Affect of school travel plans on children's physical activity during the winter and summer.	• To assess the affect of the school TP on the MVPA of primary school children • To examine the difference in MVPA by season.
Study 4: Can a 12-week, whole school intervention increase primary school children's moderate to vigorous intensity physical activity?	

5.2 Introduction

Active commuting to school has been identified as an important opportunity for children and adolescents to accumulate recommended amounts of MVPA (Tudor-Locke *et al.*, 2001; Merom *et al.*, 2005; Faulkner *et al.*, 2009; NICE, 2009; van Sluijs *et al.*, 2009) and adopt important health behaviours that can be maintained into adulthood (Cooper *et al.*, 2006). A number of studies have found that not only does the journey to school itself influence amounts of MVPA, but also those who walk and cycle to school are more active overall throughout the day (Cooper *et al.*, 2003, 2005; Michaud-Tomson & Davidson, 2003; Sirard *et al.*, 2005; Faulkner *et al.*, 2009; van Sluijs *et al.*, 2009). Tudor-Locke et al.

(2003), in a study looking at the energy expenditure of children who actively and passively travelled to school, found that children who actively commuted expended significantly more energy than those who travelled passively. Furthermore, Mackett et al. (2005) stated that for many children, one week of walking to and from school consumes more energy than a week's worth of PE lessons (2 hours of PE), which are the only formal and mandatory opportunities for physical activity provided in schools. However, over the past 20 years the trend has been for children to shift from walking to travelling by car (Badland & Schofield, 2005; Macket *et al.*, 2005). The rates of primary school children in England who are driven to school have doubled during this time to 47%, while the proportion of children who travelled to school by foot or cycle has decreased sharply (DfES, 2003). More recently, figures from Scotland show that in 2009, of the 415,000 children surveyed, only 49.9% travelled to school actively (walk, cycle, scooter or skateboards), a reduction of 1.9% from the previous year (Sustrans, 2010). There are many different barriers that have been proposed to account for the low levels of active commuting in children. These include parental safety concerns related to travel distance, traffic, crime and bullying (CDC, 1999; Kerr *et al.*, 2006; Rowland *et al.*, 2006), as well as physical environmental factors such as, pavement infrastructure, accessibility to public transportation, urban vs. rural location and weather conditions (Davison *et al.*, 2008; Rowland *et al.*, 2006; Timperio *et al.*, 2004).

The greater use of motorised transport to school has resulted in increased pollution and congestion around schools (Moodie *et al.*, 2009; Marshall *et al.*, 2010). With the greater demand for the reduction of carbon emissions, this has prompted the previous British government to promote active transport through initiatives such as the school travel plan (TP) (Rowland *et al.*, 2006; Wen *et al.*, 2008). The school TP aims to increase children's physical activity levels through increasing the incidence of walking and cycling to school, decrease traffic pollution, increase public access to public transport, and reduce casualties (Rowland *et al.*, 2006), as 124 children were killed and 2683 were seriously injured while walking and cycling in England in 2008 (D*f*T, 2010). Sustrans, the UK's main sustainable transport charity, advocates the use of the school TP to enable people to choose active travel more often (Sustrans, 2007). Furthermore, NICE (2009) in its recent paper outlining guidance on the promotion of physical activity in children and young people, strongly advocated the use of the school TP to facilitate increased physical activity in children. Despite this strong advocacy, little attention has been given to the effectiveness of the school TP in increasing physical activity, with only one study published in the literature examining its implementation. Rowland et al. (2006) conducted a randomised controlled trial to examine the effects of 16 hours of cumulative assistance from an expert travel plan officer on the proportion of children who walked or cycled to school, as well as the proportion of schools that actually produced and implemented their TP. The authors found that having a TP coordinator led to increased numbers of schools that produced a TP; however, there was no evidence that these TPs actually changed travel patterns or reduced parental fears around active travel. Rowland et al. (2006) suggested that a change in travel patterns resulting from TPs may take a number of years to occur due to the time it takes to implement the different activities associated with the TP, as recommended by the UK government (e.g., identifying safe routes to school, setting up a walking bus). With the amount of resources that are being made available for school TPs as a result of government recommendations, it is surprising that there is such a small evidence base supporting the work (Ogalvie *et al.*, 2004; Wen *et al.*, 2008).

A number of studies have noted that in summer, when the weather is more temperate and there are longer hours of daylight, that children's overall physical activity is significantly higher than during the winter (Rifas-Shinman *et al.*, 2001; Rowlands & Hughes, 2006; Duncan *et al.*, 2008; Kolle *et al.*, 2009; Rowlands, Pligrim & Eston, 2009). This is because more favourable weather and longer daylight hours may encourage more outdoor play (Carson & Spence, 2010). Indeed, in their study of 1115 five to twelve year olds pedometer measured physical activity, Duncan et al. (2008) found that on days of moderate rainfall, physical activity was significantly reduced. Furthermore, the authors found that in comparing winter and summer physical activity, a 10°C increase in mean ambient temperature demonstrated a 1700 and 3400 step increase in boys during the week and weekend days respectively. Caron and Spence (2010)'s recent review of the seasonal variability of children and adolescent's physical activity found consistent data, across a number of different countries, supporting the effects of seasonality in children over the age of 6 years old. The authors were keen to point out however, that extreme increases in temperature experienced in some countries/geographical areas, may have negative effects on physical activity during the summer and that the number of daylight hours in the winter may be more significant than temperature in influencing physical activity behaviour. These data suggest that it may be important to consider seasonality when designing interventions aiming to increase physical activity in children, or when monitoring physical activity in this population. This is especially true when considering interventions that aim to change travel to school behaviour, as poor weather conditions have been identified as one of the barriers to active commuting in children (Dellinger & Staunton, 1999; Davison *et al.*, 2008; Rowland *et al.*, 2006; Timperio *et al.*, 2004).

While there is limited literature to support the supposition that seasonality and weather is a determinant of active commuting behaviour in children and adolescents, a recent review by King et al. (2010) examined the correlates of accelerometer measured physical activity and sedentary behaviour in 480 seven year old English children. They found that active commuting to school, child interest in physical activity, child weight status and season was significantly associated with habitual total physical activity, habitual MVPA and habitual sedentary behaviour. More specifically, children were significantly more active in the summer compared to the winter, spring and autumn; were more active if they travelled to school by active means and if they were male. Furthermore, a recent study by Børrestad, Andersen and Bere (2010) found there to be large seasonal variations in active commuting behaviour in a large sample (*n*=996) of Norwegian 11-12 year old children. The authors found that children used passive travel more during the autumn, winter and spring compared to the summer, with a significant majority of those who cycled during the summer opting to walk in the winter. This change in behaviour was associated with more cold, wet and snowy weather in autumn, winter and spring compared to summer. The applicability of these results to the UK population is however unclear, as the majority of the Norwegian sample studied in this research were active commuters (62% in summer and 59% in the winter compared to 49.9% in the UK), with the most dominant mode of transport being cycling. Also, Norway experiences much colder weather than the UK and much greater variation in daylight hours, which may affect the change in active commuting behaviour.

The aim of this study was to assess the affect of the school TP on the MVPA of primary school children by (1) comparing the MVPA of children who attended schools with an established TP with those attending schools just embarking on theirs, and (2) by examining the difference in MVPA by season. It was hypothesised that children from schools with an established TP would accumulate more daily MVPA compared to those who attended a new TP school, as established TPs would have had longer to influence behaviour change. Furthermore, it was hypothesised that children's MVPA would be greater during the summer season compared to the winter, as the weather is more likely to favour active commuting and other physical activity opportunities in the summer.

5.3 Methods

5.3.1 Subjects and Settings

Children were recruited from six schools in Liverpool, England. The majority of schools who took part in the present study were situated in areas of high social and economic deprivation, with four of the schools reported by Ofsted (2010) as having 50% or more of pupils eligible for free school meals; while the other two schools were considered to have average or below average numbers of children eligible for free school meals. Schools were a convenience sample, identified by the city's TravelWise team as those that would likely to agree to take part in the study (http://www.gotravelwise.com/index.php) and were subsequently approached with the study information. Three of the schools were deemed to have an Established TP (implemented for at least 2 years) while the other three were 'new' schools (i.e., had just drafted their TP and were in the first year of its implementation). All children in school Years three to six (age 7-11 years) from each school were invited to participate. Informed parental consent was obtained for 333 children. Due to the small number of accelerometers available (*n*=20), only 20 children (10 boys and 10 girls) per school were chosen to take part in the study. This was achieved using stratified random sampling (Thomas, Nelson & Silverman, 2005). Ethical approval was obtained from the University's Ethics Committee.

5.3.2 Instruments and procedures

In each school ten girls and ten boys were randomly selected to wear an Actigraph uni-dimensional accelerometer (Model GT1M, ActiGraph, LLC, Fort Walton Beach, FL) for one school week (5 consecutive days) during the winter (November and December, 2005) and again in the summer (June and July 2006). Accelerometers were chosen to measure physical activity across the day as they provide a reliable (Brage *et al.*, 2003, Metcalf *et al.*, 2002, Welk *et al.*, 2004) and valid (Eston *et al.*, 1998, Nichols *et al.*, 1999, Trost *et al.*, 1998), objective field measure of physical activity in children. The children were instructed to wear the Actigraph unit on an elastic belt provided by the manufacturer, as close to the child's centre of gravity as possible (Trost *et al.*, 2005), from the point of waking until they went to bed. Exceptions to this rule were during bathing, swimming or during activities such as playing rugby or contact martial arts, so not to damage the unit or injure the wearer or opponent. Children were encouraged to seek the assistance of an adult to help with adjustment of the elastic belts if they were at all uncomfortable.

In order to ensure that high and very high intensity physical activity was measured, MVPA was calculated using 5 second measurement epochs (Nilsson *et al.*, 2002). After the measurement period, data were downloaded from the ActiGraph and then uploaded to the MAHUffe software (http://www.mrc-epid.cam.ac.uk/Research/PA/Downloads.html) for data reduction. The amount of time children engaged in MVPA was calculated using age-specific cut-points determined by Freedson *et al.* (1997).

Data were first checked for compliance to the protocol over the monitoring period. To be included in the analyses, it was desirable for children to have three (Mattocks *et al.*, 2008) 'completely observed' days of data as defined by Catellier et al., (2005). Firstly, the minimum number of hours per day that the ActiGraphs were worn was determined. Sustained 20 min periods of zero counts were deemed to indicate that the monitor had been removed, and total 'missing' counts for those periods represented the duration that monitors were not worn (Catellier *et al.*, 2005). For inclusion in the analyses, each child was required to have produced counts for ≥7.8 h on each measurement day. This figure represented 'nonmissing' counts for at least 80% of a standard measurement day, which was defined as the length of time that at least 70% of the sample wore the monitor (Catellier *et al.*, 2005). Children who recorded less than the criterion on more than 3 days were excluded from the main analyses (Mattocks *et al.*, 2008).

According to the techniques of Lohman, Roche and Martorell (1998), stature was measured to the nearest 0.1 cm using a Leicester Height Measure (Birmingham, England), with the child stood upright and barefoot and body mass was calculated to the nearest 0.1kg using Seca weighing scales (Birmingham, England). Body mass index was calculated as $kg \cdot m^{-2}$. Each child was asked to identify how they travelled to school by ticking the relevant answer to the question 'How do you usually travel to school?'. The options available were 'walk', 'car', 'bus', 'bicycle' and 'other'. If the child answered 'other', then there was a space to state the mode of transport. Those who reported that they walked, cycled or scootered (following the 'other' response) to school were deemed active commuters and those who travelled by car or bus were deemed passive commuters.

During the winter data collection, data were obtained from 143 children from the six schools. Data were lost from six children due to faulty ActiGraphs. After data cleaning a further 20 children were omitted from the analyses due to insufficient number of days' data, leaving 117 (81.2% compliance). During the summer data collection, ActiGraph accelerometers were administered to the same 143 children from whom data were collected in winter. Data cleaning resulted in only 69 children (48.3% compliance) meeting the inclusion criteria for the number of days monitoring, of which 29 were from the New TP group and 40 were from the Established TP group. Once children were matched by season, 45 children (17 New TP (males n=9, females n=8), 28 Established TP (males n=21, females n= 7)), had both winter and summer physical activity data which could be used in the analysis.

5.3.3 Statistical Analyses

The percentage of children who actively and passively commuted to school was calculated by TP. All data were first checked for normality using the Shapiro-Wilk test and any outliers were checked for faulty measurements. Initial analyses were conducted using independent t-tests to explore any difference between the anthropometric characteristics of the groups. The difference in whole day MVPA between the TP condition and season was examined using a 2 x 2 way repeated measures ANCOVA, with BMI included as a covariate. Greenhouse-Geisser correction factors were applied where appropriate and all analyses were conducted using SPSS version 14.0 (SPSS Inc. Chicago, IL.) and statistical significance was set to $p<0.05$. In order to examine the meaningfulness of the outcomes, effect sizes (ES) were calculated using the equation proposed by Thalheimer and Cook (2002):

$$d = \frac{\bar{x}_t - \bar{x}_c}{\sqrt{MSE\left(\frac{n_t + n_c - 2}{n_t + n_c}\right)}}$$

5.4 Results

Fifty six percent of children from the New TP schools and 45% from Established TP schools were classified as active commuters during the winter season. The response rate to the transport questionnaire during the summer was markedly reduced, with two schools not returning any data. Shapiro-Wilk analyses revealed that all physical activity data were deemed to be normally distributed ($p>0.05$). Preliminary analyses demonstrated that there were no significant group differences in stature, mass or BMI ($p>0.05$) (Table 5.1). Across the whole day, all children exceeded the current physical activity for health guidelines proposed by DH of at least 60 minutes of MVPA per day (winter range: 73.50 to 216.06 minutes, summer range: 63.42 to 226.33 minutes).

Table 5. 1 Mean (±SD) anthropometric characteristics of Liverpool students in order of TP group.

	New TP†		**Established TP**†	
	Males (*n*=9)†	**Females (*n*=8)** †	**Males (*n*=21)** †	**Females (*n*=7)** †
Age(y)	8.48 (1.28)	8.43 (1.12)	8.50 (0.85)	8.3 (0.82)
Stature (m)	1.36 (0.08)	1.39 (0.08)	1.33 (0.17)	1.35 (0.08)
Mass (kg)	35.48 (8.08)	36.33 (4.27)	39.29 (15.07)	35.57 (8.67)
BMI (kg·m^{-2})	18.76 (3.22)	19.56 (1.79)	20.38 (5.90)	19.31 (2.95)

†All P values for the anthropometric comparisons between intervention groups and gender were greater than 0.05.

Results of the 2 (TP) x 2 (season) way repeated measures ANCOVA on whole day MVPA revealed no significant main effect for TP condition or season. However, table 5.2 shows that overall, children were more active during the summer by 7.81 minutes ($F_{(1,35)} = 0.089$, $p=0.768$, d=0.1). In addition, the New TP children accumulated 5.2% (7.24 minutes) more whole day MVPA during winter and 15.66% (24.11 minutes) more whole day MVPA during summer, compared to the children from Established TP schools ($F_{(1,35)} = 0.955$, $p=0.207$, $d=0.33$).

Table 5.2 Mean (±SD) time spent in MVPA (minutes) during the winter and summer seasons by TP group.

Season	New TP (*n*=23)	Established TP (*n*=15)	Total (*n*=38)
Winter	139.46 (28.16)†	132.22 (34.25)†	136.60 (30.47)†
Summer	153.93 (45.72)†	129.82 (32.73)†	144.41 (42.32)†

† All P values for the comparisons between TP groups and season were greater than 0.05

5.5 Discussion

This study examined the effect of the primary school TP on the daily MVPA of children during the winter and the summer. Given the suggestion that school TPs may require time to influence travel patterns (Rowland *et al.*, 2006), it was hypothesised that children attending schools with an Established TP would be more physically active than those who attend schools where the TP had only recently been introduced. However, results revealed that even though not significant, children in the New TP schools accumulated 7.24 (winter) and 24.11 (summer) more minutes of MVPA (5.2% and 15.66% respectively) throughout the day compared with those in the Established TP school children (Table 5.2). The lack of statistical significance may be attributable to the small sample sizes (n= 23 and 15 respectively), as the effect size was calculated as $d=0.1$. The difference in observed MVPA was mirrored by an 11% difference in the number of children actively commuting to school in the New TP schools compared to the Established TP schools. In their study examining the effects of site specific advice and support on the development of the school travel plan, Rowland et al. (2006) found that only schools who had committed to and implemented the scheme were successful in completing a TP. While the majority of the schools had produced a TP, fewer than half of these schools had developed a walking bus or were pro-active in increasing physical activity. Authors suggested that this may be due to a reluctance of staff to engage in all areas of a TP due to time constraints and/or that the active transport needs of a number of the schools required urban planning, which would require a longer time frame to be implemented. Therefore, a possible reason for the contrary finding to the initial hypothesis may be that staff, children and parents from New TP schools may have been more enthusiastic about its purpose than those in the Established TP schools, where the initiative may have become stagnant due to resource constraints. If this were the case, such a situation could be confounded by the year-on-year change in the population of schools.

Each year, one class of Year 6 children leaves the school to be replaced by a new group of children in year 3. For those schools in the present study with an established TP, it had been at least 2 years since the initiative had been first introduced and so over the course of that time, these schools would have lost two classes of children (approximately 60 pupils) and parents who were familiar with the TP. This is an important issue to note when considering the way in which the TP aims to increase the numbers of children actively commuting to school, particularly through such activities as 'walking buses' (DCSF, 2003) which are dependent on the support and involvement of staff and parents. This is because children's active commuting is negatively associated with parental concerns regarding walking and cycling to school (Kerr *et al.*, 2006). More specifically, parents' perceptions of the local neighbourhood (including concerns about road safety, heavy traffic, strangers, and access to parks and sports facilities) are most related to children's walking and cycling behaviour (Timperio *et al.*, 2004, 2006). As part of the TP process, schools are required to identify safe routes to school in which they are supported by road safety officers, highway engineers and the local authority (DCSF, 2003). Schools are encouraged to promote their defined safe route to school and to facilitate active commuting by applying for funds to improve facilities to sustain walking and cycling to school. By promoting initiatives such as the safe route to school, walking buses, park-and-stride (an initiative to get parents to park further away from the school premises and walk some of the way), walk to school weeks, 'walking Wednesdays' etc, the TP potentially contributes to reducing the perceived barriers associated with active commuting to school for both parents and children (Timperio *et al.*, 2006; Hume *et al.*, 2009; Carver *et al.*, 2010). If parents are unaware of the TP and the safe routes to school, then they may be less likely to allow their children to walk or cycle to school if they feel it is unsafe to do so (Kerr *et al.*, 2006; Hendricks *et al.*, 2009; Carver *et al.*, 2010). However, the school travel plan is designed as a 'living document' and schools are encouraged to update it at least once a year. This though would only occur if the working group within the school were engaged in the process. It is also reasonable to assume however, that schools would make new parents and children aware of the school TP upon induction to the school. Collection of qualitative data on the process of delivery and the receipt of the TP in each school would have provided a more tangible insight into establishing this supposition as fact. The difference in MVPA between the two TP groups suggests that it may be important for schools to remind children and parents of the purpose and importance of the school TP at the beginning and throughout each school year, to engage new pupils and to re-encourage existing pupils and parents to walk and cycle to school.

The secondary hypothesis proposed was that children would accumulate significantly more MVPA during the summer time than during the winter, as a number of authors have observed a seasonal difference in MVPA in primary school aged children (Rowland *et al.*, 2009; Carson & Spence, 2010; King *et al.*, 2010). This hypothesis was also based on the premise that time spent outdoors is correlated with physical activity (Burdette *et al.*, 2004) and during the summer, there would be an increase in daylight hours (Nov- Dec: 10-8 hrs. vs. June-July: 16-16.5 hrs.; (Met Office, 2010) and an increase in drier and warmer weather which would support favourable parental safety perceptions for active commuting and outdoor play across the day. Although not statistically significant, overall children accumulated 5% (6.39 minutes) more MVPA during the summer than during the winter, which is a result supported by previous research (Rifas- Shinman *et al.*, 2001; Rowlands & Hughes, 2006; Kolle *et al.*, 2009; Rowlands, Pligrim & Eston, 2009; Carson & Spence, 2010; King *et al.*, 2010). However, when comparing the two TP groups by season, Table 5.2 suggests that only children in the New TP increased their MVPA during summer. One logical hypothesis to explain this finding may have been that those children who did not actively commute to school during the winter, did so in the summer as a result of the improved weather etc.

Again, these data were not available, as a result of the majority of children/schools not completing the transport questionnaire during the summer data collection period. A number of link teachers within the schools did not prioritise the completion of the questionnaires and others felt that they did not have sufficient time at the end of the school term. Another possible explanation for the difference in activity may be a variability in time available for physical activity during discrete time periods. When considering the journey to school, the amount of time available to increase physical activity is constricted to the amount of time allocated to that journey. That is, if a journey takes ten minutes from home to school, and only ten minutes is allocated for that journey before the child has to attend school, then there is no 'spare' time available for children to play in the playground before they go into the classroom and therefore less time to accumulate physical activity.

Without allocating more time to the journey to school or any additional time for play before school, then it would be unlikely to expect much variation in MVPA. This supposition is supported by Fairclough et al. (2007), who examined the variability of primary school children's whole day and segmented day MVPA and found that the pre-school segment of the day was the most stable.

The increase in activity during the summer may be attributable to the greater length of daylight hours available for children to play outside once they are at home (Burdette *et al.*, 2004; Met Office, 2010). The difference in MVPA between the TP schools suggests that the New TP may have had an additional influence. It may be that the parents of the children attending the New TP schools had fewer perceived barriers than those from the Established TP schools (Rowland *et al.*, 2006; Hume *et al.*, 2009). However, the difference in MVPA between the groups was relatively small with a negligible ES, which again was likely due to the small sample sizes of the New TP and Est TP groups. Had there not been such a high level of attrition in participants who recorded data from the winter to the summer, then a larger sample size may have shown the difference to be significant.

5.6 Strengths and Limitations

This study is the first to examine the impact of the school TP on physical activity levels in children, which is notable given that organisations such as NICE (2009) strongly advocated within their guidance, the use of the school TP to facilitate increased physical activity in children. In addition, it has been recently highlighted in the literature (King *et al.*, 2010) that the study of seasonality in objectively measured physical activity is very limited, therefore another strength of this study is that physical activity was assessed using a valid and objective measure, during discrete periods of the day and over the winter and summer seasons. The results provide some evidence to support previous research that has found that children are more physically active in the summer months (Rifas- Shinman *et al.*, 2001; Rowlands & Hughes, 2006; Kolle *et al.*, 2009; Rowlands, Pligrim & Eston, 2009; Carson & Spence, 2010; King *et al.*, 2010). The implications for future research is such that research designs involving the monitoring and evaluations of physical activity in children should consider the impact of season on any changes in physical activity over time and that one measurement period may not fully encompass children's normal physical activity. Furthermore, the impact of seasonality may also have implications for the provision of children's physical activity opportunities, however the reasons for a reduction in physical activity in the winter months requires further study. One suggestion for consideration may be to examine the impact of seasonal variations in the PE curriculum and how it affects children's daily MVPA. During the winter months, teachers are largely confined to delivering PE indoors due to the weather (increased precipitation and reduced ambient temperature) which may limit the amount of MVPA children accumulate; or possibly, teachers may opt to deliver swimming lessons during this term, which requires children to remove their accelerometers when monitoring physical activity which would reduce the amount of MVPA captured during the winter months.

The present study was also limited in a number of areas, most notably by the lack of compliance and subsequent small final sample size; the cross sectional design used and absence of a control group. Over the winter and summer data collection periods, compliance to the study protocol fell from 81.2% to 48.3% respectively, characterised mainly by children not wearing the accelerometers on at least 3 whole days. The reason for this is unclear, but it may be because children felt over burdened by the process of having to wear the monitor every day for a week, or simply because they forgot to wear the units. Alternatively, it may have been the result of a lack of support from the class teacher to remind the children to wear their accelerometer each day and therefore a lack of a whole school approach to the study. The use of retrospective interviews and focus groups may have provided an insight into why there was such a high drop-out rate over the course of the study.

Another limitation to the study is the method used to classify active and passive commuters. The questionnaire used asked the children to classify their typical mode of travel in to a single category, whereas children may use one or more means (both active and passive) of travel in a single journey to and from school. For example, one of the activities that was promoted by the Travelwise team was the 'Park and Stride', whereby parents who brought their children to school by car would be encouraged to park further away from the school and then walk the remainder of the way to the school gates. By only allowing children to choose one mode of transport to school and not a combination would mean that children who took part in the 'Park and Stride' would have been misclassified. Determining all the potential travel modes to school and subsequent combinations of travel may however pose a problem for researchers and may also require very large sample sizes in order to determine differences between groups. However, future research should examine the contribution of combined active/passive transportation to children's daily physical activity.

Future research should also use a longitudinal study design in order to track physical activity and mode of travel to school in a larger sample of children. Qualitative methods should also be used in order to examine the reasons for the mode of transport used by children and parents during the journey to and from school. Of course, the difference in MVPA between the two TP groups may be purely as a result of the children from the New TP schools being generally more active than those from the Established TP schools. By having a control group to compare the New TP and Established TP data to would help to clarify this point. Despite these limitations, the difference in MVPA between the two TP groups suggests that it may be important for schools to remind children and parents of the purpose and importance of the school TP at the beginning and throughout each school year, to engage new pupils and to re-encourage existing pupils and parents to walk and cycle to school.

5.7 Conclusions

NICE (2006, 2009) has recently emphasised the school TP as a measure to increase children's daily physical activity. The present study demonstrates that the school TP has potential to indirectly increase children's daily physical activity through the promotion of safe routes to school and active transport to school. In addition, the study also found that although not significant, children's MVPA was greater in the new TP schools compared to those in the established TP schools, suggesting that the TP is most effective when it is first implemented. The school TP should therefore be re-marketed each year in order to maintain its effectiveness. In order to optimise the role of the school TP, further research is needed into what motivates parents and children to actively commute to and from school. Furthermore, the impact of seasonality may also have implications for the provision of children's physical activity opportunities, however the reasons for a reduction in physical activity in the winter months requires further study.

Chapter 6 Study 4: Can a 12-week, whole school intervention increase primary school children's moderate to vigorous intensity physical activity?

6.1 Thesis Study Map

Study	Aims
Study 1: Measurement accuracy of a pedometer for measuring physical activity in a primary school setting	• To validate the Ez-V model of pedometer for the use in primary school children.
Study 2: The effect of feedback and information on children's pedometer step counts at school.	• To examine the effects of providing primary school children with feedback and information relating to the number of pedometer steps accumulated during a full school day. • To examine whether there was a gender difference in step counts per day.
Study 3: Affect of school travel plans on children's physical activity during the winter and summer.	• To assess the affect of the school TP on the MVPA of primary school children • To examine the difference in MVPA by season.
Study 4: Can a 12-week, whole school intervention increase primary school children's moderate to vigorous intensity physical activity?	• To evaluate the affect of a multi component, whole school intervention increase the MVPA of primary school children. • To examine whether feedback from pedometers as well as information on how and why children should be physically active could increase and maintain children's mean daily step count over 5 weeks. • To identify whether the whole school intervention affected the most or least active children's pedometer measured physical activity

6.2 Introduction

The prevention and management of childhood obesity in the UK is a public health priority (DH, 2004). In order to aid the reduction in the prevalence of childhood obesity, NICE published their guidelines for the prevention, identification, assessment and management of overweight and obesity in adults and children in England and Wales (NICE, 2006). Authors identified schools as one of the key settings for the delivery of their recommendations for meeting the target to halt the annual rise in obesity in children younger than 11 years by 2010. The key priority for implementation within the school setting identified by NICE (2006) was for head teachers, in collaboration with parents and pupils, to assess the whole school environment in order to ensure that the ethos of all school policies helps children and young people to maintain a healthy weight, eat a healthy diet and be physically active. In their 2009 report, NICE further highlighted the school as one of the key setting for the implementation of their guidelines on promoting physical activity, active play and sport for pre-school and school-age children and young people. This vehicle for health promotion is important because lifestyle and risk behaviours relating to physical activity and chronic diseases are learned early at school (Rogers *et al.*, 1998) as well as playing an important role in providing opportunities for children to be active and develop healthy eating habits (NICE, 2009). As a result, there has been increasing pressure for schools to provide healthy environments for children, as highlighted by recent Ofsted regulations requiring that schools provide evidence of pupils adopting healthy lifestyles (Ofsted, 2009).

In recent years there have been a number of interventions and programs that have focused on the primary school setting in order to increase children's physical activity. In the USA, project SPARK (Sports, Play and Active Recreation for Kids) aimed to increase children's physical activity during PE classes through a health related PE programme and after school through a self-management programme (Sallis *et al.*, 1997). The integration of physical activity in the primary school curriculum has been considered in different forms. Examples from the literature include the Take 10! programme, a resource for teachers that uses instruction cards for providing blocks of 10 minutes of physical activity through the curriculum (Stewart *et al.*, 2004), however Salmon (2010) reports that when piloting the feasibility of activity breaks into the school day, teachers felt that a ten minute break was too long to permanently incorporate into the school day, whereas a two minute break would be more feasible in a 'real world' setting. Others include the use of pedometers to promote physical activity throughout the day (Oliver, Schofeild & McEvoy, 2009); the use of health related PE (Fairclough, Butcher & Stratton, 2008; Verstraete *et al.*, 2007), classroom based health education and extracurricular physical activity promotion; and computer and media based resources in addition to signposting of local physical activity events (Gorely *et al.*, 2009).

In 2006, Oliver et al. conducted a feasibility study on an intervention that used an integrated curriculum approach to increase habitual physical activity in primary school aged children. Authors examined the use of pedometers to integrate physical activity across the curriculum by designing a four-week 'virtual walk' competition, whereby children would accumulate pedometer steps in order to move themselves along a 'virtual walk' around New Zealand. A thematic approach to the delivery of the intervention was used, whereby different subjects, such as English, maths, social studies, PE and statistics were linked to the 'virtual walk'. Lesson plans were designed in order to achieve this and were based on New Zealand's national curriculum. Physical activity data were collected via pedometry at baseline, and pedometer steps were recorded every day over the four week intervention period by the class teachers. Results of the study showed that at baseline, 80 % of children (n=61) were already achieving recommended daily step counts. Overall, when all children's data were analysed together, no significant difference was found between baseline steps per day and those during the intervention. However, when children were separated out into physical activity quartiles, the least active children (i.e., those accumulating less than 15,000 steps per day) significantly increased their daily physical activity. The results of this study advocate the use of pedometers as a means of integrating physical activity across the curriculum and that this method of physical activity promotion may be an effective way of targeting the least active children within a population without being singled out.

Verstraete et al. (2007) designed a comprehensive physical activity programme for use in 16 Belgian primary schools (8 condition and 8 control). The intervention was based on the SPARK programme (Sallis *et al.*, 1997) and aimed to increase children's physical activity during PE classes and outside of school by implementing a health related PE programme and a self-management programme. In addition, physical activity was also promoted during playtimes. Physical activity was measured via accelerometry and physical activity questionnaire. Measurements were taken at baseline and post-test, following 24 months of the intervention. Results revealed that children in the intervention schools engaged in significantly more MVPA than those in the control schools, which was magnified by a decrease in MVPA in the control schools over the 24 month period. The results of the test battery found no difference in fitness from baseline to follow-up in the intervention group. This suggests that although the increase in physical activity was significant, the amount of physical activity increase was not of sufficient intensity to improve cardiovascular fitness. However, children's body fatness, measured by sum of skinfolds, was significantly higher in the control group post-test, suggesting that the intervention was successful in maintaining or reducing body fatness in the intervention schools.

A non-randomised control trial in the UK was recently published by Gorely and colleagues (2009). The 'GreatFun2Run' intervention trial ran for ten months and was run by an events management company, whereby a holistic approach to children's health education was adopted. Teaching resources such as a CD-ROM were introduced to classroom teachers that contained lesson plans for including health and activity related issues across the curriculum (literacy, numeracy, history, design, science and geography) and included the importance of good food and nutrition as well as physical activity for health. Teachers, pupils and parents were given access to an interactive website which supported the content of the CD-ROM, while two different events were highlighted in order to provide children with physical activity goals and promote mass participation. Further support for the programme was provided by a local media campaign and children were supplied with a summer activity wall planner to record their activity out of school. Physical activity was measured during the intervention via pedometry and accelerometry and data were collected at baseline, midway and at the end of the intervention. Additional data such as aerobic fitness, fruit and vegetable intake, anthropometric information, knowledge of healthy lifestyles and psychological measures were also taken. The main findings of the study found that by the end of the intervention children in the intervention schools were taking part in 20 minutes more MVPA per day than those in the control schools. This was as a result of increasing their own MVPA by up to a minute a month for the 10 month intervention, and the control group reducing their MVPA at the same level. No follow up data post intervention has been reported and so it is not possible to demonstrate the sustainability of this intervention for increasing physical activity.

In a review of evidence based strategies to promote physical activity in children, Timperio, Slamon and Ball (2004) suggest that studies that incorporate a whole school approach which include curricular, policy and environmental changes are more effective than those that incorporated curriculum-only lead approaches (De Meij *et al.*, 2011). Despite this advocacy, there remains a lack of effective intervention strategies that use a whole school approach to promote physical activity in school children (De Meij *et al.*, 2011). A possible reason for the lack of research in this area may be due to the fact that using an integrated approach can be time consuming and problematic, requiring teachers with sufficient content knowledge and experience. This may be especially true in the UK primary school setting, as non-specialist teachers are required to deliver PE and few schools have access to a physical activity specialist. There remains a gap between physical activity research and the delivery of programmes in practice and as yet, research has still to determine the best approach to promote health-enhancing levels of physical activity in UK primary schools. Before there can be a change in curriculum and/or school policies in the UK, there needs to be an evidence base that physical activity interventions in UK schools work, in order to inform policy makers at government level.

The aim of the present study was to evaluate the affect of a multi component, whole school intervention increase the MVPA of primary school children. Secondly, the study examined whether feedback from pedometers as well as information on how and why children should be physically active could increase and maintain children's mean daily step count over 5 weeks. Furthermore, the study aimed to identify whether the whole school intervention affected the most or least active children's pedometer measured physical activity.

6.3 Methods

The primary school which took part in the present study was located in an area of high social and economic deprivation (Ofsted, 2007), was recruited as a result of previous collaborations between the Liverpool John Moores University and Blackpool City Council. The initial study proposal was introduced to Blackpool City Council's Director of Physical Activity and Leisure, who agreed to identify a suitable school to approach with the same proposal. After a period of consideration, the present school was identified and recruited. The main reasons for approaching this school in particular, was because the head teacher was deemed to be pro-active and an advocate of promoting physical activity, as previous research conducted by Barnett et al. (2006) found that higher opportunity for physical activity in schools was associated with role modelling of physical activity by the school principal. Contact was then made between the researcher and the school's head teacher and a meeting was set for the initial consultation.

6.3.1 Design

The initial consultation process began during a meeting in July 2006 between the head teacher, the Physical Activity Officer from Blackpool Council and the Year 5 class teacher (who was also the school's physical education coordinator). It was explained to the group that the intervention would be delivered to all children in Years 3-6 (236 children); however, due to limited physical activity monitoring resources only 60 children would be able to take part in this aspect of the intervention. The Year 5 class along with class 3-4 were chosen by the head teacher to take part in the monitoring process.

In compliance with the MRC framework for developing complex interventions (Craig *et al.*, 2008), a number of opportunities during the school day for physical activity promotion had previously been identified in the literature as being effective and so the purpose of the meeting was to introduce and discuss these ideas with the staff and to agree on a design for the study. It was decided by the head teacher that any change in active commuting policy would require much work in order for it to be implemented and would therefore not be feasible to pursue for the present study. In order to deliver the information about the benefits of a healthy lifestyle, the school agreed to organise a Health Week, whereby the children would also gain experience of different physical activities and be exposed to the Be Active Stay Healthy (BASH) curriculum. BASH is a five lessons scheme of work, delivered in conjunction with the National Curriculum and aims to increase children's physical activity levels and understanding of the relationship between exercise and health (Fairclough *et al.*, 2008). The school were planning to build new physical playground equipment such as climbing frames and 'three way shooters' built in the new school term and the staff agreed that the Physical Activity Officer could train some of the students in 'Playtime Pals', a scheme aiming to get older primary aged children to initiate and play games with younger children. Finally, the staff were happy to deliver a period of pedometer usage, aimed at providing the students with feedback as to their physical activity level alongside a challenge, in order to motivate them to increase their steps. Once an action plan had been agreed, a further meeting was timetabled closer to the beginning of the school term in September 2006, to include the Year 3-4 class teacher.

During the second meeting, the school staff and the Physical Activity Officer were given a more detailed explanation of the intervention and the timetable of its implementation. Figure 6.1 demonstrates the timeline of the intervention and the points at which physical activity monitoring would take place. A detailed explanation was given to each member of staff as to their responsibility for the intervention. The physical activity officer and Year 5 class teacher were made responsible for the organisation of the health week, as this was an activity that they had already had planned for the school. During this meeting, the school where also given informed consent forms and information letters for parents and children explaining the intervention. It was decided by the head teacher that these would be in the form of a negative response, whereby parents would only return the document if they objected to their child's inclusion in the study.

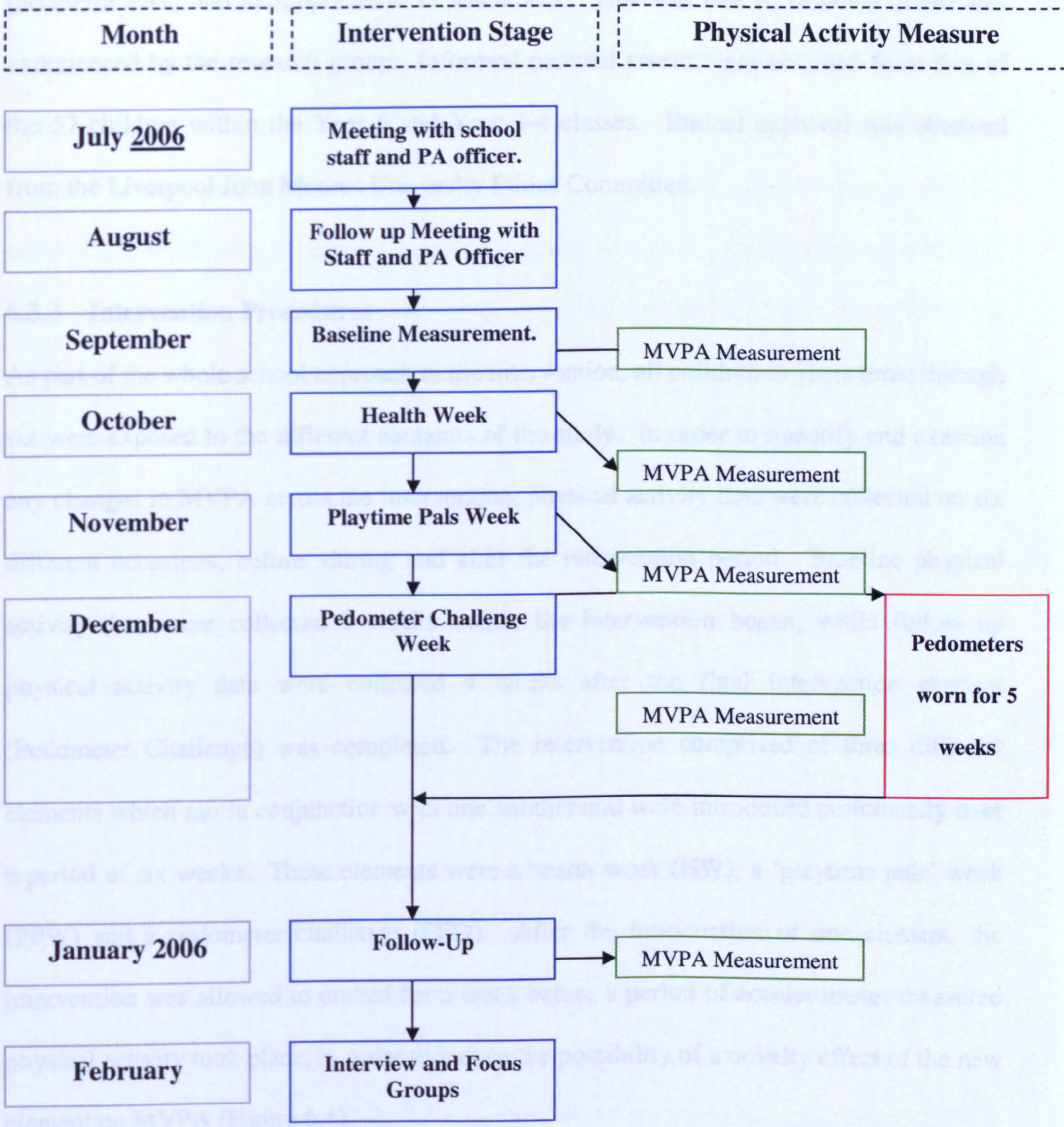

Figure 6.1 Timeline of study development, implementation and data collection.

6.3.2 Subjects and Settings

The intervention was targeted at all the children within Year classes 3-6 in the primary school and all parents/guardians were provided with the project information. However, it is important to note that only two classes took part in the main physical activity monitoring (accelerometry) and anthropometric measurement. This was due to resource constraints experienced by the research group. Informed parental assent were obtained from five of the 57 children within the Year 5 and Year 3-4 classes. Ethical approval was obtained from the Liverpool John Moores University Ethics Committee.

6.3.3 Intervention Procedures

As part of the whole school approach to the intervention, all children in years three through six were exposed to the different elements of the study. In order to quantify and examine any changes in MVPA across the intervention, physical activity data were collected on six different occasions, before, during and after the intervention period. Baseline physical activity data were collected 2 weeks before the intervention began, while follow up physical activity data were collected 4 weeks after the final intervention element (Pedometer Challenge) was completed. The intervention comprised of three different elements which ran in conjunction with one another and were introduced periodically over a period of six weeks. These elements were a health week (HW), a 'playtime pals' week (PPW) and a pedometer challenge (PED). After the introduction of one element, the intervention was allowed to embed for a week before a period of accelerometer measured physical activity took place, in order to reduce the possibility of a novelty effect of the new element on MVPA (Figure 6.1).

6.3.3.1 Health Week

Following the baseline physical activity measurement, the intervention began with a 'health week', in order to introduce and develop the relationship between physical activity and health to the children. During this time, children were provided with information on the benefits of physical activity and ways in which they could increase their physical activity via the Physical Activity Officer, who also delivered the BASH curriculum. Children were given the opportunity to experience different activities (such as mini golf and orienteering), along with information on how to pursue any activities they enjoyed. In addition to this, children took part in lessons where the relationship between physical activity and health was re-enforced and were asked to produce work such as posters, to demonstrate their understanding. The importance of the health week was to build the children's confidence and understanding of why they need to continue physical activity throughout life as outlined in the NICE guidelines (NICE, 2006, 2009).

6.3.3.2 Playtime Pals Week

During this element, volunteers from Year six were 'trained' to deliver playtime games to their peers during morning and afternoon break times (15 and 10 minutes respectively) and during the longer lunch break (60 minutes). The training of these children was delivered by the Physical Activity Officer from Blackpool Council associated with the project and took place during a school day afternoon. The training taught the children new games and ways of getting their peers to join-in, in addition to instructing newcomers how to play the games. New equipment such as bats and balls, hoops, bean bags etc. were also provided to facilitate the Playtime Pals and to encourage children to increase their physical activity through play. In addition, physical structures such as 3-way-shooters and climbing equipment which made up a purpose built 'Trim Trail' were also introduced. The introduction of play equipment and trained individuals to playgrounds has been found to increase children's physical activity during break-time (Verstraete *et al.*, 2006; Loucaides *et al.*, 2009).

6.3.3.3 Pedometer Challenge

The pedometer challenge element of the intervention involved providing all children with a pedometer to measure the number of steps they accumulated during the school day. Each child was asked to wear their pedometer and record their steps at the end of each day. The class teachers were asked to work into their lesson time, an opportunity where the class could measure their step length. Individual children were required to walk 20 paces at their normal walking speed, and the distance covered was recorded. Step length was calculated at distance travelled in twenty steps divided by the number of steps (Beets *et al.*, 2005). With this information, the students could include their step count into a specially formulated spread sheet in Microsoft Excel and calculate how far they had walked over a time period. A challenge was set by each class to walk a given distance, competing against each other. Teachers were encouraged to use the pedometers and the information they provide across the curriculum (including engaging the children with inputting data into the spread sheet), along with the information they had received during the health week. Additional information was also provided to the children about how they could increase their steps and how the pedometers could motivate them to increase their activity (Butcher *et al.*, 2007).

6.3.4 Measurement

6.3.4.1 Anthropometry

Measurements of stature and body mass were taken at the beginning of the study using standardised procedures (Norton *et al.*, 1996). Children's stature was measured to the nearest 0.1 cm using a Leicester Height Measure (Seca Ltd., Birmingham, England). Children's body mass was also measured and were calculated to the nearest 0.1kg using Seca Weighing Scales (Seca Ltd., Birmingham, England). These procedures took place with the children barefoot (Lohman *et al.*, 1988) and wearing their normal school uniform. In order to determine whether the children were under weight, normal weight, overweight or obese for their age according to Cole et al. (2000), stature and body mass were used to calculate each child's BMI (i.e., Mass/Stature^2).

6.3.4.2 Physical Activity

Children who did not return the informed assent forms from the two participating classes who provided informed consent were asked to wear an Actigraph uni-dimensional accelerometer (Model GT1M, ActiGraph, LLC, Fort Walton Beach, FL) for one school week (5 consecutive days) on 5 occasions between September 2006 and January 2007. Figure 6.1 demonstrates the timeline of when these occasions took place. These occasions were at baseline, during the week after each element was implemented and at follow up. Accelerometers were chosen to measure physical activity across the day as they provide a reliable (Brage *et al.*, 2003, Metcalf *et al.*, 2002, Welk *et al.*, 2004) and valid (Eston *et al.*, 1998, Nichols *et al.*, 1999, Trost *et al.*, 1998), objective field measure of physical activity in children. Children were told to only remove their accelerometer when they went to bed, when they bathed or showered, or were involved in any water-based activities such as swimming, and to put the monitor back on in the same position as soon as they could thereafter. If at any time the children felt the monitors were too tight or too loose, they were encouraged to seek help from the researcher or a teacher in order to adjust the belt.

Data were first checked for compliance to the protocol over the monitoring period. To be included in the analyses, it was desirable for children to have three (Mattocks *et al.*, 2008) 'completely observed' days of data as defined by Catellier et al. (2005). Firstly, the minimum number of hours per day that the ActiGraphs were worn was determined.

Sustained 20 min periods of zero counts were deemed to indicate that the monitor had been removed, and total 'missing' counts for those periods represented the duration that monitors were not worn (Catellier *et al.*, 2005). For inclusion in the analyses, each child was required to have produced counts for ≥7.22 h on each measurement day. This figure represented 'nonmissing' counts for at least 80% of a standard measurement day, which was defined as the length of time that at least 70% of the sample wore the monitor (Catellier *et al.*, 2006). Children who recorded less than the criterion on more than 3 days were excluded from the main analyses (Mattocks *et al.*, 2008).

During the Pedometer Challenge, children in the two monitoring classes were asked to wear an unsealed Yamax SW-200 DIGIWALKER (Yamax Corp., Tokyo, Japan) on the waistband above the right hip, in order to measure the number of steps taken during the school day. Children were asked to wear the pedometers from when they arrived at school and at the end of each day they recorded the number of steps they had taken on personalised record sheets. To ensure that steps were recorded accurately, the class teachers monitored this process. Pedometers were then reset and removed in preparation for the next day, when each child would wear the same unit. This method has been successfully used previously in schoolchildren of the same age (Butcher *et al.*, 2007). As previously stated, a lack of resources meant that not all children in Years 3-6 were provided with a Yamax SW-200 DIGIWALKER. In order to ensure that all children were given the opportunity to use a pedometer, the remaining classes were provided with a mixture of Ez-V Digital Pedometers (RYP Sports, USA) and other unidentified model units. Class teachers were encouraged to incorporate the inputting of pedometer data from children's personal record sheets into an already formatted Microsoft Excel spread sheet, within the curriculum. The inputting of data was supervised by the Year 5 class teacher and the spread sheets were forwarded to the researcher, whereby the data cleaning process took place. Upon receipt of the data files, the raw pedometer step counts recorded were observed for compliance to the protocol. Using motion sensors outside of a laboratory setting poses a number of logistical problems which may impact on the compliance to the protocol. These problems include losing and breaking of the monitor, forgetting to wear it and participant discomfort (Crocker *et al.*, 2001: Rowe *et al.*, 2004). Counts below 1,000 or above 30,000 steps were deleted and treated as missing data (Rowe *et al.*, 2004). The issue of how to treat missing pedometer data such as this was discussed by Rowe et al. (2004). With such high levels of missing data observed when measuring physical activity with pedometers in children as seen in their study (29% of children demonstrated missing data), deletion of these data would represent a waste of resources and a possible reduction of statistical power. The authors found that when missing data were replaced with an individually derived mean, the nature of the group did not change. It was therefore determined that this method of missing data treatment was most appropriate for use in the present studies. Missing data were therefore replaced with the child's own mean weekly end-of-day score, following procedures outlined by Kang et al. (2003) and used previously by Butcher et al. (2007) and more recently by Kang and Brinthaupt (2009). In order to examine the effect of the pedometer challenge on the most active and least active children, children were separated into the Highest (>6116 steps and Lowest 50th (≤6116 steps) percentile by week 1 mean pedometer steps.

6.3.4.3 Focus Groups and Interviews

Described as "a carefully planned discussion, designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment" (Krueger (1994, p.6), focus groups have become widely used in gaining children's views on health-related matters, as well as to help with programme development and evaluation (Peterson-Sweeney, 2005; Jepson *et al.*, 2010). Focus groups have been widely used with children and adolescents in health care settings to assess their perceptions about a number of topics, but most notably related to sensitive factors or behaviours, such as food choices and eating behaviour; sexual activity and sexual health behaviours; drug use and alcohol consumption, as these subjects may be difficult to talk about on an individual basis (Heary & Hennessy, 2002; Peterson-Sweeney, 2005). This is because focus groups allow children to interact with one another, stimulating thought and conversation in a safe environment. Participants are seen as the experts and as a result, feel empowered to share their opinions amongst the group. More recently, focus groups have been used to gain information on children and adolescents' physical activity behaviours (Brockman & Jago, 2010) and also to provide process data related to physical activity interventions (Gorely *et al.*, 2009). While focus groups can yield valuable data for researchers, they require detailed planning. It is also important to acknowledge that while focus groups can promote conversation amongst children, strong personalities within the group may inhibit interaction and a 'group think' may arise if members are afraid to voice their options. A skilled moderator is therefore required in order to avoid this (Heary & Hennessy, 2002; Peterson-Sweeney, 2005).

Following the collection of the final physical activity data (2 weeks), qualitative data were collected from a sample of the Year 5 and Year 3-4 class children and the Year five class teacher in order to help explain how the children responded to each element of the intervention. Two semi-structured focus groups were conducted; one with six children from Year 5 class and the other with six children from Year 3-4 class. An interview was conducted with the Year five class teacher, who was also the main contact and the person responsible for PE within the school. Each interview and focus group took place in a quiet classroom within the school and followed a semi-structured question schedule. These were recorded with use of a digital voice recorder, with the consent of the attendees and then later transcribed. Semi-structured question guidelines and the focus group/interview transcriptions can be found in the appendices (Appendix I-III). Because the sample size of the children who took part in the focus groups was small and only one teacher was interviewed, the data collected during the focus groups and interview was used to support the quantitative analyses in the form of illustrative verbatim quotes, which is in line with the approach taken by Gorely et al. (2009).

6.3.5 Statistical Analyses

All data were first assessed for normality using the Shapiro-Wilk test and any outliers were checked for faulty measurements. When the data were explored using a five-way repeated measures ANCOVA (BMI as a co-variate), only 6 children had sufficient accelerometer data for each measurement point following baseline, interventions and follow-up. With such a reduced sample size it was felt that conventional hypothesis testing may not hold sufficient statistical power and therefore not detect changes present in the children's MVPA. Indeed, Batterham and Hopkins, (2006) have criticised the use of traditional inferential statistics in the form of null-hypothesis testing and confidence intervals as they can be misleading, depending on the magnitude of the statistic, error of measurement, and sample size. The authors also comment that null-hypothesis testing and the use of confidence intervals alone fail to deal with the real-world significance of an outcome and that this form of testing gives little information on the magnitude and direction of change (Batterham & Hopkins, 2006). Therefore, in order to best evaluate the intervention, a magnitude based interpretation of the data was adopted. The Q statistic (Froehlich, 1999) was used, which is a magnitude based interpretation of confidence intervals proposed by

Batterham and Hopkins (2006). These authors suggest a four level scale which allows researchers to determine whether the probability of any difference between two groups, or the effect of an intervention is beneficial, trivial, harmful or unclear in a 'real life' setting. In order to interpret data this way it is necessary to quantify the probability that a clinically worthwhile effect has been realised when a minimum worthwhile effect lies within the 95% confidence interval (Batterham & Hopkins, 2006). In order to calculate the Q value, the minimal worthwhile effect was determined. In health research settings this is known as the minimum clinically important difference (MCID) and represents the clinically effective or important change (Froehlich, 1999). The MCID is typically defined before analysis by referring to the empirical evidence. However, it is possible to calculate the MCID threshold in the absence of robust empirical evidence by using a value derived from 0.2 standard deviation of the grand mean (Froehlich, 1999). The next step was to calculate the test statistic which is calculated as the difference between the minimum clinical effect and the measured effect (mean 1 – mean 2), divided by the standard error of the effect size (Froehlich, 1999):

$$t_Q = \frac{\text{MCID - mean difference}}{\text{SE}}$$

Finally, in order to determine the Q value, the two-tailed probability of the test statistic was calculated using the *t* distribution. As with all probabilities, the Q value ranges from 0 to 1 and so can be expressed as a percentage. This the can be used to infer whether the effect is beneficial, harmful, trivial or unclear (Froehlich, 1999; Figure 6.2).

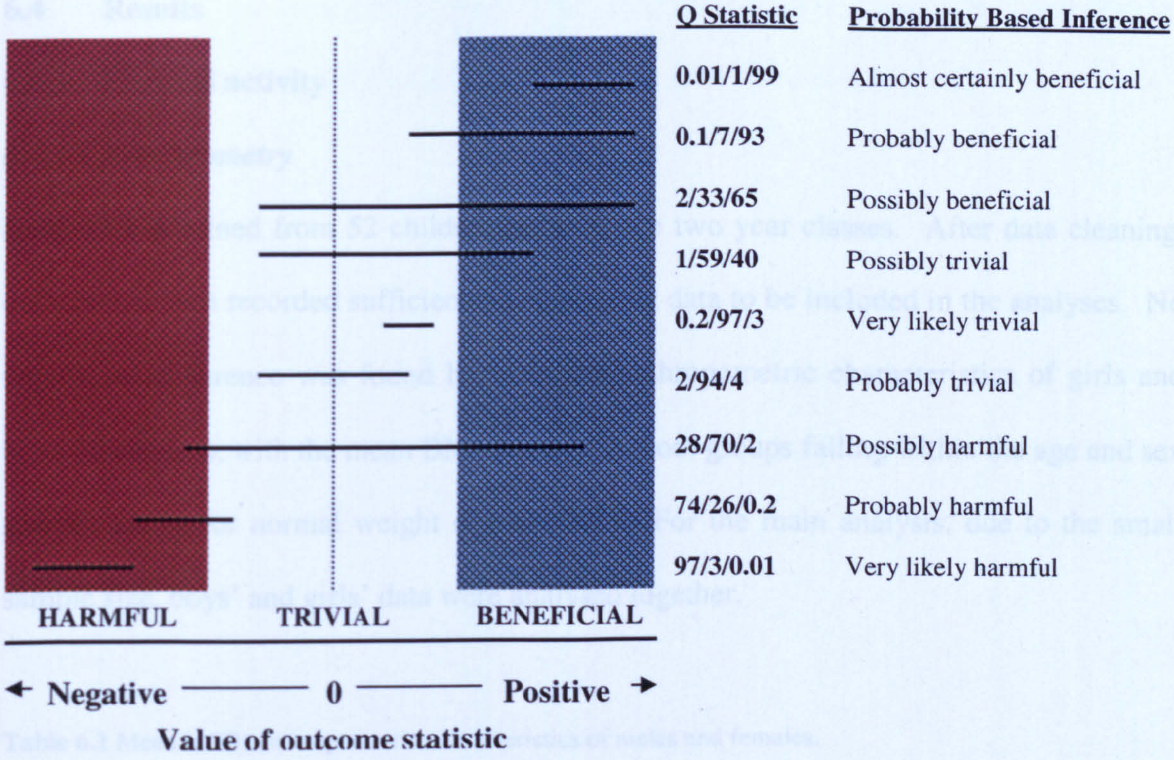

Figure 6.2. Graphical representation demonstrates how different inferences that can be drawn from when the possible magnitudes represented by the confidence interval are determined by referring crudely to a 3-level (beneficial, trivial, and harmful) scale of magnitudes (Batterham & Hopkins, 2006)

In order to examine whether the pedometers had been successful in significantly increasing the mean school day pedometer steps of children across the pedometer challenge weeks, a 2 (gender) x 5 (week) repeated measures ANCOVA with step length as the covariate, was conducted. In order to examine the difference in mean school day pedometer steps by physical activity group from weeks 1 to 5, a 2 (gender) x 2 (activity group) x 2 (week) repeated measures ANCOVA with step length as the covariate was conducted. Greenhouse-Geisser correction factors were applied where appropriate and analyses were performed using SPSS for Windows Version 14.0 (SPSS Inc. Chicago, IL.), with statistical significance set to $p<0.05$.

6.4 Results

6.4.1 Physical activity

6.4.1.1 Accelerometry

Data were obtained from 52 children between the two year classes. After data cleaning, only 38 children recorded sufficient accelerometer data to be included in the analyses. No significant difference was found between the anthropometric characteristics of girls and boys (Table 6.1), with the mean BMI (*n*= 37) for both groups falling within the age and sex specific range for normal weight (Cole, 2000). For the main analysis, due to the small sample size, boys' and girls' data were analysed together.

Table 6.1 Mean (±SD) anthropometric characteristics of males and females.

	Stature (m)[†]	Mass (kg)[†]	BMI (kg·m^{-2})[†]
Males (n=17)	1.34 (0.08)	29.53 (6.50)	16.37 (2.29)
Females (n=22)	1.34 (0.06)	29.55 (5.06)	16.45 (1.73)

[†] All P values for the anthropometric comparisons between males and females were greater than 0.05.

Descriptive results of the repeated measures ANCOVAs (BMI) are demonstrated in Table 6.2. The statistical results of these analyses were used to provide the *F* value to calculate the Q statistic. With the MCID assumed as 0.20 SD from the grand mean, the only comparison that was deemed to have a beneficial qualitative inference (Q statistic) was baseline to follow up (2.2/2.4/95.4; 6.57 minutes; Table 6.2), despite mean time spent in MVPA increasing above baseline during the HW (3.12 minutes) and the PPW (6.28 minutes). The probability that the difference in MVPA between baseline and follow-up was at least the MCID is 95% and therefore the increase in MVPA is likely to be beneficial and very unlikely to be harmful. Despite an increase of 6.28 minutes from baseline to the health week the MCID was found to be trivial and unlikely to be beneficial.

Table 6.2 Results of the analyses between baseline school day MVPA and intervention weeks' school day MVPA.

Pair					**95% Confidence Interval**		**Q (%)**				
	MVPA (minutes)	***F***	***df***	***p***	**Lower**	**Upper**	**Harmful**	**Trivial**	**Beneficial**	**MVPA Change (mins)**	**Inference**
BL-HW (*n*=13)	**62.16 (13.40)** **65.27 (15.13)**	0.03	12	0.886	-7.74	1.23	1.2	96.8	2	3.12	Unclear
BL-PPW (*n*=16)	**71.25 (15.83)** **77.53 (14.70)**	0.01	15	0.922	-11.47	-0.4	0	100	0	6.28	Unlikely beneficial
BL-PED (*n*=16)	**68.17 (18.75)** **67.53 (22.36)**	1.51	15	0.239	-4.87	6.15	6.2	15	78.8	-0.64	Unclear
BL-FU (*n*=15)	**67.48 (17.70)** **74.05 (20.52)**	4.08	14	0.064	-15.85	2.75	2.2	2.4	95.4	6.57	Very likely benefici

Table 6.3 Mean (±SD) pedometer steps per day for the males and females during the pedometer challenge weeks.

Gender	**Week 1**		**Week 2**		**Week 3**		**Week 4**		**Week 5**	
Males (*n*=47)[**]	6778.44	(1945.14)	7254.93	(1803.46)	7370.84	(1019.68)	7297.78	(1565.68)	7464.20	(1813.89)
Females (*n*=52	6220.23	(1140.63)	6549.22	(1323.81)	6919.14	(2232.14)	6467.88	(1364.99)	6472.78	(1161.99)
Total (*n*=99)	6485.24	(1591.08)	6884.25	(1601.29)	7133.58	(1769.84)	6861.87	(1514.52)	6943.46	(1579.44)

[**] P<0.01 demonstrating significant main effect for gender.

6.4.1.1 Pedometer Challenge

The mean school day pedometer steps from weeks one to five are demonstrated in Table 6.4. The results of the gender by week repeated measures ANCOVA (step length) revealed that there was no difference in overall mean school day pedometer steps over the 5 week pedometer challenge ($F_{(1, 96)}$= 1.413, p=0.229, d=0.24). A main effect for gender ($F_{(1, 95)}$= 9.987, p=0.002, d=0.65) shows that males' mean school day step counts were significantly higher than females'.

When comparing mean pedometer steps per day from week 1 to 5, the results of the gender (2) by activity group (2) by week (2) repeated measures ANCOVA (step length) revealed a significant main effect for week ($F_{(1, 93)}$= 5.845, p=0.18, d=0.24), with children accumulating more steps in week five compared to week one (Table 6.4). A significant interaction between week and activity group ($F_{(1, 93)}$= 29.562, p=0.000, d=1.11; Figure 6.3) revealed that children in the lowest active 50% group significantly increased their steps from week one to week five ($F_{(1, 47)}$= 20.847, p=0.000, d=0.93; Figure 6.3), while the highest active 50% did not ($F_{(1, 47)}$= 0.000, p=0.990, d=0; Figure 6.3). A significant gender by activity group interaction ($F_{(1, 93)}$= 9.293, p=0.003, d=0.63; Figure 6.3) was revealed and follow up gender (2) by week (2) repeated measures ANCOVAs found that males in the highest active 50% group accumulated significantly more steps than the females ($F_{(1, 46)}$= 14.701, p=0.000, d=0.81; Figure 6.3), in the highest active 50% group, while there was no significant difference between the males' and females' pedometer steps in the lowest 50% group ($F_{(1, 46)}$= 0.456, p=0.503, d=0.14; Figure 6.3).

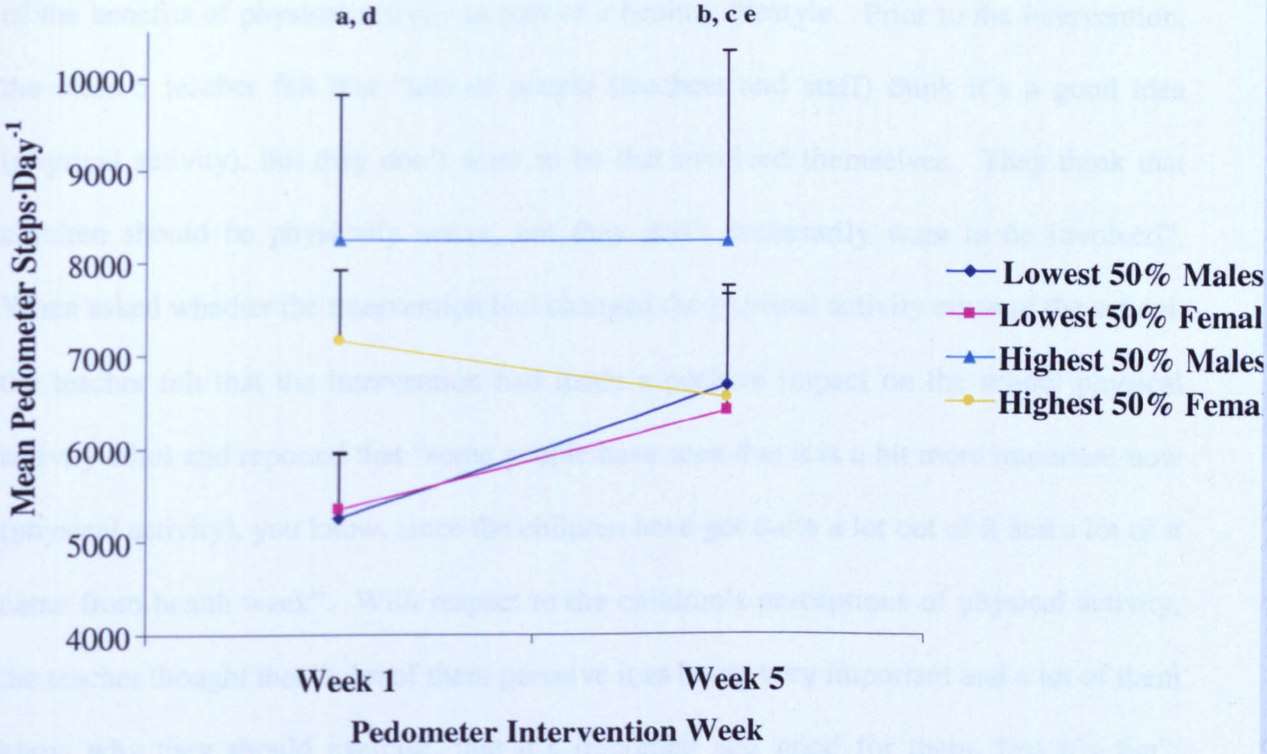

Figure 6.3 Mean (±SD) pedometer steps per day for the lowest active 50% and highest active 50% boys and girls on weeks one and five. [a] AVCOVA $p<0.05$, week 1 vs week 5; [b] AVCOVA $p<0.001$, activity group vs week; [c] AVCOVA $p<0.001$, lowest active 50% vs highest active 50% vs week; [d] AVCOVA $p<0.05$, gender vs activity group; [e] ANCOVA $p<0.001$, highest active 50% males vs highest active 50% females.

6.4.2 Feedback from teachers and pupils

An interview was conducted with the Year 5 class teacher and two focus groups were conducted with children from class 3-4 (n=6) and Year 5 (n=6) in order to gain in insight into their views of the overall intervention. More specifically, further information was sought regarding which intervention elements 'worked' or did not work and how the intervention could be improved.

By using a whole school approach to physical activity promotion, it was envisaged that the intervention would have a positive impact on the school's physical activity ethos and in particular, that the Health Week would help to increase children and teachers' knowledge of the benefits of physical activity as part of a healthy lifestyle. Prior to the intervention, the class 5 teacher felt that "lots of people (teachers and staff) think it's a good idea (physical activity), but they don't want to be that involved themselves. They think that children should be physically active, but they don't necessarily want to be involved". When asked whether the intervention had changed the physical activity ethos of the school, the teacher felt that the intervention had made a positive impact on the school physical activity ethos and reported that "some people have seen that it is a bit more important now (physical activity), you know, since the children have got quite a lot out of it and a lot of it came from health week". With respect to the children's perceptions of physical activity, the teacher thought that "a lot of them perceive it as being very important and a lot of them know why they should exercise, that it's important and good for them, that it's fun". Overall, Year 5 teacher thought that the health week had been successful in increasing children's physical activity and health related knowledge, but that this might be greater in the Year 5 children due to the BASH curriculum they were exposed to.

When asked to explain what they did during health week, children from the year five class were able to remember the different activities they took part in, recalling the orienteering, 'tri-golf', 'boxercise' and the BASH lessons in particular. When asked whether they would like to pursue these activities, the children agreed that they would and that they would like to try the other activities that other classes were offered. In recalling the BASH lesson detailing the circulatory system, one Year 5 girl reported that "'we learnt about the heart. We put cones around and we had to run 'round, and the heart and lungs were pumping in the middle...and I was the muscle... and we had to pull balls out and keep running round and put balls in the hoop and pick up another and run round again and put that in the hoop". Children also reported enjoyment of this activity, with one boy aged 9 stating "I quite liked BASH.'

When asked whether there had been a change in physical activity behaviour of the children after the implementation of the Playtime Pals, the Year 5 class teacher thought that "from talking to our lunchtime supervisors, there's been more, better play going on at lunchtimes with the 'pals' going out and helping. Getting the new equipment and the 'trim trail' up and running, the 3 way shooter, meant that more children were active at lunchtime because they're not just stood around, they could go and climb on something, play...especially with the 3 way shooter, because you got them running around then after the ball, so that's really made a difference". The Year 5 class teacher also felt that despite initial teething problems with children wanting to play with some of the equipment at the same time, the general behaviour of the children had improved with the implementation of the Playtime Pals. This was observed once a routine was established and it was felt that the change in behaviour was as a result of the children being "occupied and busy". Changes were somewhat short lived it was revealed as "the 'pals' had a bit of a novelty effect. Some of them decided they didn't want to do it anymore". The teacher was quick to explain that as a result of this "we've drawn it up that now they're in a team (the Playtime Pals), and they do it for a half term, so instead of having different people on different days, that team of 6 people do it for half a term. They're still only out 2 or 3 times a week, but they're doing it and then the other team will take over. Because I think that's it, some of them start, the Y6's think they can't be bothered to do it today...and introducing all those old games that people used to play at playtimes but don't now because they're all into computers and they don't know what to do."

Commentary from the Year 5 class children's recall of the Playtime Pals supported the views of the teacher, especially regarding the longevity of the Playtime Pals. One male stated "...well all of a sudden they've quite stopped now, haven't they? They've stopped now, because I know people who are pals who have..." Despite this, all the children who took part in the focus group believe that they are more active now during playtimes since the introduction of the 'pals' and the equipment, as there is much more for them to do.

When asked to describe the effect that the Pedometer Challenge had on the children, the Year 5 class teacher gave a mixed response. She stated that the children enjoyed the task, but that problems with children shaking the pedometers to increase the counts displayed and children forgetting to log their steps made it difficult. When asked if the effects of the pedometers (in terms of physical activity) were maintained over the weeks, the teacher thought that physical activity had dropped off. The teacher went on to clarify and it was felt that there wasn't much consistency between the classes: "...the first couple of weeks they were fine, but it started to get...we weren't so bad...but I know some of the other classes had problems with lots of the pedometers not working. I think that, sort of, put them off, 'well mine's not working so I'm not bothered..."

It was the intention of the pedometer intervention that the monitors would be incorporated into the curriculum. When asked whether she was able to use the pedometers within her lessons, the teacher replied:

"...I did on a Friday afternoon, I'd get my children to write about what they'd been doing, and we'd talk about it. I mean, a lot of them go on the field to play football, so you'd be able to ask 'so why is so-and-so's steps not as high as someone else'?...Well, they've been on the field playing football while *they've* been in the lunchtime activity room, or they maybe didn't want to go out. So that was good to show them how the steps build up." The teacher was also asked if she felt that the introduction of the pedometers would have been more relevant during the Health Week. She believed this to be the case, so that the children could themselves make comparisons between weeks where they had more opportunity for increasing their steps with those where they had fewer.

During the focus groups children were asked about their compliance to the pedometer challenge. To begin with, some of the children got confused about which were the pedometers and which were the accelerometers. One Year five male commented that he preferred wearing '...the ones without the strap [pedometer], because the ones with the strap [accelerometer] were digging into me...' Another male from the same group commented that the accelerometer would slip from its position and would leave a mark on his skin and would even fall off when he was running. All students found it difficult to remember to wear their pedometers and accelerometers, with difficulty arising in particular with remembering to reset the pedometer at the beginning of the day: '...on my pedometer once, I managed to get over 8000, but when it was playtime, I opened my pedometer to see how many steps I'd done and I realised that I hadn't re-set it, I was on like...21000 and had to re-start it...' (Male, Year 5).

There were mixed responses as to whether or not the children looked at the pedometers and whether it encouraged them to be more active and accumulate more steps. However, one Year five female confirmed that she checked her pedometer every break time and recounted that '...sometimes it was really low and I thought 'Oh no!' everybody's gonna get higher, so I started to run...' When asked what kind of things the children did to increase their steps, one Year 5 male replied: '...Um, run around...um, what we did, is for like 3 days, all my mates and me, we just ran around the netball court, trying to get loads and loads of steps…' One male had become confused about the purpose of the pedometer and thought that it was 'cheating' to look at the display. The issue of cheating was brought up again by the males in the focus group, and they recalled that they had argued with one another about the number of steps they had taken.

Another purpose of the interview and focus groups was to gather process related data regarding compliance to wearing the accelerometers, as this was a limitation highlighted in Study 3. The Year five class teacher commented that one of the biggest problem she encountered during the intervention was gathering the pedometer data from the other class teachers and ensuring the children returned their accelerometers. The teacher commented that '...it didn't seem to matter how you did it, they still forgot them'. In the Year five class, the teacher felt that '…the ones that were causing problems were the ones where the parents had split up so, one day they'd be at one parents' and the next day they'd be at another one's and that's where the problem was, they'd leave it at one and because of the animosity between the parents, it wasn't like 'here's the belt, here you are'. It wasn't until they went back to that parent's that they could get it back'. After further discussion, the teacher felt that the issue of accelerometer non-compliance may have been alleviated if the intervention had been presented directly to all parents, rather than via in information sheet, as this would allow the opportunity for questions etc. When the children did wear the accelerometers, the teacher did not recall that any of the children found that they were uncomfortable. While this was echoed by the Year five children, the Year 3-4 children found the accelerometers to be 'awkward' and that belts 'rubs on ya'. Another female from Year 3-4 thought that the accelerometers were '…quite good, but the next day it I kept forgetting it and by the end of when we were wearing them I lost it'.

6.5 Discussion

This study examined the affect of a theoretically driven (Welk, 1999), multi component, whole school intervention aimed at increasing 7-11 year old children's school day MVPA. From baseline to follow-up, children increased their MVPA by 6.57 minutes during the school day, which according to the Q statistic was likely to be beneficial. Put another way, the increase in MVPA was clinically important for the children.

The purpose of the Health Week was to increase the children's knowledge and understanding of the benefits of a healthy lifestyle, as well as giving them information and ideas about how to be more physically active at school and at home. It was hypothesised that by increasing knowledge and understanding of the relationship between health and physical activity, children would develop positive attitudes to physical activity (Fairclough, Stratton & Butcher, 2008) and therefore increase healthful levels of physical activity. One of the ways this was achieved was through the delivery of the BASH curriculum by the Blackpool Council's physical activity officer. A pilot study of the BASH curriculum by Fairclough, Stratton and Butcher (2008) found that the five lesson unit of work was successful in significantly increasing children's health related exercise knowledge by 23%. During the data collection period following the Health Week, children's MVPA increased by 3.12 minutes during the school day, however it was unclear as to whether it was beneficial or not via the Q statistic.

The incorporation of the Playtime Pals and additional playground equipment during recess was to help facilitate children's MVPA during these periods of the day. As playtime made up approximately 65 minutes of the school day (morning playtime- 15 minutes; lunchtime approximately 40 minutes available for playtime; and 10 minutes for afternoon play), by optimising this opportunity for physical activity and in line with previous research which examined the impact of playground equipment (Verstraete *et al.*, 2006; Loucaides *et al.*, 2009) and playground markings (Ridgers *et al.*, 2007; Stratton & Mullan, 2003; Loucaides *et al.*, 2009) on children's playtime physical activity, it was hypothesised that children would significantly increase their MVPA during this time. Indeed, from baseline to the PPW, MVPA was increased by 6.28 minutes, which was similar to the difference observed between Baseline and Follow-up (6.57 minutes), however the Q statistic determined the change as unlikely beneficial This is likely due to the much higher upper confidence intervals demonstrated in this comparison (-4.87–6.15 Vs -15.85–2.75). The purpose of the Playtime Pals was for older children to introduce and play traditional playground games with younger children, so that the older children would act as role models to the younger children. This was based on the SDT, which states that individuals have three innate psychological needs: competence, relatedness and autonomy which affect behaviour through increases in motivation (Ryan & Deci, 2000). By providing children with peers to initiate and play games during playtime it was intended that children would feel relatedness and also feel confident and competent to be physically active, as in accordance with Welk's (1999) YPAP model. This was supported by Jago et al. (2009)'s study on friendship groups and physical activity in 10-11 year olds. The authors found that friends were key in initiating physical activity in children and this occurred through one or more of three ways: co-participation, peer modelling and verbal encouragement.

The purpose of the Pedometer Challenge was to develop the research presented in Chapter 4, which found that by providing children with feedback on how physically active they were through the use of a pedometer and by providing information on how to be more active; children were able to significantly increase their mean pedometer steps during the school week (Butcher *et al.*, 2007). Education regarding health related exercise and the promotion of different opportunities during the school day to increase physical activity were presented during the Health Week. During the Pedometer Challenge data collection period, there was very little change in MVPA (0.64 minutes) and it was unclear as to whether any change was of clinical importance. Despite there being little change in MVPA, the results of the pedometer data found that the mean pedometer steps of children significantly increased from week one (6485.24±1591.08 steps) to week five (6943.46 ±1579.44 steps) by 7%. This result is higher than those observed by Oliver et al. (2009), who found a 3% increase in children's mean daily pedometer steps during a four week integrated curriculum intervention, based around pedometer walking. These data however represented the whole day, both in and out of school time and the majority of children in this study were already meeting their recommended pedometer target per day, which may account for the difference. In contrast, the results of the present study are rather modest compared to the 19% increase in mean pedometers steps observed in a study by Kang and Brinthaupt (2009) which examined the effects of group and individual based step goals on primary school children's physical activity.

When the data were examined by physical activity group, it was revealed that children in the lowest active 50% group significantly increased their steps from week one to week five while the highest active 50% did not. These data support the results of Oliver et al. (2009) and Kang and Brinthaupt (2009), who both found that the least active children in their studies improved their pedometer steps the most. Oliver et al. (2009) found that the children in the lowest 25th percentile increased their mean daily pedometer step count by 50% over a four week integrated curriculum intervention. Kang and Brinthaupt (2009) found that while the least active children (lowest 33rd percentile) did not achieve as many step goals over the six week intervention as the most active children (highest 33rd percentile), they were able to increase their steps. This implies that despite not achieving a high number of step goals, the least active children were sufficiently motivated to increase their steps throughout the intervention (Ferrer-Caja & Weiss, 2000; Harter, 1987; Weiss *et al.*, 2000).

As expected, males overall mean school day step counts were significantly higher than females. This is consistent with previous research conducted in the present thesis (Chapters 4 & 5) and with other literature that have found males to be more physically active during the school day (Mota *et al.*, 2003: Riddoch *et al.*, 2004: Butcher *et al.*, 2007), during the weekend (Gidlow *et al.*, 2008) and during discrete times of the day (Mota *et al.*, 2003; Tudor-Locke, 2006; Fairclough *et al.*, 2007). However, an unexpected finding of the study was when data were examined by gender and physical activity group, it was revealed that while males in the highest active 50% group accumulated significantly more steps than the females in the highest active 50% group, there was no significant difference between the males' and females' pedometer steps in the lowest active 50% group. A possible reason for this finding may have been as a result of the incorporation of the Playtime Pals week prior to the Pedometer Challenge. While the Playtime Pals themselves 'did not last very long', the additional equipment and more variety of opportunities for children engage in physical activity during playtimes may have helped to engage the children who don't traditionally take part in moderate or vigorous intensity activities during playtimes to do so, other than through playing sport. More specifically, football has been found to dominate males' physical activity during playtimes (Ridgers *et al.*, 2007). It may be the case that the males in the least active 50% group are those who don't like football or don't perceive themselves to be good at it and therefore don't take part. To that end, it may be that the most active 50% of males continue to use their free time to play football because they enjoy doing so, while the least active 50% of males had more of an opportunity to take part in the 'new' activities. This suggests that only the lowest active children were able to increase their pedometer measured physical activity and provides support to the ceiling effect experience by the most active children as proposed by Oliver et al., (2006). Another possible suggestion could be that the males in least active 50% group have similar physical activity behaviours and preferences to the least active 50% of females. However empirical support for this supposition could not be located. A better understanding of how the most active and least active children differ in their physical activity choices and behaviours is needed. This information may help future intervention planning for this proportion of the population.

Considering the results in a different way, it may be that the least active children were more concerned with increasing their steps compared to the most active children. Support for this supposition may come from the focus group data. When asked whether it was important to know how active you are, one Year five female felt that it was 'nice to know how active you've been', while another thought it was important because they knew of the health benefits of a healthy lifestyle e.g. '...because your bones can get stronger the more active you get...' More importantly, one female thought that it was more important to know how many steps you took if you weren't very active. In contrast, the Year five males responded less favourably, with one commenting that 'it doesn't matter how many steps a day you take, because you'll still be active and still be running'. These results however do not provide a clear understanding of low active children's physical activity behaviour or characteristics.

During the interviews and focus groups, both the Year 5 class teacher and the children were asked process related questions about the intervention and its elements in order to determine the feasibility of the intervention and the likelihood of its maintenance. In particular, the Year 5 class teacher felt that the health week was successful in delivering the health related messages associated with physical activity in an enjoyable way and that the children 'got a lot out of it'. This may be attributable to the BASH curriculum, as Fairclough, Butcher and Stratton (2007) found in their study that the five lesson programme of work was responsible for a 23% increase in children's understanding of health related exercise. In addition, the children themselves enjoyed gaining new experiences of different sports and activities and were able to remember some of the key health messages 8 weeks following its delivery. It was felt that the intervention had made a positive impact on the school physical activity ethos, which supports the likelihood that any changes made, will be maintained (Welk, 1999). Indeed, the school teaching staff are making plans to link some of the intervention elements into their PSHE curriculum and are planning on repeating the Health Week each year. Furthermore, the Year 5 class teacher has plans to repeat the Pedometer Challenge across the school and is considering ways to try to make it more effective. This demonstrates that when teachers 'buy-in' to such interventions and can see their impact, it is likely that the interventions will be sustainable.

A number of interventions aimed at increasing primary school children's physical activity have had elements delivered directly by the research team, or have had direct support (e.g. McKenzie *et al.*, 2004; Verstraete *et al.*, 2007; Gorley *et al.*, 2009; Horn *et al.*, 2009). In the present study, the Year 5 class teacher/PE co-ordinator and the Physical Activity Officer were responsible for the delivery of the intervention elements, with the researcher making regular visits to collect accelerometer measured physical activity data and to ask how the intervention was progressing. When asked whether the Year 5 class teacher would have liked more help with the implementation of the intervention from the researcher, she did not think that additional support would have been necessary. By being available as a support system and by explaining the elements of the intervention in detail before the beginning of the study, the teacher felt comfortable with delivering the intervention herself. This gives support to the suggestion that the current intervention and its ecological approach is appropriate for delivery in a primary school setting by the school staff and does not require costly supplementary staff or wholesale changes to the curriculum. However, the teacher in question was a PE specialist and had the necessary training for the delivery of health related physical education. Non specialist teachers may not however feel confident to implement such an intervention and so further training may be required. Furthermore, more support from researchers may be required to help improve compliance to wearing activity monitors, especially accelerometers.

6.6 Strengths and Limitations

This study examined the effect of a theoretically driven, multi component, whole school intervention aimed at increasing 7-11 year old UK children's school day MVPA. One of the strengths of the study is that it follows much of the framework outlined by the MRC to help the development of rigorous intervention methodologies. Firstly, justification for targeting the different opportunities within the school day have been evidence based and each intervention component is supported by the literature. Secondly, by using a social-ecological model and Welk's YPAP model (1999) to design and implement the present study, it is more likely that any change in physical activity behaviour will be maintained (Inman, van Bakergem, Larosa & Garr, 2011). Thirdly, the Health Week element of the intervention, supported by the BASH curriculum was previously piloted and modelled within the same population, with the Pedometer Week intervention modelled on the Study 2 of the present thesis. By trialling these elements in similar populations, it was possible to modify and enhance the interventions for use within this larger, more complex study. Finally, in order for the present study to be feasible, it was important to design the intervention around the capabilities and resources available to the school and researcher, such that the children and staff could adopt and maintain the changes made. Feedback from the interview and focus groups suggest that this element of the study design was successful, providing support for following the MRC framework.

Although there were insufficient accelerometer data to conduct traditional statistical analyses to identify significant changes in MVPA, the use of MCID based analyses may be more informative of the impact of changes in health behaviours. The present study also provides further support for the use of pedometers to increase the lowest active children in the population to increase their physical activity, without being singled out (Oliver *et al.*, 2006; Kang & Brinthaupt, 2009). By conducting an interview with the lead teacher responsible for the intervention and focus groups with some of the children, it allowed for an informed explanation and discussion of the results and information regarding the process of implementing such an intervention within a primary school setting. Such information is important in order to evaluate the effectiveness of the intervention and in order to help inform the stepwise development of primary school based interventions which aim to improve health behaviours (Brug, Oenema & Ferreira, 2005; De Meij *et al.*, 2011).

The present study was also limited in a number of areas, most notably by the lack of compliance to wearing of accelerometers and therefore the subsequent small final sample size for comparison; and the absence of a control group. Over the data collection periods, compliance to the study protocol remained low, characterised mainly by children not wearing the accelerometers on at least 3 whole days. Most notably, only six children had sufficient data across all collection time points. One possible reason for the limited compliance may have been because children felt over burdened by the process of having to wear the monitor every day for a week, on six different occasions. Initial problems with malfunctioning ActiGraph units and therefore requirement for the children to wear the monitors for an additional week may have compounded the issue of burden.

The main reason for the marked difference between the number of monitors worn and the number of usable data may have been simply because the children forgot to wear the monitors and this was noted by all children during the focus groups. The biggest issue raised by the Year 5 class teacher with regards to the accelerometers was reminding the children to wear them each day and to return them each Friday. While the Year 5 class teacher was proactive in reminding the children to wear their accelerometers and pedometers, the same enthusiasm was not felt form the Year 3-4 class teacher, which may have had an impact on the number of days the accelerometers were worn in the Year 3-4 class. However, once the child has forgotten their monitor and arrived at school, there is little opportunity to retrieve the monitor and therefore the day's monitoring is lost. This would suggest that is most important to engage the parents in the intervention, with their role being to reinforce and remind their heir child to wear their accelerometer. More contact with the parents, as suggested by the Year 5 class teacher may help to reduce the amount of non-compliance with regards to wearing accelerometers, which is supported by the YPAP model (Welk, 1999). For example, in order to provide children with reminders via different media, one would have to assume that the children taking part had access to facilities such as email or mobile phones. The majority of children in the present study were from deprived areas of the North West of England and it would be reasonable to assume that they may not have access to a computer or a mobile phone. Furthermore, the children in this study may have been too young to possess a mobile phone. The suggestion of providing incentives to the children was beyond the means of the studies within the thesis. Finally, it was felt that during the familiarisation period, children were given sufficient information and support, however asking children to complete a wear time log may have helped to remind them. Recollecting accelerometer data has also been suggested in the literature (Trost *et al.*, 2005) and this was done with a number of children during the baseline measurement period, as some of the accelerometers had malfunctioned initially. Because of the design of the study design, the time between each intervention element and subsequent accelerometer data collection did not allow for any additional monitoring opportunities. However, as previously suggested, by asking children to re-ware accelerometers for an additional period of time may over burden them and lead to further compliance attrition. Future studies should explore children's barriers to wearing physical activity monitors and examine different ways to encourage children to wear them.

6.7 Conclusions

The school has been identified as an important environment for the promotion of healthful physical activity in children and that a whole school approach may be an effective way of increasing children's physical activity. This study demonstrated that a theoretically driven, multi-component, whole school intervention can beneficially increase children's MVPA over a 12 week period. In addition, pedometers can be successful in targeting the least active children within a school by significantly increasing their school day pedometer steps. Despite some evidence, further study is needed to determine the sustainability and feasibility of such an approach on a larger scale. Furthermore, researchers should consider the reasons for children's compliance to studies where physical activity is measured via accelerometry.

Chapter 7 Synthesis

7.1 Thesis Study Map

Study	Aims & Key Findings
Study 1: Measurement accuracy of a pedometer for measuring physical activity in a primary school setting	**Aims** • To validate the Ez-V model of pedometer for the use in primary school children. **Key Findings** • The Ez-V pedometer is deemed an accurate device with which to monitor primary school children's daily physical activity.
Study 2: The effect of feedback and information on children's pedometer step counts at school.	**Aims** • To examine the effects of providing primary school children with feedback and information relating to the number of pedometer steps accumulated during a full school day. • To examine whether there was a gender difference in step counts per day. **Key Findings** • Pedometers can provide feedback to facilitate a short term increase in children's pedometer steps during the school day. • Feedback from pedometers alone was not sufficient to elicit a statistically significant increase in steps and it is likely that providing additional physical activity information can avoid intervention fatigue. • Boys accumulated significantly more pedometer steps·min^{-1} than girls.
Study 3: Affect of school travel plans on children's physical activity during the winter and summer.	**Aims** • To assess the affect of the school TP on the MVPA of primary school children. • To examine the difference in MVPA by season. **Key Findings** • No significant difference in MVPA was found between TP or season.
Study 4: Can a 12-week, whole school intervention increase primary school children's moderate to vigorous intensity physical activity?	**Aims** • To evaluate the affect of a multi component, whole school intervention on the MVPA of primary school children. • To examine whether feedback from pedometers as well as information on how and why children should be physically active could increase and maintain children's mean daily step count over

5 weeks.

- To identify whether the whole school intervention affected the most or least active children's pedometer measured physical activity.

Key Findings

- A theoretically driven, multi-component, whole school intervention can beneficially increase children's MVPA over a 12 week period.
- Pedometers and information on how and why children should be physically active can significantly increase the least active children's mean daily step count, which can be maintained over a 5 week period.

7.2 Thesis synthesis in relation to the conceptual model

The development and maintenance of healthy physical activity behaviours from an early age is important for physiological and psychological health and wellbeing (DH, 2004; NICE, 2009). Schools provide a unique context and a number of different opportunities for children to learn and develop healthy behaviours, at a time when they are most receptive to behaviour change (Rogers *et al.*, 1998; Fox *et al.*, 2004; McKenna & Riddoch, 2005). Children from a full range of socioeconomic backgrounds attend school (in the majority) for approximately 6 hours a day (i.e., 40-45% of waking time) (Fox *et al.*, 2004), five times a week, for approximately 40 weeks of the year. Furthermore, school environments are such that they have, on the whole, the resources (in the form of space, equipment and staff) and opportunity (time in and outside of the curriculum) to deliver and reinforce health promotion strategies. To this end, NICE (2009) have outlined their recommendations for the promotion of physical activity in youth, whereby schools are encouraged to deliver multi-component physical activity programmes involving whole-school, family and community-based activities. These should include education on the benefits of a physically active lifestyle, to motivate children to engage in physical activity;

and provide opportunities for the development of children's perceived self-confidence. Furthermore, schools should consider policy and environmental changes in order to provide a supportive environment for physical activity, such as the inclusion of additional opportunities for physical activity during playtimes and out of hours. However, there remains a lack of consistent evidence that such interventions can be successful in UK schools. Because physical activity behaviour is complex, current guidance on increasing physical activity in children and young people (NICE, 2009) state that for interventions to be successful and to be maintained, they need to be based on psychological theories and models. Guidance also states that school interventions need to be based on a whole school approach. To date, there has been no study that has based an integrated, whole school intervention on such a model.

The primary aim of this thesis was to increase primary school children's MVPA through identifying opportunities during the school day and delivering interventions designed using the principles of Welk's (1999) YPAP model. The YPAP model was outlined in Chapter 1 and its framework is the only conceptual model proposed in the literature to specifically promote physical activity in children and youth. Despite the holistic nature of Welk (1999)'s model, to date, few published studies have applied its principles. Each intervention within the present thesis was stratified to reinforce, and enable children's healthy physical activity behaviour, with an aim to predispose them to maintain that behaviour.

The early work presented in this thesis investigated the use of a moderately priced pedometer (Ez-V Digital Pedometer; RYP Sports, USA) to examine the use of feedback (reinforcement) and information (enabling) to increase primary school children's pedometer measured physical activity (Study 2). The premise for the use of a modestly priced pedometer was twofold: 1) the purchase of a large amount of validated, 'research standard' pedometers were beyond the fiscal means of the study at this time, and 2) if this was a problem encountered by the research team of a University, then it would be likely that schools and coaches wishing to use pedometers to promote physical activity would face the same barrier. The results of the validation of the Ez-V digital pedometer presented in **Study 1** indicate that this model of pedometer will provide sufficiently accurate data (r=0.897) that can be used by primary school children to gain feedback on their daily physical activity and how their personal behavioural choice can affect their physical activity. These results enabled the Ez-V digital pedometer to be used with confidence in Study 2.

Study 2 compared the mean steps·min^{-1} across five consecutive days, of children from primary schools that were placed under three different conditions. The CON group children wore sealed pedometers so that they were unable to see how many steps they had taken. Children in the FB group wore unsealed pedometers, and so were free to look at the display and obtain feedback on the amount of steps they had taken. The FB+I group followed the same procedure as the FB children, except that they also received information and ideas as to how they could increase their daily steps. Results demonstrated that children in the FB+I group significantly increased their mean steps·min^{-1} compared to those in the FB and CON groups. This suggests that pedometers can provide feedback to facilitate a short term increase in children's pedometer steps during the school day, but that additional physical activity information may be important to avoid intervention fatigue. Results also demonstrated that, as seen in previous studies, males accumulated significantly more pedometer steps·min^{-1} than females (Mota *et al.*, 2003: Riddoch *et al.*, 2004; Tudor-Locke, 2006; Butcher *et al.*, 2007; Fairclough *et al.*, 2007; Gidlow *et al.*, 2008).

Study 3 examined the affect of the school TP on the whole day MVPA of primary school children by (1) comparing the MVPA of children who attended schools with an established TP with those attending schools just embarking on theirs, and (2) by examining the difference in MVPA by season. The results of the study found there to be no significant difference between the MVPA of children from the New TP and the Est TP schools, However, results revealed that even though not significant, children in the New TP schools accumulated 7.24 (winter) and 24.11 (summer) more minutes of MVPA (5.2% and 15.66% respectively) throughout the day compared with those in the Established TP school children. This trend suggests that children were most active in the summer compared to the winter, which adds support to previous research that has found a seasonal difference in children's physical activity (Rifas- Shinman *et al.*, 2001; Rowlands & Hughes, 2006; Kolle *et al.*, 2009; Rowlands, Pligrim & Eston, 2009; Carson & Spence, 2010; King *et al.*, 2010). Furthermore, the trend also suggest that the school travel plan may be most effective when it is first implemented and that schools should refresh its messages each year so that all children and parents are aware of its purpose.

Study 4 examined the affect of a 12 week, theoretically driven, multi-component, whole school intervention which aimed to increase children's school day MVPA. Results of the study showed that from baseline to follow-up, children increased their MVPA by 6.57 minutes during the school day, which statistically, was likely to be beneficial. Put another way, the increase in MVPA was clinically important for the children. Low compliance to the accelerometer measurement protocol meant that despite MVPA remaining above baseline throughout the intervention period, the clinical benefit was only seen during this comparison. Results from the Pedometer Challenge found that males' mean pedometer steps·day^{-1} were significantly higher than females' ($F_{(1, 95)}$= 9.987, p=0.002, d=0.65) and overall, mean pedometer steps·day^{-1} significantly increased from week one to week five ($F_{(1, 93)}$= 5.845, p=0.018, d=0.24). Again, this is in line with the results found in Study 2. When the lowest and highest active 50% groups were compared, children in the lowest active 50% group significantly increased their steps from week one to week five ($F_{(1, 47)}$= 20.847, p=0.000, d=0.93), while the highest active 50% did not ($F_{(1, 47)}$= 0.000, p=0.990, d=0). These findings are supported by the previous studies of Oliver et al., (2006) and Kang and Brinthaupt (2009). Most notably however, males in the highest active 50% group were found to accumulate significantly more steps than the females, in the highest active 50% group ($F_{(1, 46)}$= 14.701, p=0.000, d=0.81), while there was no significant difference between the males' and females' pedometer steps in the lowest 50% group ($F_{(1, 46)}$= 0.456, p=0.503, d=0.14). To the author's knowledge, this is the first study to observe these results which suggest that in the lowest active children, males' and females' pedometer measured physical activity is similar.

A common finding from studies 2 and 4 is that pedometers, in combination with physical activity information and education can be successful in increasing pedometer measured physical activity. However, data regarding the intensity of the activities that made up the pedometer measured data were not available during study 2 (as it was not measured) or study 4, due to the lack of compliance to the accelerometer protocol. This information is necessary to determine whether any increase in physical activity is of sufficient intensity to be of benefit to children's health. Future research should examine the use of pedometer data to calculate physical activity intensity for this reason. Despite this, the results of these two studies suggest that by using a modestly price pedometer, schools may not have to spend a lot of money to facilitate an increase in their children's physical activity during the school day. By combining this information with feedback from the pedometers, it enabled children (especially the least active children) to see how their personal behavioural choice can affect their physical activity and therefore reinforcing that behaviour. While the BASH education programme delivered in Study 4 was done so by a Physical Activity Officer from outside the school staff, the information provided to children was in line with current government recommendations on physical activity, which already forms part of health related physical education curricula and so should be delivered by class teachers. In the longer term, this approach is a more sustainable and cost-effecting approach and so teachers should be encouraged to deliver this element of the curriculum.

While the scope of the present thesis was influence the moderate to vigorous physical activity of children in the primary school setting, it is important to recognise that the scope of the results goes beyond changing primary school policy. As outlined by Welk's YPAP model (1999) and the social-ecological model for school based physical activity promotion (Inman, Baergem, LaRosa & Garr, 2011), parents/guardians and significant others as well as communities also play an important role in changing physical activity behaviour. In order for healthy physical activities to be adopted and maintained, it is important that they are enabled and reinforced by people outside of the school environment as well as within (Welk, 1999). Indeed, one of the common limitations of studies 3 and 4 was the lack of compliance to the accelerometer protocol, which resulted in a small final sample sizes for comparison. It is envisaged that the negligible ES found in Study 3 and the lack of clarity regarding clinical significance in Study 4 was due to the small numbers available for comparison. Following Study 3, the lack of compliance was considered to see if this was a phenomenon exclusive to the way data were collected in this study or whether it has been experienced by other research. However, very few studies have reported compliance to accelerometer protocols. The question was raised whether the lack of compliance was therefore as a result of inadequate preparation or support for children and teachers, or whether there were other factors associated with children wearing (or not) accelerometers for at least 3 days. After some consideration, it was decided that in order to assist in explaining any compliance issues in Study 4, questions about this issue would be asked during the semi-structured interviews. Furthermore, in order to be confident that the children were adequately prepared for wearing the accelerometers, it was ensured that sufficient information was provided during the introductory meeting about the intervention and the accelerometer protocol with the children, which included showing children an example of data that the monitors collect.

Results of the focus groups and interviews suggest that the main reason for the lack of compliance to the accelerometer protocol was that children simply forgot to wear the monitors. The fact that children had to take the monitors home, take them off (for sleeping, bathing etc.) and remember to place them back on, meant that if they had forgotten their accelerometer by the time they returned to school the next day, there would be little/no opportunity to retrieve the monitor and therefore the day's monitoring was lost. In accordance with Welk (1999) 's YPAP model and the comments of the Year 5 class teacher, it may therefore be important to engage parents and ensure that they buy in to studies where accelerometers need to be worn at home, so that they can help to reinforce and remind their child to wear the monitor. Indeed, when considering the compliance to the pedometer protocols (with the majority of children recording sufficient data), whereby children were only required to wear the pedometers during the school day (when they arrived at school to when they went home), the class teachers were on hand to remind the children to attach and remove the monitors. However, future studies need to examine the issue of compliance to accelerometer protocols in children and further explore the barriers to wearing the monitors. Furthermore, research should explore the role of parents/guardians in reminding/reinforcing accelerometer wear in primary school aged children.

Chapter 8 Conclusions & Recommendations

The overall aim of the thesis was to examine the effect of primary school based interventions aimed at increasing 7-11 year old children's MVPA.

8.1 Conclusions

8.1.1 Study 1

Study one achieved its aim in that it successfully validated the Ez-V model of pedometer for the use in primary school children, with a strong positive correlation observed overall between the monitor and observed pedometer steps (r=0.897).

8.1.2 Study 2

Feedback from pedometers is successful in facilitating a short term increase in children's pedometer steps during the school day, however this is not statistically significant after 5 days. In order to maintain a statistically significant increase in pedometer steps·min^{-1}, it is likely that physical activity information is needed to avoid intervention fatigue. Furthermore, boys were found to accumulate significantly more pedometer steps than boys across the intervention groups.

8.1.3 Study 3

While no significant differences were found between travel plan groups and season, the trend observed in the data suggest that children are more physically active during the summer and that the school travel plan may be most effective when it is first implemented.

8.1.4 Study4

A 6.57 minute increase in MVPA following the implementation of a 12 week, theoretically driven, multi-component, whole school intervention was deemed to be beneficial to 7-11 year old children. In addition, results of the Pedometer Challenge component of the overall intervention suggest that pedometers and information on how and why children should be physically active can significantly increase the least active children's mean daily step count, which can be maintained over a 5 week period. Furthermore, these results suggest that the lowest active boys and girls may have similar physical activity behaviours.

8.2 Recommendations

There are a number of recommendations from this research, including suggestions both for primary school practice and for further research.

8.2.1 Recommendations for practice

- The Ez-V pedometer will provide sufficiently accurate data that can be used by primary school children to gain feedback on their daily physical activity and how their personal behavioural choice can affect their physical activity.
- Pedometers, in combination with education to increase the children's knowledge and understanding of the benefits of a healthy lifestyle and information/ideas about how to be more physically active, can be successfully used by teachers as an intervention to increase children's school day physical activity.
- Schools should provide children with a variety of opportunities for physical activity during playtimes in order to promote moderate and vigorous intensity physical activity in the least active children.

8.3 Recommendations for future research

- Future research examining the role of pedometers in promoting children's moderate intensity physical activity is needed.
- Participant compliance to wearing accelerometers should be reported in the literature, in order to gain a better understanding of the problem internationally.
- Further research into children's barriers to accelerometer compliance needs to be conducted so that researchers can design their physical activity studies accordingly.
- Researchers should examine the role of parents/guardians in accelerometer compliance.
- Further large scale research should be conducted to examine whether season has an effect on children's physical activity and whether there is any difference during different segments of the day.
- Larger, controlled studies examining multi-component, theoretically driven, whole school interventions to increase primary school children's MVPA should be conducted.
- There is a need for observational studies aimed at determining the physical activity behaviours of the least active children in order to inform targeted interventions for physical activity promotion in this population.

Chapter 9 References

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Chapter 10 Appendices

11.1 Appendix I

Interview with Year 5 class teacher.

How long have you been working with children and how long have you been at Hawes Side school?

I've been qualified for 7.5 years and have been here for 7.

So what's your role within the school?

I'm a class teacher and I also have the responsibility for PE and within that I do a lot of the extra curricular activities. We offer...football, hockey, cricket, tennis, netball rounders and depending on the time of year, athletics. Most of it is national curriculum sports, but we have done other things. We did lacross, we do a general fitness thing, we've had somebody come in and do a junior gymnastics, but it's mainly linked to the curriculum.

Before the PA intervention, how do you feel the physical activity ethos of the school was, so how did the teachers etc feel about it?

I think that lots of people think it's a good idea, but they don't want to be that involved themselves, so they think that children should be physically active, but they don't necessarily want to be involved themselves. I don't think they're that active to want to take part in it (referring to the other staff and parents both taking part in it and facilitating it for the children).

Do you think that's changed since the intervention?

I think some people have seen that it is a bit more important now, you know, since the children have got quite a lot out of it and a lot of it came from health week when a lot of them got to try some different activities.

So in terms of the kid's ethos towards PA, how has that changed?

I think a lot of them perceive it as being very important and a lot of them know why they should exercise, that it's important and good for them, that it's fun.

Do they distinguish at all between PA and sport?

Um, Yeah I think they tend to think that it is sport, that it is playing games, I don't think that we've got that this being active at lunchtime is part of being fit, we're still pushing it. But you know, playing and sport tend to be thought of as different things.

So, in terms of walking, do they perceive that as being active?

I don't think they do. Because, as you say, PA to them is sport, playing a game or just playing. Walking- I don't think that it's perceived in the same way, I think that's one of the things to get through to the parents as well, just going on a walk is helpful.

So can you describe the activities that were on offer during HW?

We had links to some of the high schools, so they came in and did like, aerobics, and circuits with the infants and years 1&2. One of the schools came in and did orienteering with Y3&4. Then some of the SSCO's came in and did 'botcha', curling, boxercise...so we got lots of things that we wouldn't normally offer. Tri-golf was another. So in one way, it was getting them away from the normal team games and trying things they can do by themselves.

In terms of health messages, what did you do?

We gave them a lot of out areas, pathways out of it, 'well you've done this, now if you're interested, where they can move onto next' like the orienteering, tri-golf. Well you know, if you contact a local golf club...and sort of telling them where they can carry on with it and not just, try it and it doesn't go anywhere.

And so BASH was part of that?

Yeah. We did the 'be active stay healthy' with year 5.

Do you think that would have been good to do with the rest of the school?

I think it would! It's good, it's something that the authority does and is aimed at year 5, with the science links and everything, but I think that something similar, like if each year group had some kind of, even if it was somebody coming in and doing an extra activity with them, just to bring it to the forefront, so that they know what's going on.

So do you think that Y5 are more aware of the health benefits than the rest of the school?

I would think most probably because of the science links that were made in it, because one of the exercises they did was a game where you had the body pumping the blood around and I think that sort of linked into why it's healthy. They're shown an artery that's all clogged up and talk about what makes it like that, so maybe they've got more awareness than everybody else.

So overall, do you think that HW had effect of increasing PA and knowledge of health?

I think it did, yeah.

PPW- can you describe any changes in behaviour, or what happened?

I think that from talking to our lunchtime supervisors, there's been more, better play going on at lunchtimes with the PALS going out and helping. Getting the new equipment and the trim trail up and running, the 3 way shooter, meant that more children were active at lunchtime because they're not just stood around, they could go and climb on something, play...especially with the 3 way shooter, because you got them running around then after the ball, so that's really made a difference.

Did they mention anything about the behaviour of the children (LTS)?

Yeah, I think because they're occupied, I mean, we did have teething problems with the 3-way shooter when it started, like all the children wanted to play with it at the same time, but once we got them into a routine where one class at a time or 1 year group could play at lunchtime and then swap over, it does seem better and they are better behaved because they are occupied and busy.

Have the LTS said that this has been maintained?

The PALS had a bit of a novelty effect. Some of them decided they didn't want to do it anymore, so we've drawn it up that now they're in a team, and they do it for a half term, so instead of having different people on different days, that team of 6 people do it for ½ term. They're still only out 2 or 3 times a week, but they're doing it and then the other team will take over. Because I think that's it, some of them start, the Y6's think they can't be bothered to do it today... And introducing all those old games that people used to play at playtimes but don't now because they're all into computers and they don't know what to do.

What happens during wet play?

Um, we don't do PA during wet play. I mean I've been doing my take 10, so quite often we'll do that. We did think we could play them through the computers but we can't, it was only the classes with a DVD player that could carry on playing them. I think we've been quite lucky this year, because I don't think we've had many wet plays, because we try and, as long as it's not pouring down, try and get the children out.

Do you think that the weather affects their PA?

It would. I mean it's always worse, like if you've had a wet break, and then you have a wet lunchtime, n the afternoon it's horrendous, because they've had no opportunity to let off steam. Their behaviour then goes down hill because they get fractious with each other because they've not had that running around. They're not as attentive because they've not had the chance to run around and they've not had the fresh air.

PED- describe the effect that it had.

They enjoyed it (in a BUT...voice). Once you got over the initial, no you can't stand there shaking it...I mean the big thing was either they'd forget to log it...we tried to get into the habit of when they take it off at home time, write it down then what it says, because some of them would say they've done 20 million. But I think they did (enjoy it) and they quite enjoyed the competitiveness between themselves 'oh I've done 7000 and such steps today' and then seeing if they could do more.

Do you think the information given helped them?

I think it did, yes. Because it explained why and the benefits of it. It wasn't just thrown at them and told, well wear this and write down what you've got.

Do you think it might have been better if we'd have introduced it as part of the health week?

I think it might have been, it'd have been more... 'relevant?'...yes, especially if it'd been one of those weeks, they'd have seen that the week previously, and they the health week when they had all the different opportunities, then see the following week 'oh, well it went up and now it's gone down'.

Do you think the effect of the pedometers was maintained?

I think it dropped off. The first couple of weeks they were fine, but it started to get, we weren't so bad, but I know some of the other classes had problems with lots of the pedometers not working. I think that, sort of, put them off, 'well mine's not working so...'

As a teacher, were you able to use the pedometers and the information to help you in your lessons?

I did on a Friday afternoon, I'd get my children to write about what they'd been doing, and we'd talk about it. I mean, a lot of them go on the field to play football, so you'd be able to ask 'so why is so-and-so's steps not as high as someone else?...', '...well, they've been on the field playing football while *they've* been in the lunchtime activity room, or they maybe didn't want to go out...'. So that was good to show them how the steps build up. We do have 2 activity rooms, so they can, if they don't want to run around, they can come and sit down and do activities. But we do put a dance mat in each one, so it's sort of a little bit of activity. Which they quite like and it's a bit different and they don't realise they're doing any (activity)!

Did you, or could you use the pedometers for PE?

Yeah, I think I'd be a useful thing. I mean, years ago, when walkers crisps were doing them, they were quite interested and quite a few of them were wearing them and seeing...It would be interesting to see two very similarly active children and compare them (seeing how many steps they think they've done etc).

So, from the policy week, were there any changes?

The only thing we've really looked out was sort of, the playtime things, trying to get a committee of children to be in charge of taking the equipment out, but they have wained (Y6), so after Easter I'm going to get Y5 to do it.

Were you able to open up the gym after school?

We haven't really got around to do that at all really, which was a shame.

So, looking at the intervention as a whole, what were the best and worse bits?

I think the HW was really good, more children enjoyed that and got a lot out of it. And the same or the classes that did the pedometer challenge, a lot of the children, if all of the children had the same pedometers and they'd worked for the whole 5 weeks, it'd been really good. Some classes had it worse than others, some classes after a couple of weeks, nearly all the children weren't getting any readings. And I think that's why they haven't got their results sorted, because they weren't working and couln't be bothered.

What were the worst bits?

Chasing all the staff to get their results sorted out, and reminding the children to bring their monitors back! I mean, it didn't seem to matter how you did it, they still forgot them.

Do you think parents understood?

In my class, the ones that were causing problems were the ones where the parents had split up so, one day they'd be at one parents' and the next day they'd be at another one's and that's where the problem was, they'd leave it at one and because of the animosity between the parents, it wasn't like 'here's the belt, here you are'. It wasn't until they went back to that parents' that they could get it back.

How did you think the children reacted to wearing the monitors?

I think after the first few days, they were fine, most of them put them on and forgot all about them and didn't fiddle with them. It was just that first few days, but after that it was fine. They were fine with wearing the belts, no one complained having to o them. The biggest thing was reminding them, remember to bring them back on Friday.

Do you think as a school you'd like to maintain some of the aspects of the intervention?

Yeah, I think we would. I like the idea of the pedometer challenge. I mean, if we had a class set and maybe give them to one for a week and then to another week ad so on and say '1K did this many steps this week, can we beat them?' and do it like that and really get them pushing that in school. And use it on the playground and using them like that hopefully get them used to that.

Do you think having the HW at the beginning of term rather than in the spring term?

Um, I don't know. I think this time of year would have been better because the weather's getting nicer, and after Easter once the weather's getting dry they're allowed on the field, so they've got more space and that lets them do more exercise. But it did work well when we did it, but it'd be interesting to do it another time during another year and compare it.

Do you think maybe a refresher, possibly having morning assembly's that have the health messages in would be beneficial?

Um, yes...We're talking about linking it to PHSE and doing a health week, not so much the physical aspects of health, but the others, and at the same time just mentioning the physical, so they do keep that up.

How do you think we could have improved the intervention?

I don't think...The only other think I can think is maybe getting the parents in and talking to them, rather than just sending a letter home...so they could then ask any questions, Because I only had a couple in mine that didn't want to do it, maybe if they'd have known a bit more about it, they would have been more happy about taking part and it might have made them more supportive of them making sure the kids had their belts on before they went to school. It would have ironed out some of those problems.

Do you think I could have done anymore to have helped you?

I don't think so. I mean, you were always available and you were in all the time, so I don't think there was anything more you could have done.

So you felt comfortable with me just giving you instructions and just running with it?

Yeah, Yeah! Because everything was explained really well, so no.

ENDS.

Appendix II

Year 5 Focus Group

Participants: M1, G2, L1, L2, and A1

Talking about health week:
A1: BASH?
G2: We, like, taste fruit and stuff?
Tell me the things that you did?
M1: We had smoothies...and they were horrible! All gooey and...I liked the banana one.
A1: The first smoothie was horrible, but the second one was ok.
M1: The first one had loads of bits in
A1: We did BASH, we were learning about all the parts of the body...the biceps, triceps
M1: the quads and the calfs and the muscles
L1: And BASH actually stands for , Be Active, Stay Healthy.
G2: And we wore the activity belts. They hurt! They were just tight.
Did you not try and undo them? Get someone to help you?
G2: I tried. But they didn't really go.
Can you remember the other sports and activities you tried?
L2: We had a game of footie, um, I can't remember much...
G2: Skipping.
M1: Um, in games we played, cricket
A1: Netball!
G2: Um, we were doing some hockey as well.
Do you remember doing orienteering...?
L2: Yeah! You had a map and you had to find the things...
M1: Oh! And you had to turn the cones over?
A1: Yeah, that was a good game.
What about things like tri golf?
L1: Yeah.
A1: Oh yeah! When we did, like the punching...boxercise!
Do you remember the different people who came to see you?
A1: There was this man...
G2: Sarah. Sarah came in.
A1: But they were split into 2 groups. Some of us went to golf and some of us went to boxercise.
L1: And on tri golf we had these cones in the middle, and you had to hit the golf ball and try and hit the first cone.
M1: Well there was different points for different cones as well.
So of any of the things you did during health week, would you like to try or do them again?
G2: Yeah.
L1: Yeah.
All: Yeah.
Like what?
L2: Tri golf.
M1; I'd like to do tri golf, um,
A1: The groups we were split into, the people who did one couldn't do the other. So because I tried tri golf, I would like to try boxercise. Um, and maybe the other people would like to try tri golf?

G2: I would like to do boxercise and I was in boxercise.
L1: I'd like to do curling. Year 6 done it, but we didn't.
L2: I quite liked BASH.
M1: We learnt about the heart. We put cones around and we had to run round, and the heart and lungs pumping in the middle...
A1: And I was the muscle.
M1: And we had to pull balls out and keep running round and put balls in the hoop and run round again and put that in the hoop.
So did that help you understand how the heart and the lungs and the arteries and the veins work?
M1: I really didn't get it about the heart...It was like, when you were pumping, it wasn't connected...
A1: In the beginning to me, it didn't make a lot of sense, because I didn't really understand it, but then, in the end I understood it really well.
So, the things you learnt during health week, do you think they'll help you make healthier choices in the future.
All: Yeah
A1: I eat a lot more fruit now.
M1: Me and Leon, every lunchtime, we always get a pear now, or an apple.
Do you make more physically active choices? Or did it not make a difference?
M1: It did make a difference because I'm starting to do more and get more experience off it.
A1: Like when I was in year 3 I didn't do any clubs, but now I just do loads of clubs.
M1: In year 4 I couldn't really ride a bike without stabilisers, but now they've come off and that's what I was trying to learn.
Do you remember 'Playtime Pals'?
L2: Yeah, we, um, well all of a sudden they've quite stopped now, haven't they? They've stopped now, because I know people who are pals who have.
A1: My friend Franchesca started, and now she's stopped.
M1: X doesn't do it lunch times but he does it playtimes.
What things did you do before playtime pals?
M1: Kicked stones around.
A1: Play tig and that
L1: We have got a school council and they look after things and buy things.
A1: And fixes things.
L1: And gets ideas and brings them back to class.
And since?
A1: every playtime now, the boys go on the field and play football.
M1: And if it's my class's turn, I go on the trim trail.
So do you think there's more to do now?
All: Yeah, a lot.
Are you more active?
All: Yeah.
What do you remember about the pedometer challenge?
M1: I get at least over 7,000 steps a day, no 8,000 steps a day, so I didn't go lower than that.
A1: It was good to see how many steps you did a day, like, when you don't wear them you don't have a clue.
L1: I liked the ones without the strap, because the ones with a strap were digging into me.

M1: Because I put them on, the used to slip off and I never know and when I took it off there were marks on my skin.

So how did you feel about wearing the belts?

M1: Quite tight, but it was alright.

G2: The ones with the straps were ok and the ones without were fine.

A1: But sometime the ones with straps, they fell off when you were running.

Was it difficult to remember to put your belts on?

L2: No. Well, I used to forget sometimes.

A1: You just used to slide them over

M1: On my pedometer once, I managed to get over 8000, but when it was playtime, I opened my pedometer to see how many steps I'd done and I realised that I hadn't re-set it, I was on like...21000 and had to re-start it.

So did you look at your pedometers during the day?

L2: I didn't

A1: I checked it every playtime.

Did it make you want to take more steps?

All: Yeah!

A1: Coz, sometimes it was really low and I thought Oh no! Everybody's gonna get higher, so I started to run.

M1: Yeah, but we got *told off for doing that- it's cheating!*

So what type of things did you do to get more steps?

M1: Um, run around...um, what we did is for like 3 days, all my mates and me, we just ran around the netball court, trying to get loads and loads of steps.

A1: Yeah, we were more active, weren't we?

Did you find it a bit boring after a while though?

Some: Yeah.

L2: No.

A1: I didn't, no.

M1: But on the last week, it was getting kinda boring, because you've worn it a long time and you just don't want to wear it anymore

A1: yeah, you just, keep forgetting about it.

Georgia: It was quite annoying trying to remember to put it on.

M1: Yeah remembering to put these things on and you've got other things to remember

A1: Like I kept on forgetting to re-set it. Or put it on!

G2: I forgot to take it off.

So, do you think it was important for you to know how many steps you were taking?

L2: No, not really

M1: It doesn't matter how many steps a day you take, because you'll still be active and still be running

L1: You feel

A1: If you're not active it's more important to know how many steps you're taking.

G2: Yeah, if you're not active.

M1: The thing is we were arguing

L1: You were cheating!

M1: No, you were...

So do you think it's important to know how active you are?

L2: Yeah! Because your bones can get stronger the more active you get.

A1: It's nice to know how active you've been.

If you've been active, does it make you feel good?

L1: A lot!

A1 & Georgia: yeah!
L1: On Saturdays we go and play football sometimes.
M1: Not sometime, mostly all the time.
So, do you think you could have taken more steps?
Girls: Yeah.
And how do you think you could have done that?
M1: Not forgetting about them really!
L2: Take smaller strides as well!
A1: Yeah, I forgot about them
M1: When you used to stamp, it used to give you like 5 steps.
So in general, how did you feel about the belts?
G2: They were ok, because I didn't really notice them
So what was the best thing about the physical activity project?
M1: It was fun!
A1: I think...um, I liked all of them really
L1: I can't really think...but I would say BASH
A1: Yeah, because you learnt more
M1: We learnt a lot more
G2: Especially about the heart and everything and the biceps
A1: You weren't like in just BASH or in an activity, you were learning as well.
L2: And you weren't doing it for 5 minutes.
So do you think that you're more likely to do an activity if you understand why you're doing it?
G2: yeah

ENDS

11.2 Appendix III

Year 3-4 Focus Group

Participants: *D1, G1, C1 & C2.*

If you can remember, what kind of things did you do during Health Week?

Can't remember...

C2: Running...All sorts, play football.

C1: At home I kept on taking my dog for a walk and running

What other things did you do during Health week?

C1: I had to eat broccoli and stuff

C2: Ah that's nice!

G1: I did some jumping and skipping

Did you do things like orienteering...?

C2: I've forgot what that is.

So do you find it really hard to remember all that way back?

All: Yeah!

Do you remember any messages you learnt about being active?

C2: Noooooo.

D1: When you run, your heart gets pumping and it pumps your blood around your body.

C2: We did PE and Miss Ford made us feel our hearts and it was beating well fast and it was about to burst out.

C1: She does it all the time!

D1: It makes us run around and she makes us feel our hearts and if we don't run around before PE, you might pull a muscle.

Do you think the things you have learnt have helped you make healthier choices? Give examples.

Girls: Yeah

C2: Kind of. Because I always play football and always do PE

D1: That's healthy...do you eat broccoli?

C2: Yeah and cauliflower

D1: Do you eat chocolate?

Before the Playtime Pals and the new equipment, tell me the kinds of things you would do during playtime.

D1: When I was in year 2 and went and did PALS, we did hoola hoping and stuff like that.

C2: Most of the lads play football and others chase me and Lewis.

G1: We play like tic and stuck in the mud and stuff

C1: And we go around all the people and we pat them on the back and sometimes they don't know and sometimes they do and sometimes we pretend it's not us and sit down

D1: Me and my friends, we play this baby game and I'm the teacher and I have to teach them ballet.

G1: There's this white bit on the playground and we have to push eachother and sit them down and if you go in there it means that your 'out' because you can't let them go in there and sit down.

C2: Sounds like a naughty game.

D1: Sometimes we can play love hate kiss or marry. You cover your eyes or think of something and they have to pick one and the one they pick they have to do.

What kinds of things do you do now, do you play with the shoots and things now?

C2: Nooo, we're not allowed. They don't let us. We only get the pupil's footballs the soft ones.

C1: But the boys get some exercise because they're always out playing stupid football.

C2: Stupid?!!! It's better than what you play!

G1: Yeah, but you keep knocking us down.

So do you think that the boys are more active than the girls?

D1: The girls could do better.

C2: Anyway, me and Lewis don't play football that often anymore because the girls are normally chasing us.

D1: The girls, if they get a boy to chase, and the boys can get more active.

What did you think about the Pedometer Challenge?

C2: It was very good.

D1: It made us feel interesting, because it helps us to get into games more and more active and more healthy.

C2: Yaeh!

C1: It was alright.

C2: It was alright?! It was fantastic!

Was it difficult to remember to put your Pedometer on?

C1: Yeah. I kept leaving mine at home.

C2: I took mine home and when I was sleeping it kept on going up.

D1: I took mine home and I lost it...

I mean the ones that you kept in school and had to write down how many steps you took...

C2: Oh! The ones you kept in school....I loved them!

D1: I didn't really like that one. The sheets that you had to write them down, they got muddled and some people lost theirs in school or they ran out...

G1: I liked it, but people kept grabbing them

C1: They'd press the button when you weren't supposed to and I didn't like it.

G1: yeah.

Did you look at your Pedometer during the day?

All: Yeah!

D1: we weren't really allowed, so we had to sneak them really.

C2: I got 20 thousand only.

Did miss ford tell you that you weren't allowed?

G1: Yeah, but we didn't listen.

D1: We sneaked it!

When you did look at them, did it make you want to take more steps?

All: Yeah.

G1: Coz once I had 73 when I'd just done, when I'd just put it on.

C2: I normally got up to 20000

D1: I think someone, he was just sat down and he did 70 something...

Is it important for you to know how many steps you take? Why?

C2: Yes.

D1: Because you can see how much walking and running you've been doing to keep healthy.

C1: It's fun and it's really important because you really have to know how many steps you're taking.

Why do you think that?...Do you think it's important to be active?

All: Yeah

C2: You could know because you could try and beat that score.

D1: If you just sat in bed all the time and watched TV and never moved around or done some jogging, your heart would just wouldn't work quite right, your blood might go that little bit slower

Do you think you could have taken more steps? If so, how could you have done this?

All: Yep

C2: Only if we took them home, we could have done loads more.

C1; Could do some more runnin

Do you think you always have to do running?

C2: No

G1: No

C2: Could just sit down, but you're still getting exercise because you're still moving, you might fidget

C1: You know when you get that pain in your hip when you run all the time...

C2: A stitch?

C1: Yeah. Stitches, they really hurt you and, um, my friend, she's got a big trampoline and I jump on it a lot and I get a stitch

C2: Once I ran to the hills, by the beaches, one day I ran down there

D1: Sometimes when you go really fast, you get a stitch and it really hurts and yu have to stop running.

How did you feel about wearing the activity belts?

C2: Awkward...

D1: Not very good

Why?

C2: Because it rubs on ya.

C1: I thought it was quite good, but the next day it I kept forgetting it and by the end of when we were wearing them I lost it.

G1: Alright, but it wasn't really comfortable

C2: Yeah, because it rubs you

Others: yeah

Was it difficult to remember to wear them?

D1: And sometimes if you fell, you could smash it

C1: And it kept flashing and it got on my nerves

What were the best bits about the physical activity project?

C2: Like when you got to see your steps and stuff.

C1: When you got jogging and it got more and more. I couldn't wait to see it go up!

D1: It made the class more active and into games and stuff

C1: Yeah, we really had more energy then

G1: It made it more healthy and interested in games

What other things would you like to do in school?

C2: Play football!

D1: If there was more things on the playground, we could be more active. Not just pictures on the floor. If we had like a little climbing frame and a slide and swings, you could get people more active and stuff.

G1: yeah, coz all we have is the trim trail

C2: we could make the field into a racing track

What do you think about your PE lessons?

C2: Oh fantastic!

G1: We got out the climbing frames and did different ways of moving, that's what we did last time

C2: Throwing those circle things like what year 6 did....

So when you have PE, do you like it?

C2: Yeah!

G1: Not that much

C1: I do.

D1: If we could do it in our school uniform it'd be oh, but when you have to get changed it's hard work.

In your spare time, what kinds of things do you do?

C2: Play football. Play on my PS2

D1: On most days I get active because I just skate around with my mum for a little bit. Then I go to my grandmas and go for a little sleep and then I'll either play in the back garden or play with my dog, then I go home and I just have a little run about in the house

G1: I normally play with my dog or I will play on my trampoline

C1: I play with my friend or I'll go on the internet or on Mario

D1: That's not very active!

Would you prefer to do something physically active or watch TV/play on the computer?

C2: Active things!!

G1: Active things

D1: Um, watching TV

G1: Yeah, both I like doing

C1: I think I like doing active things better, but I don't do it. Sometimes I go in my friend's back garden and go trampolining

D1: Sometimes I feel like going running out the back, but sometimes I feel lazy and I watching TV, or I go on the PS2

C1: I sometimes go dancing in my friends room.

ENDS.